CGS1-1

Soil for Peace

The Soil-Peace Nexus

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As an elixir of life, soil is the basis of all terrestrial and coastal biomes. Soil and its quality are principal sources of food, fuel, fabric and shelter, and the foundation of civilization. Thus, soil has influenced development, persistence, fall and recovery of civilizations throughout the human history. Powerful civilizations have thrived on soils of good quality because advances in science, art, and philosophy depend on its quality and sustainability. Mesopotamia, Indus (Harappan), Mayas, Chinese and other civilizations flourished and advanced in regions of favorable soil, water and climate. Present day centers of high population density and thriving economies also coincide with regions of high soil quality (e.g. alluvial plains, loess soils, volcanic soils, Histosols/Chernozems). Only if the basic necessities are met can citizens focus on stewardship, education, music, and culture. No doubt that climate change has played a key role in evolution and progress of agriculture. However, some sites of prehistoric civilizations and powerful nations are now covered by degraded soils, denuded lands, and desertified ecosystems because citizens of these nations took their soils for granted. It is now widely understood that aridization (i.e., Indus valley, Mesopotamia) may not have been the principal cause of abandonment and vanishing of these cultures. Indeed, thriving civilizations, with fertile soils, can adapt to changing climate (e.g., by manuring, terracing, irrigation, cropping systems). Soil quality and its productivity are also critical to political and social stability and to human health and wellbeing. The critical soil-civilization nexus was, is and will remain essential to human survival and wellbeing. Therefore, in addition to agricultural use, soil science must also be studied in relation to other uses of interest to modern civilizations including roads and civil structures, hydrologic systems (e.g., dams, canals) ceramics, industry (e.g., aluminum, cement), medicines (e.g., streptomycin), germplasm and biodiversity, denaturing of pollutants and filtering of water, carbon sequestrationand adaptation to climate change, space exploration, human and planetary history, art and poetry, religion ,philosophy, governance and policies etc. Above all, sustainable management of soil for high productivity is also essential to peace and ethnic harmony at local, regional and global scales. For global peace and political stability, the critical soil resource must be used, improved, restored, judiciously governed and never ever taken for granted.

CGS1-2

Soil for Peace

Soils for Peace and Security

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Soils are the basis of the world's agroecosystems, which provide food, fiber, feed and fuel to the global population. As a nonrenewable resource, the preservation of soils is paramount to sustain world peace and security. However, soil preservations currently faces numerous geographical, social and economic challenges. Specifically, how does the world develop sustainable agricultural systems and processes that meet the needs of present day society without diminishing productivity for future generations? Moreover, use of crop residues, forage crops, animal waste, and other agricultural waste for bioenergy production could deprive agroecosystems of important inputs for future soil productivity. Our goal is to continue to develop new technologies to improve agricultural production by using fewer resources (less land, water, energy, and fertilizers). Attempts should be made to maximize bioenergy production with minimal effect upon agroecosystem balances. Further, considerable uncertainty persists regarding the issue of soils and climate change. Alternative management strategies, such as no-till, minimum-till and no-burn, are practical conditions under which active carbon sequestration in soils could be feasible. Terrestrial C sequestration is often presented as a "win-win" situation to offset a substantial portion of anthropic CO2 emissions. In sub-Saharan Africa, long periods of drought have resulted in poor corn and millet harvests, which have led to a population suffering from malnutrition. The introduction and adoption of genetically modified (GM) corn and soybeans is promising as a means to halt the decline in crop yields in developing countries. Ultimately, the global aim for soils should be that as a provider of a significantly sustainable food and fuel supply for the global population.

CGS1-3

Soil for Peace

Starting Unification in Korean Peninsula from Soil

Yang Ho-Seung

World Vision Korea

Every Living things come from the ground, prospering from things given by the fertile soil. Even Mankind has made a living off of the things given by the fertile ground. Excluding few of the successful countries whom have harvested its fruits from development, most of the third world underdeveloped countries are still living off of agriculture, and to them land and soil itself is life. Situation applies for DPRK also. DPRK has been in food crisis for almost 20 years and in an effort to overcome this situation DPRK has been very open to support and cooperation in agricultural sector. World Vision has started humanitarian aid in DPRK starting 1994 with emergency food relief. After few years, feeling that emergency food is not the solution to the “food problem” shifted gear into Agricultural development project in 1998 and working to this day. Potato, vegetable, fruit, and other areas were covered to provide material / technical support and started to realize the importance of soil, which is an essence to all crops. World Vision has connected scientists in North and South Korea so that there can be steady contact in field of soil since 2002, when World Vision and KAAS (Korea Academy of Agricultural Science) held the 2nd Joint Agricultural Science Symposium at Pyongyang. On 2009, scientists from North and South Korea have gone through a joint research project on the soil of DPRK. Although there has been difficulties due to tension between North-South, if we use the trust and experience to continue the steady exchange and cooperation we will be able to walk towards unification. Unification and cooperation started through soil has shown lots of possibility and this small unification through soil will play a part to unification and world peace. We ask and expect all of World Soil Experts to play their part for peace and prosper.

CGS2-1

Soil Security

Soil Security Symposium: Introduction

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Soil Security, an overarching concept of soil motivated by sustainable development, is concerned with the maintenance and improvement of the global soil resource to produce food, fibre and fresh water, contribute to energy and climate sustainability, and to maintain the biodiversity and the overall protection of the ecosystem. The term 'security' is used here for soil in the same sense that it is used widely for food and water. It is argued that soil has an integral part to play in the global environmental sustainability challenges of food security, water security, energy sustain-ability, climate stability, biodiversity, and ecosystem service delivery. Indeed, soil has the same existential status as these issues and should be recognised and highlighted similarly. The concept of soil security is multi-dimensional. It acknowledges the five dimensions of (1) capability, (2) condition, (3) capital, (4) connectivity and (5) codification, of soil entities which encompass the social, economic and biophysical sciences and recognise policy and legal frameworks. Consequently, the soil security concept is somewhat wider than the cognate notions of soil quality, health and protection.
Key experts from a variety of backgrounds will give their appreciation of Soil Security from their diverse points of view.

Andrea Koch, Alex McBratney, Mark Adams, Damien Field, Robert Hill, John Crawford, Budiman Minasny, Rattan Lal, Lynette Abbott, Anthony O'Donnell, Denis Angers, Jeffrey Baldock, Edward Barbier, Dan Binkley, William Parton, Diana H. Wall, Michael Bird, Johan Bouma, Claire Chenu, Cornelia Butler Flora, Keith Goulding, Sabine Grunwald, Jon Hempel, Julie Jastrow, Johannes Lehmann, Klaus Lorenz, Cristine L. Morgan, Charles W. Rice, David Whitehead, Iain Young, Michael Zimmermann. 2013. Soil security: solving the global soil crisis. Global Policy Journal 4, 434-441.
Alex McBratney, Damien Field, Andrea Koch. 2014. The dimensions of soil security. Geoderma 213, 203-213.

CGS2-2

Soil Security

Reaching out from the Soil Box in Pursuit of Soil Security

Johan Bouma

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Soil security can only be achieved when the global soil resource is maintained and improved. This requires a major effort by soil scientists in at least two directions: (i) getting more engaged with major interdisciplinary programs focusing on food, water, climate, biodiversity, energy and health, issues that – as yet in contrast to soil - are widely acknowledged to be important to reach sustainable development goals (SDG's); (ii) confronting the: "Knowledge Gap", which indicates that too much existing knowledge is not being applied in practice, by exploring and taking an active role in introducing innovative transdisciplinary approaches. Ad(i): Simulation models are indispensible tools to not only characterize the dynamics of current ecosystems at different scales in space and time but to also explore future conditions by scenario analysis predicting effects of possible management measures. Ecosystems are highly complex and simulations involve gross simplifications which should, however, not imply that soil data used are either too simplified or even omitted. To demonstrate the significance of soil input, studies are needed comparing modeling of ecosystem dynamics with and without soils input. Also, soil dynamics cannot properly be represented by using automatically generated pedotransfer functions, bypassing soil expertise. Soil scientists will become more interesting as interdisciplinary partners when their expertise is more transparently and engagingly presented by: (i) considering any soil type as a "living"body in a landscape context , soil scientists can act as facilitators to articulate the exciting stories she has to tell, building on the deep affinity with " land" of most people. Representing soil in terms of a limited, sterile set of characteristics does no justice to a "living"soil. Emphasize not only genoforms, as defined by soil classification –the capability dimension, but also phenoforms – the condition dimension, showing the effects of management.(ii) further developing and applying new monitoring, remote and proximal sensing techniques, digital soil mapping and accessible databases that go beyond presenting standard soil characteristics. Ad (ii) Educate socially intelligent knowledge brokers that can work with stakeholders and policy makers in a bottom-up and co-learning mode to transform plans, based on a joint research process, into practical results – the connectivity dimension. Knowledge brokers have "T-shaped "skills, combining disciplinary depth with a broad understandig of the socio-economic societal context. Knowledge brokers are only one manifestation of a proposed new research paradigm represented by a Community of Scientific Practice (CSP)where basic research will continue to be judged by peer review and publication indices while knowledge brokers are to be judged differently considering societal impact. CSP's require at least: (i) re-connecting the knowledge chain, which appears to be broken now, by linking tacit to basic knowledge in a two-way manner; (ii) simplifying soil terminology being used which is now unnecessarily complex for outsiders. The seven soil functions, defined in the European Soil Protection Strategy, can form the central focus of research from which condition, risk and resilience definitions can be derived as well as the specific contributions that soils can make to ecosystem services – the capital dimension. (iii) taking time to identify all stakeholders and their opinions and goals at the start of any research program. Never say that something cannot be done as this is the quickest way to alienate stakeholders and policy makers. Just show the economic, social and environmental consequences of any idea, however weird it may appear at first sight. Start with existing knowledge and define and focus new research on gaps that arise ; (iv) formulating a series of options for "wicked" environmental problems, for which "silver-bullet" solutions never exist. A choice among options has

to be grudgingly made in the stakeholder and policy arena (not by scientists) and will always represent a compromise between conflicting economic, social and environmental objectives, requiring tradeoffs – the codification dimension. Scientists are in a unique position to make such tradeoffs transparant but it requires continuing attention and involvement and much more time than is usually available.; (v) guarding the independance of the scientific enterprise. Going back to the "roots" of the profession when our pioneers discovered that soil was more than dirt obscuring rocks, working closely with land users. Soil scientists are in an excellent position to claim the role of knowledge brokers in land-related inter- and transdisciplinary programs focused on SDG's.

CGS2-3

Soil Security

Investing in Green Growth Involves Investing in Soil Security

Anna van Paddenburg

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Green growth is essentially an approach to achieve a number of simultaneous objectives bringing us closer to achieving true sustainable development: avoiding and curbing greenhouse gas emissions, building resilience to change, using resources more efficiently, providing sustainable and equitably-distributed increases in GDP and standards of living, and valuing the often economically invisible natural capital that have underpinned economic success over the centuries.

The Global Green Growth Institute (GGGI) is a new kind of intergovernmental organization (IO), established officially as an IO in October 2012, founded on the belief that economic growth and environmental sustainability are not merely compatible objectives; their integration is essential for the future of humankind. Many international organisations involved in land use and natural resource management concern themselves with issues related to soil quality, health, productivity, or more generally soil security, as it forms part of the natural capital important to lasting and equitable economies, especialy in countries with large agriculture and natural resource economies, such as Indonesia.

There are multiple definitions and uncertainty in building the best framework to measure such growth, including appropriate selection of performance indicators, and adoption of the best available tools. In Indonesia, a joint program with its Government has illuminated five dimensions of green growth as a basis to measure green growth performance: economic growth, inclusiveness and equity, resilience, green house gas emission, healthy and productive ecosystems. Each dimension when positively nurtured will contribute to green growth[(1)].

The healthy and productive ecosystems dimension highlights growth which depends on and sustains natural capital, especially the natural stocks which supply a continuous flow of important ecosystem services. These stocks, include soil, forest, water etc. provide essential contributions to economic growth and human well-being but are often omitted from decision making as they are not seen as inputs to economic production. Indicators relevant to soil as well as the value of these stocks needs to be better quantified, in order to include the contribution of these often omitted services to the performance of growth in a particular geography.

Assessment of indicator of soil security will be required. For example, a macro-economic analysis done on Borneo in 2012 using the Systems Dynamics model highlights that Borneo's economy is driven by built capital, human capital and natural capital, including ecosystem services derived from the natural stock 'soil' . The state of these ecosystem service can influence other variables, both in a positive and a negative way. While empirical evidence on the value of soil exists in limited form, driving investment and policy reform towards growth which values natural capital, may benefit from investments into applied research which can highlight the strengths of these linkages and the value that services derived from soil provide to the local and global economy.

To be able to carry out the above applied research, one must understand, the five C's of soil security. For sustainable green growth these five soil dimensions required to be measured, monitored and where necessary, modified.

(1) *Government of Indonesia – GGGI Green Growth Program, launched at the Global Green Growth Forum in Copenhagen, October 2013*

CGS2-4

Soil Security

Soil Security and International Climate Policy

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International climate change negotiations are leading towards a new major agreement in 2015. There is a real opportunity to deliver a win for soil security in the midst of these discussions. If protocols for the measurement, verification and reporting of increased soil carbon can be agreed, then there is a real incentive for nation States in terms of achieving climate change targets. We now have a window to give more focus to the sequestration opportunities presented by soil. More education is needed regarding the positive consequences that a global movement towards restoration of soil C can make towards sustainable development, with the capacity to significantly improve and maintain soils to sustain productivity, water retention, biosecurity and climate and energy security. Many nation states are well advanced in developing national protocols to count soil carbon as a sink. Australia's Carbon Farming Initiative has made significant inroads into the development of measurement-based protocols for soil carbon sequestration, which will count towards the nation's carbon account. The World Bank has implemented a model-based project in Kenya with significant early results. Advances in digital soil mapping will support this effort. The soil science community is to be encouraged to continue to raise the flag for soil security, and to seek to inform public policy makers and the general public on the science that supports it.

CGS3-1

Soil-Plant Welfares for Human

Soil's Capacity to Meet the National Nutrition Values in Korea

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Human health is the supreme concern in any occasions and thus food quality and consumption become an important issue not only in our daily life but also in science. Enormous information on nutrition facts of crops and food, and related health indicators such as body mass index and % of guideline daily amount (GDA) etc. are available. However, capacity of soils to meet the nutrition values in the national scope is less known. This $_{\text{plenary}}$ will introduce the protocol to assess the adequacy of Korean soils to nourish human health. To assess the soil's capacity to meet the national nutrition values, considered were four basic components such as the national dietary reference intakes (DRI), total amounts of crops and food consumed, total annual crop productions and national-wide soil fertility values. The national soil map for the selected soil attributes was constructed using web-GIS tool and necessary components to calculate the nutrition value were extracted to use. The national nutrition requirements for total population were calculated from the Dietary Reference Intakes. Total production and consumption of food and crops were estimated from the national D/B system. Mass of nutrients that soil can supply to plant or human was calculated based on national average concentration of nutrient and cultivation areas. Suitability of soil to provide nutrients to human was evaluated by comparing the values from four components. Some of results showed that nitrogen in Korean soil could meet only parts of the protein demands by Korean. Also, about 30% of potassium in soil could supply to Korean diet to meet the recommendation. On the contrary, all of calcium and magnesium needed by Korean were totally provided by soil. Cases of micronutrients and other nutrition facts will be introduced. Authors introduce new terminologies for "Soil Welfare" and "Plant Welfare" in this plenary: Soil welfare refers to soil capacity to provide nutrition values to human health and thus it can encompass concepts of soil security, health, sustainability etc. Plant welfare refers to the well balanced plant nutrition facts that can provide to human health through diet. Soil and plant welfare concepts can be used for soil value estimation and policy and regulation for the sustainable management of soil.

Key words: Soil capacity, Human nutrition, Soil welfare, Plant welfare, Security

CGS3-2

Soil-Plant Welfares for Human

Soil Science in the Anthropocene: Golden Opportunities and Grand Challenges

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Land degradation, water quality and quantity, air quality, climate change, and food security are foremost issues of our time. Soil provides the substrate where all of these challenges commingle and interlace. We, as soil scientists, must be at the forefront in addressing and providing solutions to these vexing challenges that threaten humankind. It is also incumbent that we tackle the research needs in an interdisciplinary manner by interacting with other natural scientists, social scientists, engineers, and humanists. We must also communicate the results and solutions in a meaningful way to decision makers and the public.

The importance of basic soil biogeochemical research to address these global challenges has never been more important. Combining advanced molecular-scale analytical techniques with studies at the macroscopic and landscape scale, and over an array of temporal scales, are necessary to address some of the most important scientific questions related to environmental quality and degradation. This presentation will include case studies dealing with soil, air, and water contamination and carbon cycling/sequestration to show how the application of a multi-scale, interdisciplinary approach can provide important insights into environmental degradation and restoration.

CGS3-3

Soil-Plant Welfares for Human

Soil Biodiversity and Sustainability

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Soil biodiversity is key to the maintenance of soil functioning and plant production, but is generally overlooked in global policies addressing food security, climate change, loss of biodiversity and desertification. Yet, soils are well known as living dynamic interfaces: they are inhabited by millions of largely unseen and unknown microbial and animal species that are intimately interacting with plants and animal biodiversity that live above-ground. Recent scientific advances in soil biodiversity have accelerated knowledge on the identity of species, the factors determining their biogeographical patterns, and their key role in biogeochemical cycling in terrestrial ecosystems. Society receives services from the activities of soil biological communities such as decomposition, cleansing of water, regulation of pests, nutrient cycling and food, feed and fiber production. Land use change, tillage, agrochemical use, GMOs, nitrogen enrichment and climate change all affect soil biodiversity and consequently, above-ground biodiversity and functioning. In a rapidly changing world, restoration and conservation of soil biodiversity is, therefore, critical in order to sustain our soil resource and the rapidly growing world population. The challenge is to promote interactions between scientists, policy makers, land managers and other end-users in order to increase the implementation of findings on the benefits of soil biodiversity and ways to restore and conserve it. The Global Soil Biodiversity Initiative (GSBI) was launched in 2011 in Wageningen, The Netherlands, to promote translation of expert scientific knowledge on soil biodiversity into actionable science for environmental policy and sustainable land management. GSBI's Secretariat office is at Colorado State University, USA, which provides basic funding. Scientists may register and be updated on news and activities at http://www.globalsoilbiodiversity.org. Activities of GSBI include: (1) Global Soil Biodiversity Atlas of current knowledge on soil biodiversity across natural and managed systems to bring awareness to the importance of soil biodiversity in maintaining ecosystem services (target date- December 2014, supported by the European Commission-Joint Research Centre). (2) A proposal for the first Global Soil Biodiversity Assessment to bring the rapidly developing science of soil biodiversity and ecosystem services into local to global management of lands for global sustainability. (3) Synthesis and working groups to establish frameworks to improve understanding of global distribution of soil biodiversity and ecosystem services. (4) Determining and promoting research areas needed for soil biodiversity: GSBI identifies research gaps and endorses research networks such as, the Global Urban Soil Ecology Experimental Network (GLUSEEN) and an assessment of soil biodiversity in Central Park, New York City. (5) Organizing the first international Soil Biodiversity conference with the EU - EcoFinders project in Dijon, France (2-5 December 2014). The GSBI is directly relevant to soil scientists and terrestrial ecologists, encourages collaborations of research projects and networks. Moreover, the management of soil biodiversity for ecosystem services is relevant to the sustainability of global lands and has caught the attention of policy makers and those concerned parties interested in sustaining biodiversity, healthy soils, people and global biogeochemical processes for our future earth.

CGS4-1

IUSS for Global Soils: Future Nexus

The Iuss (1924-2014) as a Link to Global Soil Science and Scientists

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Following rapid developments in geology and biology the systematic and scientific study of soils started somewhere in the beginning of the 19th century. There were groups who studied soils in the field and groups who studied soils in the laboratory, and themerger of these two contributed to the establishment of soil science as a scientific discipline. That was greatly facilitated by the meetings that resulted in the establishment of the International Society of Soil Science (ISSS). The ISSS was formed at The Fourth International Conference on Pedology in 1924. The conference recommended more uniform methods of soil analysis, a definite nomenclature for soil classification, the preparation of agro-geological maps of Europe, the organization of soil investigations in countries where these had not yet started, and an introduction to the study of soils into the curricula of intermediary and higher schools. It was decided to encourage soil research world-wide as its primary goal.

Membership of the ISSS increased from around 550 in the 1950s to over 60,000 today. The ISSS was admitted as a Union member of the International Council for Science (ICSU) in 1993, and in 1998 the ISSS was restructured into the International Union of Soil Sciences (IUSS). The IUSS has encouraged international exchanges of ideas and collaborations through the organization of international congresses, known as the World Congress of Soil Science. A total of 19 international congresses have been organized, with eight of these congresses held in Europe, five in the Americas, three in Asia, two in Australia, and one in Africa. The IUSS maintains a website (www.iuss.org) since 2001 with a variety of information about soils, publishes twice per year a Bulletin (since 1952) and publishes a monthly electronic newsletter (IUSS Alert) since 2005. The IUSS initiated the Soil Map of the World, which was prepared in the 1960s and 1970s and a whole range of other scientific initiatives, publications and cooperating journals.There are four divisions (Division 1 - Soil in Space and Time, Division 2 - Soil properties and processes, Division 3 - Soil Use and Management, and Division 4 - The Role of Soils in Sustaining Society and the Environment). Each division is further divided into five or six commissions. In addition, there are nine active working groups. The IUSS has two major awards: the Dokuchaev and von Liebig award and these are widely regarded as the Nobel prizes of soil science.

The discipline of soil science has matured and there have been staggering developments. Soil science has applied techniques from the fundamental sciences (chemistry, physics, mathematics) and the applied sciences (e.g. geostatistics, ecology, remote sensing) to develop its own thriving subdisciplines (e.g. pedometrics, proximal soil sensing). Soil science is thriving and there are an increasing number of projects that consist of consortia of university and research centres, scientific publications with increasing impact, and increased outreach and interaction with the general public.There is awareness on the role of soils in sustaining ecosystems functions and in relation to climate change, food production, water availability or bioenergy production. The IUSS established 5th December as the World Soil Day, and played a key role in the International Year of Planet earth triennium (2007-2009) that has put soils back on the global agenda. Global attention to soil science has resulted in projects and initiatives such as GlobalSoilMap, Global Soil Biodiversity Initiative, Global Soil Week, Intergovernmental Technical Panel on Soils, Global Soil Partnership, Global Land Project and several others.

The IUSS continues to foster all branches of soil science by encouraging global cooperation but most of all by providing a platform to advance the soil science discipline. Many of today's environmental and ecological issues require local or national solutions but global scientific cooperation to come up with the best possible solutions. The past 90 years has shown that international cooperation and a strong scientific union contributes to the advancement of the soil science discipline, and that the IUSS is the most important global link to world's leading soil science and soil scientists.

CGS4-2

IUSS for Global Soils: Future Nexus

Strengthening the Role of Soil and Land in the Sustainable Development Goals : A Proposal to Increase Collaboration between IUSS and the Global Soil Week

Alexander Muller

IASS, Germany

- The ongoing negotiations of the UN on Sustainable Development Goals following the decisions of the Rio+20 conference in 2012 offer a unique opportunity to highlight the importance of soils for sustainable development. The UN General Assembly in its Resolution A/RES/66/288* from 27 July 2012 recognized “the need for urgent action to reverse land degradation” and stated: ”In view of this, we will strive to achieve a land-degradation-neutral world in the context of sustainable development.”
- The UN negotiations on sustainable development goals, the annual celebrations of World Soil Day on 05. Dec. and the International Year of Soils in 2015 have to be used to raise awareness on the importance of sustainable soil management.
- However, the international community is far from fully recognizing the need for bold action to reverse land degradation and to implement the existing knowledge on sustainable soil management on a global level. Soils still have to be considered as a forgotten resource when it comes to governance at global level!
- New forms of partnerships and cooperation with multiple stakeholders have to be developed and an intensive discussion on appropriate forms of governance of land and soil and the role of soils in the Nexus-debate has to be initiated.
- The international debate on the “Nexus between Water, Energy and Food” as analytical tool to assess linkages between the different sectors puts integrated resource management on the scientific and political agenda. The different nexus assessments send a clear message: a fundamentally different approach is needed in understanding and managing natural resources in the context of growing pressures on the environment. Business as usual has the potential to undermine the basis for food security and to threaten human development.
- The current Nexus debate is focusing on efficiency, integrated assessment and use of natural resources and the competition and inter-linkages of different sectors (energy and food) with the natural resource base with a strong focus on water. It has to be noted that the Nexus-approach can best be understood when its origin in the history of Integrated Water Resource Management (IWRM) is taken into account. The role of soils in the Nexus is still underdeveloped and not recognized. The tremendous amount of excellent soil scientific research has not been sufficiently taken up by these policy processes.
- Representing global soil science, IUSS needs to be involved in the Nexus and SDG debates. To be powerful in these debates, those working on soil and land have to work in partnership.
- Therefore the collaboration between IUSS and the Global Soil Week (IASS) should focus on the following two areas:
- The integration of soils in the Nexus approach. Soils are an essential part of the natural resource nexus and without soils the Nexus is not complete.
- In their assessments, the nexus-community recognizes the inter-connected nature of natural resources and identifies rising scarcity and competition as the most challenging issues. We are missing the problem of unequal access to natural resources as an additional key element in the Nexus debate. Integrating governance of natural resources and esp. access to land and natural resources to the Nexus debate would further develop the approach. The strong linkages between unsecure access to land and unsustainable soil management could be seen as a starting point for further discussions at the Global Soil Week.

O1-1

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Integrated Management Strategies for Arsenic in Paddy Rice Fields

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Agricultural soils have been contaminated with heavy metals due to rapid industrialization and economic growth, resulting in severe health threats to people who consumed crops contaminated with elevated levels of toxic metals.This is especially true in paddy rice fields contaminated with arsenic, where rice is actively taken up and accumulated inorganic arsenic in the grains, posing health risks on the consumers. Arsenic is classified as a Group A carcinogen by the United States Environmental Protection Agency (EPA). Arsenic contamination of geogenic origin is a public health (causing arsenicosis, black foot disease, cancers, etc.) in a number of regions/countries, e.g., Bangladesh, West Bengal (India), Chile, Vietnam, Cambodia, and Inner Mongolia (China), through drinking contaminated ground water, and consuming crops, especially rice irrigated by the contaminated water. Rice is a staple diet of 3 billion people in the world, and in most of the countries with higher concentrations of arsenic in underground water,contributing to extra intake of arsenic, in addition to drinking water.Arsenic has both inorganic and organic forms: (1) Inorganic arsenic: the major form of As in water (groundwater and surface water), soil and various foods, with arsenate [As(V)] generally dominates in aerobic soils and arsenite [As(III)] in flooded soils; (2) Organic arsenic: the main organic species are monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA), usually at lower concentrations than inorganic arsenic species. This presentation will highlight the major issues concerning arsenic contamination and associated health risks, by citing some regional examples. The potential strategies (or their combination) to mitigate arsenic contamination in rice are discussed, including (1) Growing upland rice instead of lowland rice; (2) Growing paddy rice aerobically in raised beds; (3) Changing the metabolism of rice by manipulating arsenic accumulation in rice; (4) Breeding rice with low levels of arsenic in grains; (5) Selection of suitable arbuscularmycorrhizal fungi (AMF) or bacteria/rice combinations, to lower the uptake of arsenic by rice grains; (6) Growing arsenic hyperaccumlating/accumulating plants to lower soil arsenic concentrations before planting rice; (7) Removing arsenic from groundwater using adsorbents and/or microorganisms; (8) Addingbinders for lowering the mobility and bioavailability of arsenic in soils; (9) Using ex situ treatment technologies (such as soil washing); and (10) Blendinglow arsenic rice with high arsenic rice before sale..

O1-2

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Risks of Metals and Metalloids in Subsistence Farms around Metal Mines and Agronomic Interventions

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In high rainfall regions of developing countries, subsistence farming in the peripheral areas of metal mines (such as gold and base metal mines) is a common land use option to grow pulse crops and/or vegetables for local household consumptions, such as south China, Laos and Africa countries (e.g. Ghana). Unfortunately, risks of heavy metals and metalloids in these farming systems have been largely overlooked or ignored, due to the poor information access and/or low socio-economic situation, which would have profound and legacy impacts on the health of local population. The present talk aims to review reported levels of heavy metals and/or metalloids in soils, typical soil types, major crop/vegetable species, and common agronomic (mainly fertilization) practices in the subsistence farming systems, particularly, in relation to their phytoavailability in soils, root uptake efficiency of different species, and impacts of fertilizer practices on plant uptake and accumulation of metals and metalloids. A set of agronomic practices or options of soil remediation and fertilization technology have been proposed, with the aim to immobilize metals and metalloids in soil and reduce their uptake and accumulation in crops and vegetables. The exclusion of certain crop/vegetable species from the farming systems has been suggested based on the current knowledge of root acquisition mechanisms of metals and metalloids from acidic soils. While recognising the necessity of subsistence farming in low socio-economic circumstances, local mine management and government regulators should improve the management of mine wastes and water to avoid further entry of metals and metalloids into the peripheral subsistence farms, through water runoffs in these high rainfall regions.

Keywords：*subsistence farm, metals, metalloid, phytoavailability, uptake*

O1-3

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Effects of Soil Amendment on Cadmium and Arsenic Concentration and Arsenic Speciation in Rice Grain

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A health-based guidance value for Cd of 25 μg kg^{-1} bodyweight per month was established by the Joint Food and Agriculture Organization / World Health Organization Expert Committee on Food Additives, and a maximum level (ML) of 0.4 mg kg^{-1} for Cd in white rice grains has been adopted by the Codex Alimentarius Commission (2006). Rice is a staple crop in Asia, and is the principal source of dietary intake of Cd; therefore, minimizing the intake of Cd from rice is an important health issue. Although flooding of paddy fields effectively reduces grain levels of Cd, anaerobic conditions in paddy soil lead to arsenic (As) mobilization and therefore the uptake of As by rice could increase.

The Ministry of Agriculture, Forestry, and Fisheries of Japan analyzed the As content of staple crops in Japan and found that an average value of total As and inorganic As concentration in brown rice were 0.17 mg kg^{-1} and 0.15 mg kg^{-1}, respectively (2003-2005). As concentration in most other agricultural products was below the detection limit. Seafood is a common source of organic As. Rice is therefore a major source of dietary intake of inorganic As. As is a carcinogen, and the intake of inorganic As in rice carries a significant risk for cancer in populations for whom rice is a staple food. In some cases, human intake of As from the consumption of rice exceeds that from drinking water. The 7th session of the codex committee on contaminants in food (CCCF, 2013) agreed that the electronic working group on As in rice would prepare a discussion paper on a ML for inorganic As in rice and rice products for consideration at the 8th session of the CCCF (2014)

As is present in rice grain both as inorganic As (mainly arsenite) and as dimethylarsinic acid (DMA). Inorganic As is generally considered to be more toxic than methylated As compounds. The grain of aerobically grown rice contains As almost exclusively in the form of inorganic As, whereas in anaerobically grown rice, DMA accounts for the majority of the total As. It has not yet been resolved whether DMA in rice is taken up from the soil or synthesized from inorganic As in planta. One possible explanation for the greater percentage of DMA in rice grain is that DMA is synthesized in the soil or rhizoplane and translocates to the grain. The objective of this study is to investigate the simultaneous effects on Cd and As levels in rice grains induced by soil amendment of paddy soil. We also investigated the effect of DMA, methylarsonic acid (MMA) and arsenite amendment on As speciation in rice grain grown in soil and in solution culture.

When rice was grown under flooded conditions, amendment of iron-containing material, silicates material and aluminum oxide material to the soil lowered the As concentration in rice grain and rice straw. Although amendment of the iron-containing material did not affect on the changes of Eh in soil, it lowered As concentration in soil solution. So As might be adsorbed by the material. When rice was grown under flooded conditions after the heading stage, DMA amendment to the soil resulted in higher DMA concentration in brown rice and rice straw. In the solution culture, not only DMA amendment but also MMA or arsenite amendment increased the DMA concentration in brown rice and rice straw. DMA was detected in the solution amended by MMA or arsenite with young rice plants.

We also investigated the methylation of As in solution culture under suppression of bacterial activity. When the solution included the antibacterial agent chloramphenicol, DMA concentration in the solution decreased dramatically. When only the soil was incubated with MMA or arsenite, only a slight amount of DMA was detected in the soil. These results suggest that rice rhizosphere associated bacteria would be involved in the formation of DMA in brown rice.

Keywords：*arsenic, rice, dimethylarsinic acid, cadmium*

O1-4

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Cadmium Phytoremediation in a Contaminated Paddy Soil: a Field Study in Mae Sot District, Thailand

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Cadmium (Cd) contamination in paddy soils has been reported near many zinc (Zn) mining and smelting plants of rice-producing countries. Cadmium present at high concentrations in these polluted soils is problematic since it can contaminate rice and subsequently enter the human food chain. Long-term consumption of this heavy metal can cause chronic itai-itai disease, which is characterized by renal proximal tubular dysfunction and osteomalacia. This research aimed to test the capacity of five plants, known to hyperaccumulate Cd, i.e. Chromolaena odorata (P1), Nicotiana tabacum (P2) Gynura pseudochina (P3), Crassocephalum crepidioides (P4), and Conyza sumatrensis (P5), to remediate Cd in a contaminated paddy soil at Mae Sot district, Tak Province, Thailand. This was achieved by conducting in-situ field-scale experiments in the contaminated agricultural field. The Bioaccumulation Factor (BF), Translocation Factor (TF), Vegetation Factor (VF) from weeds or grass, as well as total Cd uptake per plant were used to determine which one, among the five plants studied, was the best choice for local farmers to phytoremediate their polluted lands. The goal was also to employ a solidification technique to effectively dispose of the Cd hyperaccumulator plants after their harvest. Hence, this study proceeded in four stages: 1) selections of Cd-hyperaccumulator plant and paddy site 2) test of the plant abilities to uptake Cd in the selected paddy fields, 3) measurements in the soils before and after phytoremediation of the amounts of Cd and other relevant elements as well as numbers and types of rhizo-microorganisms, and 4) disposal of Cd-hyperaccumulator plants using a solidification technique. The five types of Cd-hyperaccumulator plants were planted under local environmental conditions in individual 5 x 5 m2 plots in paddy soils containing very high amounts of Cd (above 60 mg.kg-1) using a randomized complete block design (RCBD) approach, with three replications. On the 37th day after planting, fifteen plants and rhizosphere soils were randomly collected from each plot as representative samples to measure the amounts of Cd in plant tissues and rhizosphere soils as well as to determine the types and amounts of microorganism around rhizosphere and bulk soil. On the 57th day after planting, all remaining plants in the field were harvested. Fifteen plants randomly chosen per plot were analyzed following the same methods than those used to analyze the plants collected on the 37th day after planting. The remaining harvested plants were used for the fourth stage of this study.

Results showed that the numbers and types of rhizo-microorganisms present in the five plants were not significantly different from each other. The highest numbers of rhizo-microorganism were found in P1, followed by P2. The highest variation of rhizo-microorganism types was found in P2. The highest total Cd uptake at both harvesting time was found in P2, which was the only plant along with P4 that had BF ~ 1, TF > 1, and BF > 50. Hence, P2 and P4 fulfilled all the criteria characteristic of hyperaccumulating plants. Although P3 had the highest TF and VG values, its BF was lower than the ones of P2 and P4. The ashes of the five plants were considered hazardous wastes since their total Cd contents were higher than 100 mg.kg-1. They were successfully disposed in construction binding materials using a solidification technique at a cost less than 30 US dollars per hectare. To summarize, this study demonstrated that Nicotiana tabacum (P2), Gynura pseudochina (P3), and Crassocephalum crepidioides (P4) were the most suitable plants for local farmers to remediate their polluted paddy soils at Mae Sot, and the solidification method could be employed to dispose of the plants after harvest.

Keywords：*Cd phytoremediation in paddy soil, Cd contaminated paddy soil, solidification technique, Tobacco*

O1-5

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Heavy Metal(loid) Levels in Paddy Soils and Brown Rice in Korea

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This study was conducted to analyse the background levels of heavy metal(loid)s, including arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni) lead (Pb), mercury (Hg), and zinc (Zn) in major rice growing non-contaminated paddy soils and brown rice in Korea. The samples were collected from 82 sites in the year 2012. The total contents of As, Cd, Cr, Cu, Ni, Pb, Hg and Zn in soil were determined using ICP-OES after aqua regia digestion, and in brown rice using ICP-MS after hot plate digestion method. Mercury levels in soil and brown rice were directly analyzed using an automatic Hg analyzer. The average As, Cd, Cr, Cu, Ni, Pb, Hg and Zn levels in paddy soils were 4.377 (0.159-18.942) 0.254 (0.036-0.817), 44.364 (17.952-91.102), 13.238 (3.456-27.849), 13.601 (3.775-34.988), 21.306 (8.468-36.652), 0.047 (0.008-0.201), and 54.103 (19.194-103.61) mg/kg, respectively. This result indicate that the heavy metal(loid) levels in all sampled paddy soils are within the permissible limits as per the Korean Soil Environment Conservation Act. The average As, Cd, Cr, Cu, Ni, Pb, Hg and Zn levels in brown rice were 0.069 (0.001-0.269), 0.024 (0.003-0.141), 0.311 (0.121-4.261), 4.270 (1.259-16.979), 0.345 (0.039-2.767), 0.198 (0.041-1.004), 0.002 (0.001-0.008), and 22.635 (14.099-35.088) mg/kg, respectively. The average BCF (bioconcentration factor) values of As, Cd, Cr, Cu, Ni, Pb, Hg and Zn in brown rice were 0.016 (0.001-0.120), 0.121 (0.005-0.699), 0.009 (0.002-0.200), 0.399 (0.049-2.605), 0.033 (0.004-0.440), 0.009 (0.002-0.060), 0.060 (0.016-0.181), and 0.473 (0.190-1.074), respectively. The results show that the levels of heavy metal(loid)s in all sampled brown rice are generally within the acceptable limit for human consumption.

Keywords：*Cadmium, Lead, Mercury, Paddy soil, Brown rice, Bioconcentration factor*

O1-6

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Cadmium Contamination and its Risk Management

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Cadmium (Cd) has been identified as one of the major heavy metals reaching the food chain through various geogenic and anthropogenic activities. In many East and South Asian countries including Japan, Bangladesh, Indonesia, and Korea, Cd accumulation in rice (Oryza sativa L.) ecosystems and its subsequent transfer to the human food chain is a major environmental issue. Rice soils in these countries have been affected by Cd accumulation derived from fertilizer and manure application, mine tailings, and refining plants. Excessive intake of Cd into the human body is detrimental to human health, causing serious illnesses such as itai-itai disease. To ensure the safety of foods, the concentrations of Cd in staple crops should be below a standard value; this applies particularly to rice because 34-50% of the Cd intake by people in many Asian countries has been derived from rice. Therefore, development of remediation methods for Cd-contaminated rice soils has become an urgent task to ensure food safety. This paper provides an overview of the various sources of Cd in rice ecosystems and the biogeochemical processes that regulate Cd bioavailability to organisms, including microbes, plants, animals, and humans. Because of the complexity involved in dealing with Cd in rice ecosystems, exacerbated by the Cd source, site characteristics, and the nature of water management strategies, we have attempted to describe an “integrated” approach that employs a combination of remediation technologies, with the aim of securing methods that are economically and technologically viable.

Keywords：*Cadmium, Input Sources, Bioavailability, Mobilization, Phytoremediation, Soil Washing*

O1-7

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Response of Dissolved Arsenic and Cadmium Concentrations in Paddy Soils to Changes in the Air-Filled Porosity: Field Monitoring by Tdr and Suction Lysimetry

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Introduction
Dissolved arsenic (As) and cadmium (Cd) concentrations in paddy soil are sensitive to changes in the redox conditions, on which air-filled porosity during alternate submergence and drainage exerts a dominant influence by controlling oxygen diffusion in soil. Analyzing pore water extracted from soil cores taken at different rice growing stages, Nakamura et al. (2012) found that dissolved As concentrations were appreciable only when the air-filled porosity was smaller than a threshold value of 0.03–0.10 m^3/m^3 while dissolved Cd concentrations linearly increased with the air-filled porosity. Temporal changes of the dissolved concentrations were, however, beyond the scope of their work. In the present study, we investigated temporal changes in the dissolved As and Cd concentrations in response to the changes in the air-filled porosity in paddy soils under different water managements.

Materials and Methods
Field monitoring of dissolved As and Cd concentrations and air-filled porosity was conducted during rice growing seasons in 2010–2012 in a paddy field (Typic Hydroaquent) in Niigata Prefecture, Japan. The field had two different water management plots; following one-month ponding after transplanting in May and subsequent midseason drainage for approximately 20 days until mid-July, the prolonged ponding plot was submerged for a total of six weeks around the heading stage, whereas no irrigation was practiced after midseason drainage in the saving-water plot. In the both plots, the field was drained two weeks before the harvest. Pore water samples were collected in duplicate every one or two weeks from the 5 cm and 15 cm depths, using suction cup soil-solution samplers. The samples were immediately acidified with 10% HNO_3, and analyzed for dissolved As and Cd by ICP-MS. Air-filled porosity of soil was measured with TDR probes installed in duplicate at 5 cm and 15 cm depths. The air-filled porosity was estimated using the TDR output vs. air-filled porosity relations determined on soil cores collected in the fields.

Results and Discussion
Dissolved As and Cd concentrations in both plots responded to changes in the air-filled porosity in the way as expected from the results of the previous study in which soil core sampling was employed (Nakamura et al., 2012). Build-up of high As concentrations (20–50 μg/L) in the prolonged ponding plot were associated with low air-filled porosities of 0.05–0.08 m^3/m^3 during the ponding periods. Increase of the air-filled porosity to 0.09–0.12 m^3/m^3 or more in the midseason and preharvest drainage periods led to decrease of the dissolved As to near zero. In the saving-water plot, the air-filled porosity after midseason drainage was in the range of 0.11–0.54 m^3/m^3, and the dissolved As was mostly below 3 μg/L except for occasional increases to 10–15 μg/L with concomitant decreases in the air-filled porosity.
Higher air-filled porosity in the saving water plot produced dissolved Cd concentrations in the range of 2–7 μg/L, which decreased in response to decreases in the air-filled porosity by rain or irrigation. In contrast, dissolved Cd concentration during the prolonged ponding was close to zero, and was consistent with the low air-filled porosity of the soil.
Plots of the dissolved As and Cd concentrations against the air-filled porosity reveal that the dissolved As was appreciable only when the air-filled porosity was below a threshold value of 0.07–0.08 m^3/m^3, whereas the dissolved Cd concentration was positively correlated with the air-filled porosity. These relations, as observed by TDR and suction lysimetry, are in accord with those found by Nakamura et al. (2012) employing soil core sampling. The results suggest that As immobilization during drainage periods is a rapid process triggered by the invasion of O_2 into soil, and that by avoiding excessive drainage conductive to Cd solubilization through appropriate water management, dissolved As and Cd could be simultaneously kept at low levels. Future study should focus on the dynamics of dissolved As and Cd during intermittent ponding in paddy fields.

Reference
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Keywords：*air-filled porosity, arsenic, cadmium, paddy, TDR, suction lysimetry*

O2-1

[IDS1] Folk Soil Knowledge for Soil Taxonomy and Assessment

Soil Perception by Humans: from Ethnopedology to Neuropedology

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The perception of soils varied between the epochs. In the pre-agrarian epoch the soil had a negative connotation for human beings, because it was a dangerous source of potherb, full of poisonous beings such as snakes, spiders, millipedes etc. After the Neolithic agrarian revolution the perception of soils somewhat changed: the myths of the agricultural era regarded soil as "mother", the source of life. In the cosmogony of that epoch the soil was commonly regarded as a material used by demiurges for constructing humans or as a habitat of the first people. At the same time the soil was a mysterious object that also caused fear, because to a great extent the reasons for soil fertility or infertility remained unknown. Negative soil properties were attributed to the effect of evil spirits or to some discontent of the gods. These views remained until late medieval epoch. For example, in the infamous 'kattekleigronden' (cat clays, i.e. acid sulphate soils) quick soil acidification due to pyrite oxidation had a strong negative effect on the crops: this effect was attributed to witchcraft, and cats were commonly associated with witchery thus giving name to these soils. In some cultures vernacular soil classification considered the weird world rather than physical soil properties. For example, the Shipobo people in Peru classified differently the soils close to the village, where friendly spirits lived, and the soils of distant areas, where hostile forces rested. Since the causes of soil fertility were attributed to supernatural forces, the ancient agriculturalists relied on praying, sacrificing, and magic rituals. There are evidences that human and animal offerings were not uncommon. In ancient Mexico the Aztects sacrificed children to the gods of fertility. In more advanced cultures like in ancient Rome the offering was reduced to ritual smoke for the gods. Though recently rational knowledge replaced the mythological perception of soils, the old beliefs are still strong in the collective memory of the humankind. Actually a common view on soil is based on its importance for agriculture. However, this vision is far from being clear. A plethora of various understandings of soil exist, depending on the focal group (farmers, scientists, politicians etc.). Even intuitively clear concepts like "soil fertility" may have different meanings and connotations. The surprising fact of the present time is that the soil, though being of major importance for the existence of human civilization, is often neglected or underestimated. One can face even an actively negative perception of soil by people of various educational level and social position. The negativism towards the soils may have several causes: a) the old pre-agrarian and agrarian fears may be still active in human mind, b) people associate soils with graveyards, and thus soil reminds the death inspiring negative emotions, c) the soil is not personalized in the mind of humans today, and thus it causes minor emotional response, d) most decision-makers are townspeople who regards soil as "dirt", e) the apologists of "green revolution" consider soil as a passive object of application of fertilizers and management practices, f) experts in other areas do not want competition for funds with soil scientists. Though some of these causes are of practical nature, we cannot neglect the perceptional nature of the others. For increasing awareness on soils, for attracting investment in soil protection we should better understand the mental processes responsible for perception of soils, their management and conservation. The key may be in the study of the past and actual soil knowledge among the agrarian cultures, i.e. in ethnopedology. We also suggest establishing neuropedology - a new discipline on the crossroad of pedology, social sciences and psychology, which should consider the history, the actual state, and the methods of control of perception of soil-related concepts.

Keywords：*history of agriculture, cultural anthropology, soil awareness, soil policy*

O2-2

[IDS1] Folk Soil Knowledge for Soil Taxonomy and Assessment

Indigenous Soil Knowledge and Soil Mapping by Zulu Farmers, Potshini, South Africa

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INTRODUCTION

Unlike scientific knowledge of soils, indigenous knowledge (IK) is not recorded but is often orally transmitted across generations. This often results in the disregard of local people's soil knowledge and experiences, who instead then depend on scientific soil information such as soil surveys, which may not convey information in a relevant and understandable form. Such an approach can fail to address the needs of local rural communities. It is therefore necessary to make soil information relevant and to communicate it with more appropriate language. This study investigated the application of soil indigenous knowledge in soil classification amongst the Zulu ethnic group of South Africa.

METHODOLOGY

A general questionnaire was administered on 50 households in Potshini village, KwaZulu-Natal, South Africa. Ten farmers were selected from these households for detailed interviews on soil and crop information. The farmers were questioned on the cropping history, major crops planted in their fields, crop suitability, use of local soil indicators, management practices and how these are associated with different soil types. They were also asked to provide detailed descriptions of common soils in the village. The same group of farmers assisted in a participatory soil survey and indicated soil distribution patterns. During this exercise the farmers were asked to map the boundaries of soil types within the village based on an aerial photograph. This was followed by transect walks during which the boundaries and transition points were georeferenced using GPS. Transects were also used to conduct on-site characterization of soil properties.

The participatory survey was followed by a detailed scientific soil survey. This was conducted by the free survey method and all observation points were georeferenced using a GPS. The soils were classified to soil form and family. Soil maps were then digitised using ArcGIS10. Both local soil maps produced by farmers and scientific maps were incorporated into GIS. This was done to compare IK and scientific maps and to determine the degree of spatial correlation at a soil form level.

RESULTS AND DISCUSSION

A total of nine soil types are recognised by farmers in Potshini village. Consistence, texture, soil moisture retention, colour and stoniness of the topsoil are primary criteria for distinguishing between soil types. The subsoil is only considered if it is close to the surface.Their soil nomenclature is very descriptive and provides specific information about some primary diagnostic attributes of the horizon it represents. It also shows farmers' understanding of soil-landscape relationships. This is further reflected in the farmers' knowledge of soil distribution patterns. Soil colour and texture are integral to the recognition of these patterns. Ten soil types were recognised in the scientific survey. Results showed a strong correlation between isibomvu and oxidic soils, as well as isidaka and gleyic soils. There is thus a positive correlation between scientific and indigenous soil classification. This was further corroborated by the defined properties of each of the indigenous soil groups which matched those defined for the scientific groups with which they correlate. Moderate correlations were observed between isibomvu (with dark topsoil) with melanic soils as well as between itshetshe and cumulic soils while ukhethe had the weakest correlation with lithic soils. This may attributed to the fact that ukhethe only covers small proportion of the study area and most of it is not mapped individually in the local map. Maize and beans were common crops grown in the village. Generally, isibomvu is considered good soils for crop production. Although isidaka is relatively good, it is often limited waterlogging.

CONCLUSION

Soil classification by the Zulu farmers at Potshini considers colour, texture, consistence and stoniness as important morphological properties of the topsoil. The descriptive nature of the classification reflects the productive potential of the soils. The correlations observed between the local and scientific classification systems is essential for integrating knowledge from both local farmers and scientific researchers, and is necessary for sustainable natural resources management in rural communities.

Keywords：*Indigenous soil knowledge, participatory soil mapping, spatial correlation*

O2-3

[IDS1] Folk Soil Knowledge for Soil Taxonomy and Assessment

Use and Management of the Soils; Local Perspective of the Land Decision-Making

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In order to better understand the use and the management of soil resource and how farmers make their decisions, it is necessary to use a spatial geographic approach which considers factors of farmer's decision-making, for example: roads, weather, human settlements, land form, etc. Regarding soils, the local knowledge of the land classes is valuable, insomuch as the farmers obtained knowledge of their lands through centuries of observations and use. However, it is necessary to raise farmer's awareness about the environmental functions of soils so they may know what is gained and what lost when they change the use of soils, and thus make better decisions. The functions of the soil can be evaluated from the morphological, physical and chemical properties of the soil profiles, while the land use can be evaluated through maps of land cover and soil use in one period of time. The state of Michoacan, Mexico is the first place in national production and international export of avocado (Persea americana). The avocado planted area in the state of Michoacan, Mexico increases in 75% in the period of 1980 to 2010. Tacambaro municipality produces 12 t/ha and has orchards within 60 years of continuous production. Production has been sustained and increased through the local knowledge about the attributes of land classes. The objective of this research was to evaluate the expansion process of the cultivation of avocado in Tacambaro, Michoacan, Mexico. There are two questions we want to answer: What are the most attractive factors for local soils used for growing avocado? Do decisions about soil use change the environmental soil functions? To evaluate and integrate the geographical space we selected three time periods (1974, 1995 and 2011). For the analysis of factors that influenced decision-making we used the AGRILOCAL model. For each one of these years a map of covert and soil use was made. The spatial relations between the cultivation of avocado, the biophysical and socioeconomic factors, were determined through proximity and coincidence. To evaluate the environmental soil functions, three criteria were used: dominant landforms; presence and age of avocado cultivation. Interviews and polls were applied to obtain of local information of land classes, soil use and soil management, the preference and the relevance of the biophysical and socioeconomical factors. In the laboratory, samples were analyzed to know the chemical and physical properties of the soils. The values of the soil profile described in the field and the laboratory results were processed with Assofu software. The local population knows three land classes: Topure, Charanda and Revuelta. Each of the three have the same avocation cultivation use, but imply a different management, because local people differentiate attributes of the land classes, such as moisture retention, agricultural suitability, textural class, among others. The landscape slope is the most limiting factor for the presence of avocado cultivation. Although there are 0 degrees inclination slopes landscapes, 3-6 degree slope factors are the most abundant, so usually avocado cultivation were found in sloping ground. However, for the three periods analyzed slope in degrees is significant in deciding the soil use in the avocado cultivation. Environmental functions of soils in the water cycle show that, in general, the soils have intermediate to high quality and quantity of groundwater recharge, while supply and availability of soil nutrients are high to very high. So the balance of environmental soil functions regarding the needs and concerns of the population should be evaluated in order to identify the expansion of the avocado cultivation process and its environmental impact.

Keywords：*Soil use, soil management, functions of the soils, expansion process, factors and avocado cultivate*

O2-4

[IDS1] Folk Soil Knowledge for Soil Taxonomy and Assessment

Ethnopedological Knowledge by Smallholder Farmers for Agriculture Practice - A Case Study in Nanga Machan, Kanowit, Sarawak, Malaysia

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Ethnopedology has been defined as a hybrid discipline between the natural and social sciences that encompasses the soil and land use knowledge systems of rural populations from the most traditional to the modern. In Sarawak, Malaysia, majority of its population in the rural are depend largely on smallholder agricultural activities to sustain their livelihood in which are mainly for their subsistence. According to the previous studies on the local knowledge by the Iban, which is one of the largest indigenous groups in Sarawak; they classify their own soil based on their past experience towards the fertility or infertility of the soils which mainly referred to the types of the above vegetation of the given land. However, still limited information is available in the indigenous soil knowledge (ethnopedology) and there are requirement where at present, local people still depends on such knowledge to sustain the fertility of soil. In ensuring that local farmers' perception is also vital in planning for future agricultural scheme or management practices, the objective of this preliminary study is to clarify the correlation between indigenous knowledge and scientific knowledge for agricultural activity based on the interview and soil physicochemical properties analysis. Our findings showed that the farmers in the study area still possess and practice their indigenous knowledge on soil classification for their subsistence farming. Much of their interpretation on soil quality largely depends on their observation of topsoil and indicators characteristics i.e. colour and texture. Indigenous knowledge is a very limited indicator to classify soil; while scientific knowledge provides in-depth information in identifying soil characteristics. However, both knowledge has shown major similarities and complementarities, thus would create better soil management practice for smallholder farmers.

Keywords：*ethnopedology, land evaluation, soil classification, Iban, Sarawak*

O2-5

[IDS1] Folk Soil Knowledge for Soil Taxonomy and Assessment

State and Regional Soil Maps using Maya Soil Classification

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One of the limitations of using traditional knowledge of soils that is most mentioned in the literature is the local character of such knowledge, which hampers its extrapolation to medium (state) and small (regional) scales. This limitation may be true and valid for several cultures having edaphic knowledge. However, regional cultures, such as the Mayan, can be the exception. Our objective was to create soil maps at medium (1:100 000) and small (1:250 000) scales using the Maya soil classification. Previously available geomorphopedologic maps of the state of Yucatán at a 1:50 000 (Bautista et al., 2013) and a 1:250 000 (Bautista et al., 2011) scale were used, in which soils were mapped according to the WRB soil group classification. The Yucatan peninsula is the northern portion of Mesoamerica, which divides the Gulf of Mexico from the Caribbean Sea on the southeastern tip of North America and the northern part of Central America with an area of approximately 145 000 km². Maps using the Maya soil classification (Bautista and Zinck, 2010) were created in ArcGis 9.3. The Mayan soil classification could be easily mapped because the WRB soil groups with prefix qualifiers have corresponding classes in the Mayan soil classification. However, since the soil map at a 1:250 000 scale does not include the primary classifiers, use of the Mayan soil classes requires over generalizing, or a complex legend with multiple classes, which makes maps to be less visually attractive. Because the Maya soil classification is ample enough regarding the number of classes, and because of the correspondence of these classes to WRB soil groups with prefix qualifiers, the creation of state soil maps using the traditional Maya knowledge was made possible, thus interrogating the validity for some millenary and widespread cultures of assuming limitations from localness of soil knowledge. The Mayan culture occupied and still occupies a large extent of territory, particularly the Yucatec Maya culture is along the Yucatan peninsula. No big mountains that hinder the interaction between peoples. This helps the spread of pedological knowledge.

Keywords：*Local soil knowledge; Mayan culture; Yucatan Peninsula*

O2-6

[IDS1] Folk Soil Knowledge for Soil Taxonomy and Assessment

Inventory of Local Knowledge about Buried Soils in the Volcanic Zone of Michoacan Mexico

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The local knowledge in a determinate region it is a useful description for evaluating soil aptitudes. Also, for knowing how many and which farmers want to participate in the design and develop of new technologies. The most interesting characteristic it is that these studies provide the researcher with a dual vision of the soil state, on one hand the holistic local knowledge, and on the other hand the technical knowledge with detailed descriptions. The aim of this research was to explain the attributes of the farmer's land classes based on the chemical and physical properties of the soils, to compare and integrate the local and the technical knowledge of soils. Thirty-five interviews were applied to key informants; the sample was 10% of the farmer population of the study zone (a larger percentage was considered unnecessary give the homogenous information reported). The sample sites were selected in accordance to the soil use and to the landform; 31 pits was dug and samples were taken by horizons of the soil profiles for subsequent laboratory analysis. With the values of the laboratory results and the information of the land classes we made a multivariable discriminant analysis to mathematically validate the local knowledge. The identified land classes correspond to: Charanda, Tocura, Cementante, Polvilla and Barrosa. This approach reported that the farmers identify the horizons and/or layers of soil profiles as land classes, that's why it is possible to find more that one class of land in a single soil profile. The land class Polvilla is deposited over the land classes Barrosa and Charanda. The more significant differences of soil properties for these land classes are: sand percentage (%), clay percentage (%), electric conductivity (μS cm-1), organic matter (%), capacity of cationic interchange (cmol kg-1) and thickness (cm). This classification is sustained by the analytic properties (physical and chemical) of the soil classes.

Keywords：*soil horizons, soil profile, land classes and local knowledge*

O3-1

Environmental Risk Management of Geologic Carbon Storage and An Introduction to the K-COSEM Research Center of Korea

Inauguration of K-COSEM (Korea CO_2 Storage Environmental Management) Research Center for geologic carbon storage in Korea: Our mission

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Carbon capture and storage (CCS) is considered as an effective technology to limit the rise in atmospheric CO_2 which causes climate instabilities. Geologic carbon storage in saline aquifers and/or depleted oil and gas reservoirs represents a practical and safe method of the disposal of large volumes of CO_2. However, long-term secure storage in deep geologic reservoirs should be demonstrated to satisfy operational and regulatory criteria, public acceptance, and auditing of carbon credits for the stored CO_2. Therefore, it is essential to monitor CO_2 leakage from storage sites and to evaluate the impact of leakage on ecosystems and human health. The Korea CO_2 Storage Environmental Management (K-COSEM) Research Center has been recently inaugurated to conduct researches on the environmental risk management of geologic carbon storage in Korea. The research missions of K-COSEM Research Center include: 1) to assess the impacts of the CO_2 leakage on shallow groundwater quality and on soil ecosystems including plants, microbes and soil solution, 2) to develop efficient and precise monitoring tools to detect and quantify the movement of leaked CO_2 through soil, groundwater and atmosphere, 3) to set up the integrated numerical modeling technique to evaluate the leakage of CO_2, and 4) to propose the regulatory frameworks to manage the geologic carbon storage. In addition to long-term monitoring of potential CO_2 leakage in storage sites, field experiments with the artificial leakage of CO_2 from depths under diverse geologic conditions will be conducted. In this presentation, we will also introduce the status of CCS technology development in Korea.

Keywords: Geologic carbon storage, Environmental risk management, Monitoring of CO2 leakage, Groundwater and soil, Korea CO_2 Storage Environmental Management Research Center.

O3-2

Environmental Risk Management of Geologic Carbon Storage and An Introduction to the K-COSEM Research Center of Korea

Effects of CO_2 Disturbance on Soil Ecosystems

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The carbon capture and storage (CSS) technology can be a promising tool to mitigate anthropogenic CO_2 emissions, and successful implementation of this technology hinges on ensuring the public and policy makers of its safety. Therefore, it is essential to monitor potential CO_2 leakage from storage sites, and evaluate the impact such leakage may have on the surrounding environment. To assess the effects of the release of high-concentration CO_2 into soil ecosystems, responses of plants and soil biota near natural CO_2 vents have been studied. More recently, field experiments that simulate leakages from CO_2-storage sites are being conducted to directly test the effects of high-level soil CO_2 on ecosystem functions. In this study, current knowledge on the impacts of CO_2 disturbance on soil ecosystems will be reviewed and directions for future research will be suggested.

Keywords： carbon capture and stora

O3-3

Environmental Risk Management of Geologic Carbon Storage and An Introduction to the K-COSEM Research Center of Korea

Soil CO_2 Efflux in Ecological Studies: Current Status and Challenges

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Soil CO_2 efflux (i.e., soil respiration; R_S) is a primary process by which an ecosystem releases sequestrated carbons (C) back to the atmosphere. R_S mainly originates from root respiration (autotrophic R_S) and soil organic matter decomposition by microbes (heterotrophic R_S). The rate of global R_S is estimated as 68–77 Pg C yr^{-1}, accounting for approximately 60% of terrestrial GPP; R_S is acknowledged as the second largest C flux between the atmosphere and terrestrial ecosystems. In addition, the global climate change may result in the R_S increase, which would consequently contribute to increasing atmospheric CO_2. Due to its significance, therefore, R_S has been remarkably studied in the past few decades. Several R_S measurement methods have been developed, which are either (1) involving CO_2 concentration determination (e.g., infrared gas analyzer using dynamic chamber, alkali absorption or gas chromatography using static chamber) or (2) a chamber type (e.g., closed chamber, open flow chamber, automatic opening-closing chamber [AOCC]). As R_S is highly heterogeneous in spatial and temporal scales, each R_S measurement method has different advantages and challenges for dealing with the scales. For instance, repeated manual measurements using closed chambers with a portable IRGA or soda lime could observe seasonal pattern and spatial variability of R_S; while AOCC measurements could continuously determine the rapid response of R_S to microclimate conditions within a limited spatial range. Moreover, new CO_2-well method has been limitedly applied. Various field and laboratory studies on R_S have contributed (1) to report R_S in various ecosystems; (2) to test the effects of environmental and vegetation factors; (3) to quantify the contribution of R_S in ecosystem C cycles and budgets; (4) to determine the temporal dependency of R_S (Q_{10}); (5) to distinguish autotrophic and heterotrophic R_S; (6) to model R_S; and (7) to estimate the response to climate change, land use change, and anthropogenic disturbances. Recent advances in R_S could be summarized as follows: (1) statistical models have improved to model the spatial heterogeneity and moisture effects of R_S; (2) heterotrophic R_S responses to substrate diffusion and oxygen availability have been modeled by dual Arrhenius and Michaelis-Menten kinetics; (3) Q_{10} values have been modeled by temperature variables; and (4) a global database of R_S has complied 4387 records from 1021 publications; (5) the R_S measurement methodologies have been applied onto other heterotrophic respirations such as coarse woody debris. However, despite the large number of R_S observations and the current knowledge of R_S, R_S studies, especially in respect to their study objectives and perspectives, need to be requestioned and redefined. Here, the discussion on R_S is extended and linked to the topic of carbon capture and storage/sequestration (CCS), a promising technology for mitigating global climate change. For a successful geologic sequestration of injected CO_2, monitoring the movement of CO_2 in soil is mandatory, as there are potential risks of CO_2 leakage. The current knowledge of R_S is expected to be practical, as it can be applied to monitoring and further to modelling of ground CO_2 pathways and CO_2 effluxes at surface soil. At the early phase of the new approach for detecting ground CO_2 leakage, experimental facilities which artificially inject and release CO_2 at a shallow subsurface will provide a new opportunity of R_S studies.

Keywords：carbon capture and sequestration, ground CO_2 leakage, review, Q_{10}, soil respiration,

O3-4

Environmental Risk Management of Geologic Carbon Storage and An Introduction to the K-COSEM Research Center of Korea

Soil Gas Movement and VOC Concentration Change in Unsaturated Zone with Fluctuating Groundwater Table: Implication for CO_2 Monitoring

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Soil gas is mainly composed of nitrogen and oxygen gases and the composition ratios of these are similar to that of the air when the soil is highly permeable and aeration is very active through the soil zone. CO_2 gas ratio in the soil zone changes seasonally and also locally depending on the biogenic activity to generate CO_2. Soil zone contaminated with organic contaminants or organic-rich soils show dynamic season variations of CO_2 and O_2 ratios. Differently from the case that CO_2 occurs ubiquitously in soil zone and the production ratio is much more important than the CO_2 movement to determine the CO_2 level, CO_2 transport is very important when CO_2 source is highly localized. The latter is the case of CO_2 leakage through a preferential path to soil zone from deep storage location. The direct data of CO_2 leakage to soil zone from deep storage facility has not been reported yet except the cases of artificial leakage in shallow-depth controlled CO_2 injection site. In this study, we propose gas transport experiments in the laboratory and a field site when the gas is originated from a NAPL source and/or the gas is originated from dissolved VOCs in groundwater. Gas extraction experiments for detection of the NAPL sources are proposed and this experiment can be helpful for detection monitoring for CO_2 leakage from a leakage channel connected to groundwater zone. Groundwater table fluctuation range and rate of rise and fall of the table is seemed to influence the gas concentration with combined effects of volatilization and air trapping during the rapid rise of the water table. Numerical simulations also are presented in this study to support the laboratory and field experiments.

Keywords: Gas transport, Unsaturated zone, NAPL source, Source identification, VOCs, CO_2 detection monitoring.

O3-5

Environmental Risk Management of Geologic Carbon Storage and An Introduction to the K-COSEM Research Center of Korea

Origin and Hydrochemistry of CO_2-Rich Springs in Korea: Implications for Long-Term Environmental Effects And Monitoring of CO_2 Leakage

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Even though the secure storage of CO_2 in deep geological reservoirs is considered as an attractive technology to significantly mitigate CO_2 emission to the atmosphere, there are many concerns of the potential leakage of geologically stored CO_2 via diverse pathways under different time scales. The successful implementation of geologic carbon storage hinges on ensuring the public and policy makers of its safety. A further concern is that migration and intrusion of CO_2 into potable groundwater will drive the acidification of groundwater and associated mobilization of potentially toxic trace metals. For quantifying the risk of CO_2 leakage and the geochemical evolution of the stored CO_2 through the life of an individual storage site, therefore it is highly needed to well understand the geochemical behavior of geologically stored CO_2 over a long time (i.e., a thousand to several hundreds of thousand years). However, the nature of the geochemical processes occurring in CO_2 storage reservoirs and during the upward leakage is very poorly understood because there are only a very limited number of observational database that was obtained from anthropogenic CO_2 injection experiments. In these contexts, careful examination of the nature and hydrochemistry of CO_2-rich springs as a natural analogue of CO_2 leakage can be much helpful to understand the environmental risks of geologic carbon storage for a long time.

CO_2-rich springs occur ubiquitously in South Korea and formed by dissolution of deep-seated CO_2 into deep groundwater (C-14 ages = 35000□45000 yrs BP). The CO_2-rich springs widely range in pH from around 4 to 9. The water type is also highly variable from Ca-HCO_3 through Ca-Na-HCO_3 to Na-HCO_3 type, even in a locality. Such variability is considered to reflect different pathways and water-rock interaction during the long-term leakage. Thus, careful examination of the characteristics of CO_2-rich springs may provide an important knowledge on the movement of CO_2 and environmental impacts of CO_2 leakage on groundwater. Comparison with the drinking water standards of Korea shows that most CO_2-rich springs is undrinkable because of the excess of TDS (ca. 80% of the samples), pH (ca. 30%). Fe (ca. 83%), Mn (ca. 70%), F (ca. 35%), Al (ca. 40%), and hardness (ca. 35%). These parameters can be used to monitor the potential impacts of CO_2 leakage into portable groundwater. In this presentation, potential pathways of two contrasting CO_2-rich springs will be also evaluated.

Keywords: Geologic carbon storage, Natural analogues, CO_2-rich groundwater, Hydrochemistry.

O3-6

Environmental Risk Management of Geologic Carbon Storage and An Introduction to the K-COSEM Research Center of Korea

Impact of Near-Surface Heterogeneities on CO_2 Leakage and the Implication to the Risk Assessment

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The present study focuses on understanding the leakage potentials of the stored supercritical CO_2 plume through caprocks generated in geostatistically created heterogeneous media. For this purpose, two hypothetical cases with different geostatistical features were developed, and two conditional geostatistical simulation models (i.e., sequential indicator simulation or SISIM and generalized coupled Markov chain or GCMC) were applied for the stochastic characterizations of the heterogeneities. Then, predictive CO_2 plume migration simulations based on stochastic realizations were performed and summarized. In the geostatistical simulations, the results from the GCMC model showed better performance than those of the SISIM model for the strongly non-stationary case, while SISIM models showed reasonable performance for the weakly non-stationary case in terms of low-permeability lenses characterization. In the subsequent predictive simulations of CO_2 plume migration, the observations in the geostatistical simulations were confirmed and the GCMC-based predictions showed underestimations in CO_2 leakage in the stationary case, while the SISIM-based predictions showed considerable overestimations in the non-stationary case. The overall results suggest that: (1) proper characterization of low-permeability layering is significantly important in the prediction of CO_2 plume behavior, especially for the leakage potential of CO_2 and (2) appropriate geostatistical techniques must be selectively employed considering the degree of stationarity of the targeting fields to minimize the uncertainties in the predictions.

Keywords：Geologic CO_2 sequestration, Geostatistics, Leakage, Sequential Indicator, Markov Chain.

O4-1

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

The State of the Art on Remediation after Nuclear Accidents prior to the Fukushima Daiichi Accident

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The response to an accidental release is divided into two phases. In the emergency situation immediately after the accident has occurred, a key route of exposure is interception of deposited radionuclides. Actions to reduce radiation doses in the emergency phase are termed countermeasures. Thereafter, in the existing situation foodchain pathways are relatively more important and actions to reduce dose are termed remediation. The behaviour of deposited radionuclides in soil, and the associated uptake by plant and animals, is a key feature determining the extent and duration of radionuclide contamination in food. Therefore, the focus for the paper is on remediation.

Many national and international guidance documents on countermeasures and remediation after nuclear accidents are largely based on experience after the Chernobyl accident. More than three years after the accident at Fukushima Daiichi NPP, it is appropriate, to start to review the lessons learnt from the Chernobyl accident and to start to identify where such guidance may need to be modified.

The importance of soil is twofold: as a long term environmental repository of radionuclides and as a source of mobile radionuclides which may be transferred into food (and therefore humans) and other organisms. The environmental mobility of radionuclides in soil is highly variable and the extent of mobility and how it changes with time is highly dependent on soil type, Radioisotopes of elements such as Cs, Sr and I can be highly mobile whereas others, such as plutonium are not. Whilst radioiodine is a potentially important exposure route in emergency situations, radiocaesium and radiostrontium are the most important dose-forming radionuclides in the long term due to the relatively long physical half lives of some of their radioisotopes. Quantification of radiocaesium behaviour in soil has been carried out using both empirical transfer parameters and semi-mechanistic models. Many remediation actions aim at reducing dose rates from contaminated soil. Because radionuclides give rise to both external and internal doses, remediation needs to address both routes of exposure. It therefore includes covering or removing soil, amending the chemical properties of soil and dilution of radionuclide activity concentrations in soil.

Most experience of remediation for radiocaesium and radiostrontium has been gained from accidents in the former Soviet Union in the East Urals (Kyshtym accident) and at Chernobyl. Decades after the Chernobyl accident the areas giving rise to higher dose rates are those with soil types which allow relatively high transfer of radiocaesium rather than those which are most contaminated. The experience regarding radiocaesium is the most important when considering the lessons learned and their relevance for the Fukushima accident. Such experience has been the key source of information used to compile international guidance documents on remediation such as the International Atomic Energy Agency's recent Technical Report Series document TRS 475 and the Euranos Handbooks on Emergency Preparedness.

The knowledge underpinning these remediation documents is largely based on experience in Eastern and Western Europe. Therefore, many soil types around the world have not been considered. It is clear three years after the Fukushima accident that we will need to revisit these documents to take into account the experience of dealing with soil contaminated by radiocaesium in Japan. The scope includes not only technical issues such as efficiency of different techniques but also their practicability, feasibility and acceptability. A further key consideration is the feasibility of coping with large volumes of contaminated soil removed from affected areas.

O4-2

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Distribution of Radionuclides in the Soil Environment and their Transfer to Vegetation following the Fukushima Nuclear Accident

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Large quantities of radionuclides were released from the accident of Fukushima Daiichi Nuclear Power Plant (FDNPP) in March 2011. Two of the most important radionuclides, from the viewpoint of environmental safety, are radioiodine and radiocesium. In this study, we focus on the distribution and behaviour of these radionuclides in the soil environment. The following 4 topics are presented.

(1) Vertical distribution of radionuclides in different agricultural and forest soils:

Depth distributions of radiocesium and radioiodine were determined in a wheat field, a rice paddy, an orchard, and a cedar forest in Koriyama, Fukushima Prefecture. Our results demonstrate in most cases that more than 90% of the radionuclides are distributed in the upper 5 cm of the soil column. Compared to radiocesium, radioiodine has been observed to penetrate deeper into the soil. This is likely due to the high retention of the cesium ion by clay minerals.

(2) Transfer of radiocesium from 3 typical Fukushima soils to agricultural crops:

Three different types of soil collected in Fukushima Prefecture were used and a leafy vegetable, komatsuna (Japanese mustard spinach, Brassica rapa var. perviridis), and rice plants (Oryza sativa) were cultivated in Wagner pots (3 L) in a greenhouse. The transfer coefficients were determined for agricultural crops and were highest for those grown in brown forest soil, followed by andsol and gray lowland soil. The lowest transfer coefficient found in gray lowland soil can be explained by the high clay mineral contents of the soil. These clay minerals likely absorb radiocesium very strongly. In additional experiments, we found that the transfer coefficients were markedly higher in komatsuna grown in soil mixed with contaminated organic matter.

(3) High radiocesium transfer to plants and mushrooms in the forest ecosystem:

Very high radiocesium concentrations (up to 20000 Bq/kg on a fresh weight basis) were found in tree leaves of koshiabura (Acanthopanax sciadophylloides) a plant related to Araliaceae, collected in forests of Iidate, ca. 37 km NW of the FDNPP. These values are much higher than the values observed for other plants collected in the forests. In forests, radiocesium generally accumulates in surface soil layers in which the content of organic matter is high. Roots of koshiabura are distributed in the shallow layers (e.g. leaf litter and humus layers). Since radiocesium is more mobile in organic layers compared to mineral soil, it is more readily taken up by plant roots. Analytical results for stable cesium show that koshiabura has an ability to absorb cesium. Mushrooms collected in forests of Fukushima Prefecture also show very high radiocesium concentrations, although the concentrations depend on the species and the sampling place. Since radiocesium circulates in forest ecosystems, a long-term study of the fate of radiosesium is necessary.

(4) Importance of translocation pathways to new tea leaves and fruits:

Most of agricultural crops showed concentrations which were lower than the Japanese guideline for foodstuffs (500 Bq/kg in 2011, and 100 Bq/kg after 2012), except for some agricultural products such as tea leaves and some fruits. The root uptake pathways for radiocesium in tea trees were found to be less important than the translocation pathways from preexisting leaves to new tea leaves formed after the accident. We also found that radiocesium deposited on the canopy (leaves, twigs and bark) of yuzu (Japanese citron, Citrus ichangensis) translocated to its fruits. Since tee and citrus trees are evergreen, the radiocesium that was initially deposited on the leaves was absorbed and migrated to the other parts of the trees.

(5) Retrospective estimation of I-131 deposition through the analysis of I-129 in Fukushima soil:

The deposition data of radioiodine in Fukushima Prefecture are necessary in order to assess thyroid doses due to the accident. However, there are not enough measured values of the deposition of I-131 on the ground, because of the short half-life of this nuclide (8 days). In order to reconstruct the I-131 deposition, we have used AMS to analyze I-129 (half life: 1570 million years) for more than 400 soil samples collected from Fukushima Prefercture and have constructed a deposition map for I-131.

Keywords：*Fukushima, radiocesium, radioiodine, soil, plant uptake,*

O4-3

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Subsurface Reactive Transport of U(vi)

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Uranium(VI) has been introduced into the subsurface from a variety of nuclear-related activities, including mining, processing, and disposal. The reactive transport of U(VI) in the subsurface significantly influences its long-term fate and effect. U(VI) enjoys a rich biogeochemistry, complexing with a wide variety of subsurface ligands, including carbonate and phosphate. U(VI) also undergoes both pH-dependent and pH-independent adsorption to a wide variety of surfaces, especially Fe oxides. The pH-dependent adsorption of U(VI) to Fe oxides has been relatively well studied. However, the adsorption of U(VI) to more complex natural mineral assemblages and the resulting effect on U(VI) fate and transport has been less well studied.

The purpose of this study was to investigate the factors controlling the reactive transport of U(VI) in heterogeneous subsurface media, with an emphasis on developing models to predict U(VI) adsorption and transport. The pH dependent adsorption of U(VI) onto three heterogeneous, subsurface media was investigated (1, 2). The three materials contained nearly identical extractable Fe oxide contents (25.3-25.8 g/kg). A model independently developed for the adsorption of U(VI) to synthetic ferrihydrite was able to predict the major features of the pH dependent U(VI) adsorption to the materials under the assumption that all the dithionite-citrate-bicarbonate (DCB) extractable Fe oxide was present as ferrihydrite. The model could predict pH-dependent U(VI) adsorption to within a root mean square error (RMSE) of 0.163-0.408, even under conditions outside of those for which the model was developed. These results indicate that this model could be used as a first approximation in predicting U(VI) adsorption and transport in the subsurface.

These models, however, dramatically underestimated the degree of retardation observed in column experiments (3). There are a number of differences between the physical and chemical conditions in batch and column experiments. These differences include the solid to solution ratio, the potential buildup of reaction products and intermediates in batch reactors, and the presence of hydrodynamic mass-transport limitations in porous media. Modeling efforts reveal that differences in solid to solution ratio in particular can lead to significant differences in the behavior of U(VI) in batch and column experiments. Experimental and modeling efforts are being undertaken to improve the predictability of U(VI) adsorption and transport between batch and column experiments and ultimately between the laboratory and the field.

Keywords：*Uranium, Soil, Nanoparticle*

O4-4

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Relationship between Radiocesium Interception Potential of Paddy Soil Clays in Fukushima and their Clay Mineralogy

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The accident at the Fukushima Daiichi Nuclear Power Plant (NPP) in March 2011 has turned attention to the fate of radionuclides in terrestrial environments. Of all the fission products released by the NPP accident, ^{137}Cs is the most important long-term contributor to the environmental contamination because of its high release rate, and longer half-life (30.1 y). Understanding the fate of ^{137}Cs in soil is particularly important for establishing proper strategies to manage the farmland contaminated by ^{137}Cs. Paddy fields are a primary target to investigate since rice is the staple food in Japan. Although it is well known that micaceous minerals adsorb ^{137}Cs much more strongly than other soil components, relationships between amount of micaceous minerals and the ^{137}Cs retention ability of natural soils has not been clearly indicated.

In this study, natural soil clays (< 2.0 μm) were fractionated from 97 paddy soils (eastern area - Hama-dori, n = 25; central area - Naka-dori, n = 36; western area - Aizu, n = 36) in Fukushima Prefecture, Japan. The composition of clay minerals were estimated from peak areas obtained using X-ray diffraction (XRD) analyses. Native K content of the clays was determined using atomic absorption spectrometry as an indicator of the amount of micaceous minerals. Radiocesium Interception Potential (RIP) of the clays was determined as a quantitative index of the ^{137}Cs retention ability. Relationships between the RIP and mineralogical characteristics of the clay fraction were investigated to clarify the mineralogical factors controlling the ^{137}Cs retention ability of soils.

The predominant clay mineral was smectite in many of the soils from Hama-dori and Aizu, while this was variable for those from Naka-dori. The average RIP for the 97 soil clays was 7.8 mol kg^{-1} and ranged from 2.4 mol kg^{-1} to 19.4 mol kg^{-1}. The RIP was significantly and positively correlated with native K content for each of the geographical regions, Hama-dori ($r = 0.76$, $p < 0.001$), Naka-dori ($r = 0.43$, $p < 0.05$), and Aizu ($r = 0.76$, $P < 0.001$), while it was not related to the relative abundance of smectite. In conclusion, the linear relationship between RIP and native K content not only indicate the predominant contribution of micaceous minerals to the ^{137}Cs retention ability of the soil clays, but also could be used to predict the ^{137}Cs retention ability of soil clays for other paddy fields in Fukushima and other areas with similar clay mineralogy.

Keywords：*Cs-fixation capacity, micaceous minerals, Radiocesium Interception Potential (RIP), native K content*

O4-5

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Distribution of Radioactive Cesium in Soil and Its Uptake by Herbaceous Plants in Temperate Pastures with Different Management after Fukushima Dai-Ichi Nuclear Power Plant Accident

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The accident of Fukushima Dai-Ichi Nuclear Power Plant (NPP) caused extensive radioactive cesium (Cs) contamination in agricultural lands in the northeastern Japan.
Radioactive Cs first deposited on surface of soils. Since Cs is strongly fixed with clay minerals especially weathered mica, soil mixing such as tillage facilitates fixation of radioactive Cs with soil minerals and significantly reduce uptake of radioactive Cs by crops. In this region except the evacuation zone, therefore, the concentrations of radioactive Cs in edible parts of various crops and vegetables are now far below the national food safety limit for general foods, 100 Bq/kg when which they are grown in the well-tilled fields. However, pastures are usually not tilled. The Cs deposited on surface remained as it was, and it may be easily taken up by herbaceous plants which develop their root into root-mat layer. Risk of contamination in herbage in permanent pastures is much higher than that in arable crops.

To evaluate the status of radioactive Cs contamination in soil and plants in permanent pastures of Field Science Center, Tohoku University, in northern Miyagi prefecture, where is 150 km north from the Fukushima Dai-Ichi NPP, we examined 1) distribution of radioactive Cs in soil, 2) concentration in various herbaceous plants in pastures with different management, and 3) change in radioactive Cs concentration in plants with maturity.
Soils and plants from 7 pastures with different managements were examined. As belowground samples, litters, root-mat layer (root-mat soil and plant roots) and subsurface soil (0–5 cm beneath of the root-mat) were collected at two to three locations in each pasture in December 2011 and May 2012. Herbage samples (four grasses, two legumes and one forb species) were collected from 9 May to 20 June in 2012 at a 14-days interval at two to five locations fixed in each pasture.

1) The distribution of radioactive Cs differed among pastures to some degree, while a large proportion of radioactive Cs was distributed in root-mat layer. In some pastures where the root-mat did not develop well, about 30-40% of radioactive Cs was distributed in subsurface soil. Based upon the concentration in soil, total amount of radioactive Cs fallout was estimated to 33 kBq m-1 in average, ranging from 29 to 43 kBq m-2. These values are comparable with those predicted from the aerial monitoring.
2) Radioactive Cs contents of herbaceous plants greatly varied among pastures. High Cs contents, about 3-4 kBq kg-1 (DW basis) were recorded in Phalaris arundinacea and other species. In contrast, the Cs contents of some plants were very low in a pasture which had been received cattle manure compost. We found a significant negative relationship between soil-to-plant transfer factors and exchangeable K content of soils.
3)Radioactive Cs content decreased with plant maturity, but its extent was smaller in legumes than grasses and forbs.

These results indicate that radioactive Cs fallout to permanent pastures remained in surface soil including root-mat layer, and that Cs content of herbaceous plants differed among pastures. This may be caused by the difference in soil exchangeable K concentrations in soil which resulted from different manure application history in each pasture.

Keywords：*radioactive cesium, grassland, pasture*

O4-6

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Layer-To-Layer Variations of 137cs Content in Soil throughout a Calendar Year within the Alienation Zone of the Chernobyl Npp

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The aim of the current research is the analysis of changes of the 137Cs specific activity level in different layers of soil during the calendar year. Soil samples were collected at a depth of 0 to 5 cm (0 to 2 inches), at a depth of 5 to 10 cm (appr. 2 to 4 inches) and from the litter layer. Three testing areas were studied within the territory of the Chernobyl nuclear power plant alienation zone ? 'Dytiatky', 'Paryshev' and 'Lelev', which differ by levels of 137Cs soil pollution. Soils on all of the testing areas belong to sod-podsolic type. Two of the testing areas - 'Paryshev' and 'Lelev' - are characterized with a thick 5-cm layer of litter; the litter layer is rather thin - 1.5 cm - within 'Dytiatky'. To investigate variations 137Cs contamination in their soils during a calendar year, sample drawing was conducted monthly from 2007 till 2012. Only areas with a surface that complies with all of the following criteria were selected for soil sampling:

-undamaged in course of the nuclear waste deposition and accident response operations;

- grass-covered;

- smooth and homogeneous.

Within all of the testing areas, gradual decrease in the annual average values of the 137Cs content for all the layers of soil has been observed.

The analysis of variation of the 137Cs specific activity levels in soil specifies that the annual fluctuations of the content of this radionuclide can be considerable (up to fivefold). In different soil layers fluctuations of the 137Cs content are staggered. Within testing areas 'Paryshev' and 'Lelev', the maximum of the 137Cs content in the litter layer corresponds to its minimum in layers from 0 to 5 cm and 5 to 10 cm deep. Within the testing area 'Dytiatky', fluctuation of the 137Cs content in the litter correlates directly to fluctuations in the 0 to 5 cm soil layer, and inversely in the deeper soil layer of 5 to 10 cm below surface.

The correlation analysis between the content of 137Cs in different soil layers and weather conditions (an amount of precipitation and air temperature) has been made. As a result, it has been established that weather conditions produce no impact on layer-to-layer variations in levels of specific activity of this radionuclide in soil throughout a calendar year.

Possibly, changes in levels of specific activity of 137Cs in different soil layers result from biotic processes in soil throughout a calendar year.

Keywords：*Chernobyl NPP, 137Cs, different layers of soil*

O4-7

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Estimation of Radiocesium In/out Flows in Paddy Fields in Fukushima, Japan

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I. Introduction

Various radionuclides, released from the Fukushima Daiichi Nuclear Power Plant of Tokyo Electric Power Company in March, 2011, once spread over the environment and severely polluted agricultural soils in Fukushima Prefecture. As a result, brown rice harvested at a 0.2% of paddy fields exceeded the provisional regulation value (500Bq/kg) in 2011. Paddy field is the main agricultural land use in Fukushima; however, knowledge on radionuclides' behavior in paddy fields is insufficient especially on the amount of their in/out flows. Such information is necessary for estimating radionuclides contamination in brown rice and developing models for predicting radionuclides dynamics at watershed scale. This study focused on estimating in/out flows of radiocesium, the most problematic radionuclide with half-lives of 2 or 30yr at four different paddy fields in Fukushima.

Ⅱ. Monitoring and measurements

Field monitoring has been conducted in the following four paddy fields in Fukushima since spring in 2011 or spring in 2012. ; (1) a reorganized paddy field facing to forest in one side (738 m^2), (2) one of the terraced paddy fields surrounded by forest in three sides (349 m^2), (3) one of the terraced paddy fields surrounded by forest in three sides (128 m^2). (4) two reorganized paddy fields in Fukushima Agricultural Technology Centre (658 m^2×2).

Water levels and turbidity (as formazin turbidity unit, FTU) of irrigation and drainage water (in/out flows) in paddy fields and precipitation have been measured at every 10 or 30 minutes. Water samples have been collected once a month for atmospheric precipitation, irrigation, surface drainage, subsurface pipe drainage, and seepage water on a ridge between terraced paddy fields. A membrane filter with a pore size of 0.025μm was used to suspended solid (SS) and filtrate samples. Suspended and dissolved concentrations of radiocesium (^{134}Cs+^{137}Cs) were determined by Ge semiconductor detector after drying the SS and filtrate samples, respectively. Based on the relationship between turbidity and radiocesium concentrations, and flow rates of irrigation and drainage water calculated from their water levels etc., in/out flows of radiocesium in paddy fields were estimated for the monitoring period of one year (23rd May, 2012 ~ 27th May, 2013).

Ⅲ. Results and Discussions

Total radiocesium concentrations of water samples ranged from 0.01 Bq/L to 1.1 ×10^3 Bq/L, which increased with SS concentration ranged from 2 mg/L to 65 g/L. Dissolved radiocesium concentration ranged from 0.001 to 0.9 Bq/L. The rates of dissolved radiocesium to all radiocesium were 2~25% for atmospheric precipitation, 6~40% for irrigation water, 0.001~40% for surface drainage, and 2 ~ 98% for subsurface pipe drainage. Radiocesium concentration of water samples, mainly taken at usual meteorological conditions, were 0.1~0.31 Bq/L for irrigation water, 0.02~1.4 Bq/L for surface drainage, and 0.2~0.9 Bq/L for atmospheric precipitation. Radiocesium inflow by irrigation, inflow by atmospheric precipitation, and outflow by surface drainage were ranged 10^2~10^3 Bq/m^2, 10^2~10^3 Bq/m^2, and 10^3~10^4 Bq/m^2 in the (1),(2) and (3) paddy fields for the one year, respectively. Radiocesium net flow in the 3 fields for the one year was estimated to be outflow of 0.2%, 0.2%, and 0.7% of the amount of radiocesium in soil to depth of 25cm, respectively. Without any disturbance, radiocesium is calculated to become half in 6.1 yr, and to become 1/5 in 39.9 yr by the atomic nucleus decays on the assumption that the radioactivity levels of ^{134}Cs and ^{137}Cs released in March, 2011 were almost the same ; the fact recognized. On the other hand, the radiocesium in the (1), (2) and (3) paddy fields is calculated to become half in 5.8 yr, and to become 1/5 in 34.6 yr in average on the additional assumption that radiocesium net flow rate is constant every year for each paddy field. This calculation cannot help containing uncertainty because of several factors that carryout of radiocesium by rice harvest is not accounted in this point, and that meteorological conditions are different every year etc.. Therefore, these monitoring and analysis have to be continued in more years.

This study was performed under a support of the Ministry of Environment, Japan.

Keywords：*radiocesium, paddy fields, in/out flows, suspended solid*

O5-1

[DS4] The Lifetime Contributions of Professor J.Keith Syers to International Soil Science-A Memorial Symposium

Keith Syers: a Champion for Soils and Agricultural Research across the World

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Keith Syers started his Professional career in 1964 when he was appointed as a Postdoctoral Fellow in the Department of Soil Science at Lincoln College in New Zealand where he worked on soil fertility in pastures. He moved to the University of Wisconsin-Madison in 1967 to work under Professor M.L. Jackson, a pioneer of fundamental studies on soil and fertilizer potassium and phosphorus. His time with Jackson in Wisconsin (1967-1972) was regarded by Keith as one of the most rewarding and stimulating research environments of his career and the experience helped shape Keith's approach and thinking in soil science. In 1972, aged only 33, he returned to New Zealand to the foundation Chair in Soil Science at Massey University where he built one of the world's leading soils teaching and research departments. During this time (1981) he was elected as Fellow of the Royal Society of New Zealand and it was whilst at Massey that he built his reputation as a research leader in the use of fertiliser P and S in agriculture.

He returned to the UK and to Newcastle University in 1986 as Professor of Soil Science and became Dean of the Faculty of Agriculture and Biological Sciences in 1989. During his time at Newcastle he was responsible for reorganising teaching and research in the agricultural and environmental sciences and served on many key national and international committees including the Scientific Advisory Committee of SCOPE Phosphorus Cycling Project, the Royal Society Interdisciplinary Science Committee and the Governing Board of CAB International. In 1995 he was appointed Chair of the Advisory Committee of the World Phosphate Institute.

Keith Syers spent much of his professional career working on problem soils and worked tirelessly through his role on international committees and advisory groups to increase sustainable food and fibre production in the developing world. He believed that the answer to future food security lay in good science and education combined with local knowledge and technology sharing. In 1992 he moved to Thailand on secondment to join the International Board for Soils Research and Management (IBSRAM) as Director of Research before returning to Newcastle in 1995. On his retirement from Newcastle in 2000, he returned to Thailand as Vice President for International Relations at Naresuan University in Phitsanulok.

His outstanding contributions to soils research have been recognised internationally and he was an elected Fellow of the Soil Science Society of America, of the New Zealand Society of Soil Science, and presented the prestigious Russell Lecture for the British Society of Soil Science in 2007. At the time of his death on 16th July 2011, Keith's lifetime contribution to international soils research had already been recognized by the Soil Science Society of America who had honored him with their Distinguished Service Award.

Keywords : Keith Syers, phosphorus, sulphur, soil and fertiliser chemistry

O5-2

[DS4] The Lifetime Contributions of Professor J.Keith Syers to International Soil Science-A Memorial Symposium

Nutrient Balances, Food Security and Fertilizer Raw Materials

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At the turn of the century, Keith Syers supervised a PhD student, William Sheldrick, who had spent his entire career working in the fertilizer industry. The project included a global assessment of nutrient balances on a country-by-country basis, comparing inputs and outputs from soil of N, P and K (Sheldrick et al., 2002; 2003; Sheldrick and Lingard, 2004). It was expected that the research would demonstrate that P was the nutrient in shortest supply, but unexpectedly this was not the case; K was shown to be the nutrient in greatest deficit on a global basis. Since then, the concept of 'peak phosphorus' has arisen (Cordell et al., 2009), highlighting the need to consider mineral resource availability in the context of food security.

Comparison of fertilizer use statistics with nutrient balances confirms the shortfall in K, when considered on a per capita basis. World production of K fertilizers needs to double to compensate for offtake at the present time, raising serious questions about the ability of global K production to feed larger populations in 2050. At the same time, 'peak phosphorus' needs to be reconsidered, given that recent changes to the way in which geological reserves are calculated have led to an increase in the reserve base by a factor of 4, extending reserve life to over 300 years, demonstrating the artificial nature of the concept.

Keith Syers took an interest in alternative sources of K (Riggs et al., 1993), and the use of silicate minerals for this purpose remains controversial. Nevertheless, recent high prices and the restricted geographical location of existing K deposits means that there is still a need to find alternatives that are affordable and available, although they may not be ideal (Manning, 2009). The use of feldspars and feldspar-bearing rocks as a source of K, as envisaged by Syers and coworkers, is still valid. Since publication of his work in 1993, a number of more recent studies have shown that silicate minerals can act as sources of K, provided soil conditions are appropriate. Keith Syers' work and approach remain as valid as ever.

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Keywords : potash, phosphorus, nutrient balance

O5-3

[DS4] The Lifetime Contributions of Professor J.Keith Syers to International Soil Science-A Memorial Symposium

Contributions of Keith Syers to Knowledge of the Sulphur Cycle

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Sulphur in agriculture was a major theme of the research conducted by Keith Syers over a 30+ year period. This research was wide-ranging and dealt with many soil, plant and animal aspects of the sulphur cycle. In the late 1970s Keith's sulphur research commenced in New Zealand, where he supervised experiments evaluating "Biosuper", made from Christmas Island phosphate rock and elemental S, as a potential alternative P and S fertiliser to single superphosphate. In New Zealand and, later, in the UK, Keith and co-workers carried out a series of fundamental sorption studies to explain the variable leaching loss of fertiliser sulphate from a range of soils. Factors influencing sulphate retention (mineralogy, surface charge density, pH, competing anions, ionic strength) in soils were reported on in a series of papers. The strong link between the retention and the mobility/leaching of sulphate was demonstrated in column studies using soils with contrasting mineralogy. Microbial transformations of applied S (elemental S, sulphate-S) formed another important component of his S research. In association with plant scientists, the influence of S on crop yield and quality was investigated. Much of the crop research focused on oilseed rape (Brassica napus L), which, because it has a high demand for S, is particularly sensitive to S limitation. In summary, Keith Syers made seminal contributions to soil and fertiliser sulphur research. Not least of his contributions was the mentoring and stimulation he provided to the students and research associates who collaborated with him in that work.

O5-4

[DS4] The Lifetime Contributions of Professor J.Keith Syers to International Soil Science-A Memorial Symposium

J.K. Syers a Protagonist for the Direct Application of Reactive Phosphate Rocks to Pasture Soils

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In the 1970's, New Zealand and Australia were faced with diminishing supplies of high grade Pacific Island phosphate rock (e.g., Nauru) for single superphosphate (SSP) manufacture. Projections indicated that future SSP manufacturing costs would escalate when lower grade phosphate rocks had to be used and questioned whether the 50% government subsidy for fertiliser application could be sustained. The Primary Production Committee of the National Research Advisory Council (NRAC) in New Zealand set up a working party to report on research required to evaluate the efficiency of phosphate fertiliser use (NRAC 1978). Keith Syers, already on this committee of NRAC (1972-1978), was selected to chair the Phosphate Fertilizer Use Working Party (1978). The working party, recommended the initiation of research into the efficiency of phosphatic fertiliser use, and, that there should be "a substantial increase in the agronomic and chemical evaluation of a representative range of phosphate fertilisers. Materials should include rock phosphates for direct application, mixtures of rock phosphates with manufactured forms and new manufactured forms." This recommendation provided the mandate for the increased government spending and research activity on the evaluation of more reactive phosphate rocks (RPRs) and their derivatives as fertilisers, which occurred from the late 1970s onwards. As a consequence, trial samples of Chatham Rise phosphorite (CRP) that had been mined from the sea bed in 1976 were made into prototype fertilisers and tested against other P sources for agronomic effectiveness. A series of glasshouse and field trials were undertaken by Massey University (Gregg and Syers, 1981) and the New Zealand Ministry of Agriculture and Fisheries (Quin, 1981) which compared products made from CRP and Sechura PR with superphosphate. The glasshouse evaluations (Mackay et al., 1984) of a range of P fertilisers were supported by detailed studies on the chemical characteristics of the rocks and their dissolution rates in soils (Syers and Mackay 1986), which lead to an early model to explain the dissolution of RPR in soils (Mackay et al., 1986). The good agronomic performance of CRP and Sechura PR in the trials and their projection of the wider potential use for RPR in New Zealand (Gregg and Syers, 1982) created keen interest in further work on alternative P fertiliser manufacture and evaluation. In 1983, Keith founded the Fertilizer and Lime Research Centre at Massey University, which went on to make and test RPR /soluble P fertiliser mixtures and develop assay techniques to test their quality (Bolan et al., 1990). This paper examines Keith Syers' role in shaping the concepts for evaluating the agronomic effectiveness of slow release phosphate fertilizers in New Zealand pastures.

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Keywords : *Slow release phosphate fertilizers, reactive phosphate rocks, agronomic evaluation, dissolution reac*

O5-5

[DS4] The Lifetime Contributions of Professor J.Keith Syers to International Soil Science-A Memorial Symposium

Pedogenesis, Nutrient Dynamics, and Ecosystem Development: the Legacy of Keith Syers and T.W. Walker

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In a remarkable article published in 1976, T.W. Walker and J.K. Syers proposed a conceptual model of phosphorus transformations during pedogenesis that has transformed our understanding of nutrient availability and limitation in terrestrial environments. Distilling data from four New Zealand soil chronosequences, they observed that nitrogen is absent from most parent materials, so nitrogen concentrations are low in young soils but increase rapidly during the early stages of ecosystem development through biological nitrogen fixation. In contrast, phosphorus is derived almost exclusively from the parent material, so phosphorus concentrations are greatest in young soils but decline continuously during pedogenesis as phosphorus is lost in runoff at a greater rate than it is replenished by bedrock weathering. At the same time, chemical transformations further reduce the biologically available phosphorus pool by sequestering it in organic and refractory inorganic forms. As a consequence of these changes, the nutrient limiting primary production varies during ecosystem development, with nitrogen limitation on young, weakly weathered soils, co-limitation by nitrogen and phosphorus on moderately weathered soils, and phosphorus limitation on old, strongly weathered soils. These changes have profound ecological implications, determining the biomass, productivity, diversity, and composition of plant and microbial communities. The Walker and Syers model therefore enables us to understand and predict spatial and temporal patterns and consequences of nutrient limitation across the landscape, and remains one of the only theoretical models to unite dynamic changes in biogeochemical cycles with the development of above and below ground biological communities. The model has important implications for the development of novel agricultural systems that seek to optimize inputs of nitrogen and phosphorus fertilizers, and is of increasing importance as we try to understand the consequences of climate change, atmospheric nitrogen deposition, and other anthropogenic disturbances of biological communities and biogeochemical cycles.

Keywords : *Phosphorus, nitrogen, pedogenesis, chronosequence*

O5-6

[DS4] The Lifetime Contributions of Professor J.Keith Syers to International Soil Science-A Memorial Symposium

Keith Syers and P Use Efficiency in Agriculture

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This presentation will focus on Keith Syers' conviction that when phosphorus (P) is used efficiently in agriculture then this will lengthen the lifespan of the global P resource, ensure the production of optimum crop yields and help minimise the risk of the transfer of P from soil to the aquatic environment, where over-enrichment with P has adverse effects on the biological balance in surface fresh water. Keith's views on P-use efficiency was summarised in "Efficiency of Soil and Fertilizer Phosphorus Use", FAO Fertilizer and Plant Nutrient Bulletin 18, co-authored with Johnny Johnston and Denis Curtin. The unifying concept was that inorganic soil P is present in four pools related to their plant availability and extractability by chemical reagents. Readily plant-available P is that extracted by reagents used in routine soil analysis. The upper limit for the amount of P in this pool is that above which there is no further increase in yield - the critical level. Percentage P recovery/efficiency of added P is determined by a balance method (P output/P input x 100). For soils at or about the critical level, when P is added to replace that removed in a harvested crop, P-use efficiency often exceeds 80-90%.

Keywords : *Phosphorus use efficiency, Keith Syers*

O5-7

[DS4] The Lifetime Contributions of Professor J.Keith Syers to International Soil Science-A Memorial Symposium

J.K. Syers on the Environmental Impact of Agriculture on Water Quality

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Keith Syers arrived at Massey University in 1972, replete with ideas and a vision for evaluating the impact of agricultural management on water quality. Prior to arriving in New Zealand, Keith spent several years at the University of Wisconsin, researching urban and agricultural runoff, which was initiated by a declining quality of the Great Lakes. Once at Massey, Keith assembled a group of keen doctoral and post graduate students to systematically assess the effects of soil phosphorus (P) chemistry, land use, and the fate and transport of P. His leadership produced ground-breaking results on the role of P sorption and desorption of added P in soil, the role of soil P in determining P loss in all flow pathways, and how simple chemical extractants of fluvial sediments and soils could estimate biologically or algal available P. These result are still key today and laid the foundation for a generation of research in the 1990's and 2000's, when the relevancy of P runoff, freshwater eutrophication, and harmful algal blooms focused global attention back to the identification and mitigation of nonpoint sources of P. As we move full circle to the present day, Keith's legacy is still widely relevant and crucial. The drivers of P-related water quality research have shifted from detergents to fertilizers, to manures, and most recently to sustaining efficient P use and recycling given the recent "discovery" that rock P was in fact a finite resource. The enthusiasm and vision of Keith and his unique ability to instill that into those who had the privilege to work with him, has provided a legacy that increased our scientific understanding of the fate of P in agricultural systems, allowed application of those findings to some agricultural production systems that are protective of the environment, and development of technically defensible environmental policy. This presentation will highlight the elucidation of P's role in soils and water quality, giving new and previously unpublished research will be given showing the long and winding road of Keith Syers's scientific contributions to nonpoint source P, which still resonate today.

Keywords : *Agriculture, algal-available phosphorus, eutrophicationmanure, nonpoint source, runoff,water quality*

O5-8

[DS4] The Lifetime Contributions of Professor J.Keith Syers to International Soil Science-A Memorial Symposium

J.K. Syers on the Issue of Cadmium in Agricultural Systems

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Keith Syers first started researching cadmium (Cd) in agricultural systems the 1970's through his contribution to the development of sensitive analytical methods to measure Cd in soils in New Zealand during his tenure at Massey University in Palmerston North. At the time, concern about Cd was relatively new and improvements in analytical practices were important in ensuring the reliability of measurements of the low concentrations of Cd present in crops and soils. Over the years, Cd in agricultural systems developed into a global issue, with regulations formulated that had a major impact on international trade. In 1999, 25 years after his initial Cd work, Prof. Syers established a project "Environmental cadmium in the food chain – sources, pathways and risks" under the management of the Scientific Committee on Problems of the Environment (SCOPE). Keith co-chaired the Scientific Advisory Committee of this project with Prof. Mike Gochfeld of Rutgers University and organised a workshop in Brussels in 2000 to review the issue of Cd in the food chain, with a follow-up workshop in Ghent in 2003 to discuss management of the Cd issue globally. Keith's broad international experience gave him the ability to critically evaluate the issue from a range of perspectives encompassing the concerns of the developed nations to minimise long-term environmental risks as well as those of the developing world, where ensuring food security was paramount. He recognised that Cd was a food quality issue where perceptions of health risks likely outweighed actual risks, and where controls on Cd could lead to increases in costs of phosphatic fertilisers and potentially penalise some developing country exporters of phosphate rock. Small-holder farmers could also risk losing important markets if their products were considered to contain excess Cd concentrations. This development was occurring in an era where food production in developing countries critically needed to increase through use of low-cost phosphate rock reserves, so that a balanced assessment of the Cd issue was needed.

The Cd issue in agriculture has developed significantly since 1976 when Keith first started working on measurement of Cd in soils. Analytical instrumentation has obviated the need for pre-concentration procedures like the one Keith and co-workers developed, and it is now routine and relatively simple to measure sub ppm concentrations of Cd in soils and crops. We have a much better understanding of the soil to plant transfer of Cd in agricultural systems, and we have developed agronomic and crop breeding methods to minimise Cd contamination of the food chain. Study of health effects in humans in soils geogenically enriched in Cd in Jamaica have challenged the level of concern shown for low concentrations of Cd in foods, and the World health Organisation has only marginally revised the tolerable intake values originally set in the 1970's. The importance of Cd interactions with other trace elements, both in the soil –plant system and in human and animal nutrition, has also been recognized, allowing more accurate assessment of risk of Cd to human health in a range of diets. We have a much better understanding of Cd balances in many agricultural systems, and these are now driving improvements in fertilizer quality in many countries towards zero net accumulation in soils. Many of these issues were raised at the SCOPE Workshops in 2000 and 2003 that Keith co-chaired. Participants at these meetings commented on Keith's innate ability to mix science of the highest quality with knowledge of policy issues where a delicate balance is needed between conservatism and economics. Keith's skills to bring divergent views to consensus will be missed as the Cd issue in agriculture is one where concerns for human health from contamination must be delicately balanced with concerns for human health by raising the cost or accessibility of essential and finite nutrient inputs for food production.

Keywords : *cadmium Syers environment*

O5-9

[DS4] The Lifetime Contributions of Professor J.Keith Syers to International Soil Science-A Memorial Symposium

Phosphorus-Metal (Loid) Interactions in Relation to Soil Remediation

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As land treatment becomes an important waste management practice, soil is increasingly being seen as a major source of metal(loid)s reaching the food chain, mainly through plant uptake and animal transfer. Land treatment of wastes has led to a significant build-up of a suite of metal(loid)s, such as arsenic (As), cadmium (Cd), copper (Cu), chromium (Cr), fluorine (F), mercury (Hg), lead (Pb), selenium (Se), and zinc (Zn). Entry of soil-borne metal(loid)s into the food chain depends on their amount and input sources, reaction with soil components, the properties of the soil, the rate of uptake by plants and the extent of ingestion by grazing animals.

With greater public awareness of the implications of contaminated soils on human and animal health there have been increasing efforts among the scientific community in developing technologies to remediate contaminated sites. Unlike organic contaminants, most metal(loid)s do not undergo biological or chemical degradation and their total concentration in soils persists for a long time. The mobilization of metal(loid)s in soils for plant uptake and leaching to groundwater can, however, be minimized by reducing their 'bioavailability' through chemical and biological immobilization. Recently there have been increasing interests in the immobilization of metal(loid)s using a range of soil amendments such as lime, phosphate (P) compounds, alkaline waste materials, and biosolids.

Regular application of P fertilizers has been identified as one of the main sources of certain metal(loid) (e.g., Cd and F) input to soil. Some of these P fertilizers that act as a source of metal(loid) contamination of agricultural soils have also been found to act as a sink for the immobilization of these metal(loid)s. For example, P amendment has often been proposed as a practical remediation option for sites with Pb-contaminated soils. Traditionally, P-metal(loid) interactions have been examined mostly in relation to P-induced deficiencies of essential elements (e.g., P-Zn interaction) and toxic elements (e.g., P-Al interaction). In this paper, case studies in which these P compounds have been used as a source for the mobilization (e.g., competitive As(V) desorption) and as a sink for the immobilization (e.g., charge-induced cation adsorption and metal precipitation) of metal(loid)s will be discussed. The practical implications of P-metal(loid) interactions are discussed in relation to the potential value of P compounds in the natural remediation of metal(loid)-contaminated soils.

Keywords : Phosphorus, heavy metal(loid)s, bioavailability, mobility, remediation

O6-1

[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Eco-Efficiency of Integrated Soil Fertility Management in Western Kenya

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To keep pace with population growth, food production in sub-Saharan Africa will have to increase 70 % by 2050. To meet this target, sustainable intensification pathways need to be identified, clearly laid out, and promoted for large-scale adoption. Agricultural eco-efficiency focuses on increasing productivity while decreasing negative impacts on natural resources. Approaches that merit the term eco-efficient must meet the economic, social, and environmental needs of the rural poor. Eco-efficiency seeks to strive toward solutions that are competitive, profitable, sustainable, and resilient in the face of a changing climate. Integrated soil fertility management (ISFM) has been promoted in Africa for quite some time as a viable strategy to boost agricultural productivity while at the same time increasing the efficient use of agricultural inputs. Whether ISFM also meets the standards of eco-efficiency remains to be proven. To address the issue, eco-efficiency indicators – particularly in regard to nitrogen (N) dynamics – of selected ISFM practices of a long-term trial of the International Center for Tropical Agriculture (CIAT) in Western Kenya were monitored and the cropping systems modeled using the biophysical crop model, CropSyst. Monitoring comprised measurements of soil nitrous oxide emissions, soil mineral N-dynamics and maize N-uptake vis-à-vis the inputs of N by the green manure cover crop, Tephrosia candida, farm yard manure, maize residues and mineral N-fertilizer. Modeling studies focused on identifying periods within the cropping seasons of peak fluxes of N, N-uptake patterns, aiming at optimizing cropping systems in terms of e.g. matching crop-N demands with soil N availability by changing mineral N fertilizer application amounts and timing. Simulating soil organic matter dynamics also allowed for identifying the long-term sustainability of the studied ISFM practices. Preliminary results point towards higher nitrous oxide emissions under maize in response to the incorporation of N-rich biomass of Tephrosia into the soil. On the other hand, this rotation allowed for abolishing mineral N-inputs without jeopardizing maize productivity in the long-run. Recommendations based on simulation scenarios will be presented on how to implement socially acceptable and economically viable ISFM strategies for increasing crop yields, maintaining soil fertility and minimizing N-losses to the environment.

Keywords：*Greenhouse gas emission from soils, N-efficiency, efficiency indicators, crop-modeling*

O6-2

[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Approaches to Buffer Crop Productivity under Variable Soil Fertility and Climatic Conditions in Sub-Saharan Africa

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Smallholder farming in much of Sub-Saharan Africa is rain-fed and thus exposed to rainfall variability. Among the climate variables, rainfall is projected to decline and have an overriding effect on crop productivity. With little scope for supplementary irrigation for the majority of farmers, a plausible strategy to maintain crop production under water-limited conditions includes balanced nutrient management for enhancing efficiency of use of the limited soil water. It is well established that co-application of judicious rates of organic and mineral nutrient resources, that include phosphorus on phosphorus-limited soils, will facilitate development of an extensive crop rooting system for efficient exploration and capture of soil water, especially at > 0.8 m depth. This paper explores case studies across East and Southern Africa, in which approaches have been used to get 'extra miles' with available limited soil water. We describe a basins-based 'conservation agriculture' system with micro-dosing of nitrogen and phosphorus fertilizers that ensured some maize grain production in acutely dry seasons, when other interventions could not result in any grain yields at rainfall of <400 mm and high soil water evaporation losses. Further, we also describe how variable N management based on the within season rainfall trends and appropriate targeting of nutrient resources across fertility gradients can be employed by farmers to maintain niches of high agronomic productivity that buffer overall farm production when the environmental conditions are uncertain.

Keywords：*soil nutrients, soil water, soil and climate variability, nutrient use efficiency*

O6-3

[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Predicting Crop Yield and Response to Nutrients from Soil Spectra: Example from Sub-Sahara Africa

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High variability in soils in sub-Sahara Africa demands site-specific recommendations for fertilizer application and management. Cheap to obtain soil spectra provide a means for characterizing farm fields and is calibrated to predict soil parameters quite well. The question remains to what extent soil spectra can describe and predict crop response directly. For this, we used standard multi-locational nutrient omission trials conducted in 5 countries namely Mali, Malawi, Kenya, Tanzania and Nigeria within the Africa Soils Information Service (AfSIS) project coordinated by International Center for Tropical Agriculture (CIAT). Soils mid infra-red spectra-derived principal components (spectra range of 4000 to 600 cm-1) were used as explanatory variables for the observed cereal grain yield. The model employed 7 principal components in addition to slope and flow accumulation parameters from a 30m digital elevation model, and seasonal rainfall observed at each site as covariates. Results showed a positive relationship between observed and fitted values for the calibration dataset (R2=0.6), although this was weaker with the prediction dataset (R2=0.5). Also, there was a stronger relationship for control yield, response to manure and to lime application compared to responses to the other nutrients. The results of this pioneering work strongly indicate the potential to predict crop response from soil spectra and to guide site-specific fertilizer and management recommendations.

Keywords：*soil spectra, crop response, prediction, site-specific recommendations*

O6-4

[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Using an Ecosystems Approach for Securing Water and Land Resources in the upper Tana Basin

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Cost-effective investment in reversing land degradation in sub-Saharan Africa (SSA) requires knowledge on where sustainable land management (SLM) interventions should be implemented within a landscape to maximize the benefits they provide. The Upper Tana Basin is an area of central Kenya that supports a large rural population of smallholder farmers but is also of national economic importance because it is a source of water and power (hydroelectricity) for most of Kenya's capital city, Nairobi. The Upper Tana Basin has high levels of sedimentation which threaten the supply of water and power to Nairobi and so is currently being proposed as a site for a major payment for ecosystem services scheme. This scheme would aim to reduce sedimentation in the rivers by increasing the adoption of SLM interventions that reduce soil erosion across the landscape. Here, we test an innovative method for mapping current locations of both land degradation and SLM interventions across the Upper Tana Basin using high resolution satellite images with the objective of providing a baseline scenario. We then use scenario analyses to investigate different SLM investment strategies to determine which would provide the most benefits in terms of improving local livelihoods, downstream benefits to the urban dwellers and overall ecosystem service provision. Our results are intended to support the implementation of the proposed payments for ecosystem services scheme by highlighting the most cost-effective investment strategy.

Keywords：*Land degradation, sustainable land management, landscape scale, ecosystem services*

O6-5

[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Beyond vs Within the Farm Gate: Nutrient and Organic Matter Solutions to Resource-Constrained Agriculture in Africa

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Sustainable soil management is starting to be understood to require a knowledge system that takes site-specific information into account. What is poorly recognized, however, is the need to consider opportunities and constraints to soil management that lie beyond the farm gate. Addition of inorganic fertilizers is the fastest and most effective remedy to addressing the yield gap in the lowest producing regions such as in Sub-Saharan Africa. Agricultural research and development efforts have neglected to reap nutrient supplies in other sectors and develop enterprises to deliver indigenous biofertilizers to farms. These can supply significant amounts of nutrients from outside farms but within national boundaries. One insufficiently explored example is the use of animal bone products, which were shown to contain two- to five-fold greater plant available phosphorus than commercial rock phosphate fertilizers, comparable to triple-super phosphate. During 2008-2011, the livestock herd in Ethiopia generated an estimated 192,000 to 330,000 tonnes of bone wastes annually. Recycling of these bones could provide up to 36,272 tonnes of phosphorus. The upper bound is 58% of a full year's worth of the 62,327 tonnes of fertilizer phosphorus consumed in Ethiopia over the same period. The current annual cost to import an equivalent amount of phosphorus is approximately US$50M-104M. This example alone from one indigenous biogenic phosphate fertilizer demonstrates the potential of recycling for developing countries. Conversely, the recent successes in boosting crop productivity through fertilizer subsidies in a small number of African countries have not been leveraged for building long-term soil capital. This is a missed opportunity for boosting soil organic matter that would enable a gradual switch to more sustainable soil practices, using decision trees that include biological as well as thermal conversion technologies. It also speaks to low recognition of the opportunities that lie in the complexity of product flows in modern society where nutrient and organic matter cycles do not easily lend themselves to a re-cycling. The pathway to sustainable agricultural systems may indeed require extending our knowledge system beyond agricultural field boundaries.

Keywords：*Nutrient management, fertilizers, phosphorus*

O6-6

[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Soils, Ecosystem Services and Poverty Alleviation: a Case Study from Sub-Saharan Africa

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Soils are a primary resource on which a significant proportion of the world's poorest people depend for their livelihoods and subsistence. Many are now reliant on degraded soils with established links to persistent poverty. Historical changes to land use and management, reflecting multiple societal and economic drivers, compounded by unsustainable contemporary management, have reduced the basic soil capital with impacts on multiple ecosystem services (e.g. water supply and retention, soil quality, biomass production) and resultant disservices e.g. erosion problems, poor water and soil quality to total loss of productive land and loss of biodiversity). These serve to compound the issues around poverty alleviation. In the broader context, The Millennium Development Goals (especially 1 & 7) cannot be addressed successfully without tackling ecosystem services supplied by soils. This talk will present the first results from the ALTER project which is funded by UK NERC and UKAID (2013-2016) to research the poverty-linked issues of soil degradation in sub-Saharan Africa. ALTER is focussing on the opportunities to improve the supply of ecosystem services by enhancing the functioning of soils at field to catchment scale, across land uses from crop to natural vegetation, and in degraded and restored land. Our case study areas in Southern Ethiopia and Western Uganda enable us to explore the parallels and distinctions between dryland areas with mineral soils and humid / wetland environments with highly organic soils and well as the contrasting social and economic situations.

Investment in soil carbon is an obvious, but neglected, opportunity to restore and enhance ecosystem services to alleviate poverty. Soil carbon is a fundamental ecosystem property which is vital to ecosystem functioning via nutrient and water dynamics, biodiversity food webs to soil formation and physical structure. Soil carbon is, as a consequence, a universal indicator of soil quality and ecosystem health and through appropriate management, enhancement in soil carbon could lead to improvements in the supply (quality and quantity) of multiple ecosystem services.

A broader view of carbon benefits and trading could realise this opportunity and achieve lasting improvements in degraded ecosystems and the livelihoods of the poor that depend on these. However, gaps in scientific evidence and lack of understanding on the links between soil carbon, soil capital, multiple ecosystem services and the resultant livelihood impacts make it difficult to assure channelling resources (financial and/or material) that could generate significant environmental, social and economic returns. Furthermore, the long-term social and environmental effects and desirability of market-based approaches (versus non market linked intervention) are unclear and must be better understood to inform more efficient investment in soil-based interventions for poverty alleviation.

Keywords: *soil, africa, carbon, ecosystem services, poverty, investment*

O6-7

[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Delivery of Hydrologic and Microbial Services by Indigenous Shrub Rhizospheres to Agroecosystems under a Changing Climate in the Sahel

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The Sahel is experiencing landscape and soil degradation that reduces food and economic security of rural, underprivileged communities that depend on ecosystem services. These challenges will be magnified in the Sahel with global climate change. The Parkland system of randomly distributed trees is an approach to address these challenges, but trees are slow growing and can compete with crops for water and nutrients. Conversely, two native shrubs, Piliostigma reticulatum and Guiera senegalensis, coexist in farmers' fields throughout the Sahel and until recently have largely been overlooked. Unfortunately, the current management of spring coppicing and burning prior to cropping, is not utilizing this organic matter effectively and little was known on how to effectively manage these shrubs. Therefore, the global objective was to determine the unrecognized ecological function of these shrubs in agroecosystems of Senegal that are representative of the Sahel. Extensive field based investigations in the Peanut Basin of Senegal included: ground surveys and remote sensing to determine the landscape levels of shrub C and biomass; hydrology and water relations between shrubs and crops; rhizosphere microbiology; residue decomposition; N and P cycling in relation to crops; and crop productivity. The major findings in Senegal are that:

- shrubs are by far the largest source of organic matter on the landscape in cropped fields
- shrubs increase soil quality
- decomposition rates are rapid enough to allow non-thermal residue management
- shrub roots perform hydraulic lift by moving water from wet sub- to dry surface-soils that appears to drive microbial processes year around.
-shrub roots recharge groundwater in the rainy season, reducing runoff and conserving water
- shrub rhizospheres promote microbial diversity and may harbor beneficial microbes
- intercropped shrubs do not compete with crops and G, senegalensis dramatically increases crop yields
- repeated application of these low quality residues (in absence of live shrubs) begins increasing yields after 2 years.

Thus these shrubs, managed, non-thermally and with optimized densities hold great potential to increase food and economic security of poor rural families while restoring degraded landscapes; increasing the ability of Sahelian communities to adapt to climate change.

Keywords：*native shrubs, Sahel, intercropping, rhizosphere microbiology/hdyrology*

O7-1

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Soil Salinity Assessment at Landscape Level using Difuse Reflectance Spectroscopy and Geostatistics

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Soil salinization caused by natural or human-induced processes is a worldwide environmental hazard impacting more than 100 countries. In Europe this problem is most pronounced in the Mediterranean basin region including the coastal region of Croatia where seawater intrudes through porous media into calcareous aquifers and salinizes both ground and surface water. This is especially evident in the Neretva River Valley (with over 6000 ha of irrigated land), located in southeastern Croatia. Agricultural production in this region, which is very important for citrus and leafy vegetable production in Croatia, is becoming more affected by periodical or occasional soil and water salinization. Identification and monitoring of the process of salinization of agricultural soils represent the basic, but also the most expensive part of the saline soil management. Spectral analysis combined with chemometrics can provide low-cost and high-density soil data for predicting various soil properties. However, a relatively weak correlation between the acquired spectra and the measurements of salinized soil properties makes spectroscopy difficult to use in salinity assessment, especially for low and moderately saline soils. It would therefore be useful if reflectance spectroscopy, combined with geostatistics, could be used as an efficient method for monitoring and mapping of soil under salinity risk. The aim of this work was to study the usefulness of a spectral indicator, derived from radiometric data, for mapping spatial distribution of soil salinity at landscape level. Using an intensive soil survey in the Neretva River valley (conducted at 1:25000 map scale), consisting of 245 agricultural topsoil (0-25 cm) samples, we assessed the feasibility of reflectance spectroscopy (RS) for describing topsoil salinity and its spatial variability across the landscape. Reflectance of air-dried and sieved (<2 mm) soil samples was measured in 2 nm bandwidths over 350-2500 nm range with a UV/VIS spectrophotometer equipped with an integrating sphere (Jasco V-560). To summarize the information content of the spectra, a partial least squares regression analysis (PLSR) was performed using electrical conductivity (EC) as a response variable and the spectra (restricted to 380-2430 nm and transformed into absorbance) as predictors. The EC values showed a large departure from normal and were transformed into Gaussian shaped variables. The PLSR was carried out on the mean centered and variance scaled data of the response and predictor (spectral data) variables. The first significant latent vector of predictors, accounting for more than 85% of the spectral variance, was extracted and used as a synthetic spectral index (SI) for topsoil salinity characterization. A multivariate geostatistical approach was applied to the dataset including SI, EC, cation exchange capacity (CEC) and Ca content. After fitting a Linear Model of Coregionalization (LMC) to the set of experimental variograms, all data were interpolated at the nodes of a 20m x 20m 2D regular grid using point ordinary co-kriging and a spherical neighborhood of 3235.87 m in size. Topsoil samples EC values have a mean of 1.5 dSm–1, ranged from 0.3 to 10.5 dSm–1, and show a highly skewed distribution with 75% of values below 2 dSm–1. CEC in the soil ranged from 0.2 to 42 cmolckg–1 and Ca concentration was from 48 to 1337 ppm indicating high variability of soil properties in the study area. An isotropic LMC was fitted to the data and included three spatial structures: a Nugget effect, a spherical model with range of 835 m, and a spherical model with range of 12,271 m; the last two components account for most of the documented spatial variation. The SI was significantly correlated to EC; a scale-dependent correlation coefficient was equal to 0.43 at shorter range and 0.83 at longer range. Comparison between the EC and SI maps revealed some similarities in the spatial dependence patterns. Despite some differences, a common trend in decreasing topsoil salinity with increasing distance from the sea is detectable. The most considerable differences between the two maps are found in the north-east and north-west parts of the area, which might be related to the presence of clayey soils at salinization risk owing to upward capillary movements. This study demonstrates that by integrating spectroscopy with multivariate geostatistics it is possible to estimate a synthetic index, which could then be used as a potential tool for soil salinity risk assessment.

Keywords：*salinity, Mediterranean, spectroscopy, geostatistic, risk assessment*

O7-2

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Spatiotemporal Variability of Soil Salinity and Its Effects on Rice Production in the North Central Coastal Region of Vietnam

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Agricultural land in the north central coastal region of Vietnam has considerably higher salinity than other regions in Vietnam. To address the adverse impacts of salinity and promote sustainable agricultural production, we investigated the spatiotemporal variability of soil salinity and its effects on rice production. Experiments were conducted at 19 different paddy field plots widely distributed in the Quang Phuoc commune, Quang Dien district of the Thua Thien Hue province in the north central coastal region of Vietnam. Soil samples were collected in January, May, and September of 2012 and 2013. We determined soil texture, cation exchangeable capacity (CEC) and the total levels of C and N to evaluate soil fertility. A saturation paste was prepared by mixing 100 g of air-dried soil with 43 ml of deionized water. We then measured the pH, electrical conductivity (EC), and water soluble cations and anions. To investigate the quality of the irrigation water, river water samples were taken in 2013 at the same time as the soil sampling. We determined the elevation of the 19 plots to evaluate its influences on salinity accumulation. Soil solutions at the 19 plots were collected every 10 days and their EC was measured to evaluate the EC variability of the paddy fields. We measured the rice yield of the winter-spring and summer-autumn cropping seasons in 2013 to determine how the soil properties influenced rice production. Finally, we analyzed the correlation between yield and relative elevation, as well as physicochemical parameters including EC, pH and CEC. The results of the physicochemical analysis indicated that the soil fertility of all samples was low with pH values of the saturation paste ranging from 4.1 to 6.2, CEC ranging from 2.0 to 6.4 $cmol_c\ kg^{-1}$, total C ranging from 0.8 to 1.5%, and total N ranging from 0.1 to 0.2%. Salinity of the main irrigation rivers was low, ranging from 0.06 to 0.11 dS m^{-1}. In the saturation extracts, the main cations were Na^+, Ca^{2+}, Mg^{2+}; and the main anions were Cl^- and SO_4^{2-}. High concentrations of Na^+ and Cl^- suggested that seawater from the lagoon had intruded into land. Elevation measurements suggested that the Quang Phuoc commune could be divided into low and high elevation areas. The low elevation area was the central part of the commune and along the lagoon, while the high elevation area was along the main irrigation rivers. The EC of the saturation extracts from the high elevation plots was less than 1.0 dS m^{-1} and stable over time; therefore, these soils were classified as non saline. In low elevation plots, the EC of the saturation extracts and soil solution were much higher than the threshold for rice growth at 1.9 dS m^{-1} and gradually increased from January until May. Moreover, soils in these areas had a lower pH and a higher SO_4^{2-} concentration in May and September, which likely had adverse effects on rice yield. The correlation analysis showed that rice yield had a negative relationship with the EC of the saturation extracts and a positive relationship with the elevation, pH and CEC. In conclusion, the EC at lower elevations was much higher than that at high elevations. At higher elevations, soils were irrigated by fresh water and thus were able to maintain low and stable EC over time. At lower elevations, soils were invaded by seawater resulting in a higher EC. Additionally, the EC in May and September was much higher than that in January because these months are in summer with higher air temperatures and surface water evaporation. Based on these results, we recommend several solutions to limit the unfavorable effects of salinity and promote rice yield. First, a comprehensive dike system should be constructed along the lagoon to prevent seawater intrusion into land. Second, it will be necessary to construct adequate drainage facilities at lower elevations to promote rapid water drainage into the canals. Third, because EC increases in May and September, enough fresh irrigation water should be frequently supplied to lower the EC during this period.

Keywords：*Lagoon, paddy, elevation, depression, saturation paste, sustainable agriculture*

O7-3

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Resource Conservation Strategies for Rice-Wheat Cropping Systems in Partially Reclaimed Salt Affected Soils and their Effects on Carbon Sequestration and Nitrogen Availability

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The Indo-Gangetic region has large extent of salt affected land area (1.2 Mha) which provides both challenge and opportunity to bolster food security and sequester carbon after reclamation. Sustainable management of partially reclaimed soils via resource conservation is key to prosperity of farmers as well as it boosts expensive initiatives to further reclaim sodic land area currently lying barren. We evaluated the changes in different soil carbon pools, nutrient release and crop yield of a long-term experiment on resource conservation strategies for rice-wheat systems on a partially reclaimed sodic soil. The total nitrogen availability scenarios were studied to analyze the release of nutrients from various treatments. Amongst all resource conservation techniques which were tested, rice-wheat crop residue addition (30% of total production) was most effective in increasing soil organic carbon. In rice, without crop residue addition (WCR), soils under zero-tillage with transplanting, summer ploughing with transplanting and direct seeding with brown manuring showed significant increase in soil organic carbon (SOC) over control (puddling in rice, conventional tillage in wheat). In these treatments relatively higher levels of carbon were attained in all aggregate fractions compared to control. Soil aggregate sizes in meso (0.25-2.0mm) and macro (2-8mm) ranges increased whereas micro (<0.25mm) fractions decreased in soils under zero-till practices both with and without crop residue addition. Direct seeding with brown manuring and zero tillage with transplanting also showed an increase of 135% and 95%, respectively, over control, in microbial biomass carbon without crop residue incorporation. In zero tillage with transplanting treatment, both with crop residue and without crop residue showed significant increase in soil carbon sequestration potential. The residue addition significantly increased the availability of nitrogen over no-addition though synchronization with crop stages played more important role. Though the changes in accrued soil carbon did not bring about significant differences in terms of grain yield, overall synthesis in terms of balance between yield and carbon sequestration indicated that summer ploughing with transplanting and zero tillage with transplanting sequestered significantly higher rates of carbon, yet yielded at par with conventional practices. These could be the appropriate alternatives to immediately replace conventional tillage and management practices for rice-wheat cropping systems in the reclaimed sodic soils of Indo-Gangetic region.

Keywords：*Carbon, nitrogen, resource conservation, salinity, sodicity*

O7-4

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Potential Short-term Effect of Cultivation and Crop Rotation Systems on Soil Quality in a Coastal Newly Reclaimed Farmland, Eastern China

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Soil quality (SQ), a measure of the sustainability of land use and soil management practices, can be assessed by indicators including soil physical, chemical and biological properties. Our primary objectives were to investigate the influence of consecutive cultivation and different crop rotation systems on individual soil quality indicators, and to examine the impact of rotation systems on soil quality using soil quality index (SQI) model. A site-specific selection of 17 potential SQ indicators representing soil chemical and physical attributes (0-10 cm) and groundwater features on 60 sampling locations and 10 representative soil profiles was chosen in a typical coastal newly-reclaimed farmland of north Jiangsu Province, China. Using ANOVA analysis, the crop rotation effect was analyzed by comparing SQ indicators between rice/rape rotation soil and cotton/barley rotation soil. An overall soil quality index (SQI) was calculated to examine whether plant biomass indices exactly responded to the SQI value. Results indicated that cultivation had significant effect on some soil profile characteristics, including SOM, SOCD, AP, CEC, AK, ECe and If. Crop rotation systems also had significant influence on some SQ indicators. Compared with cotton/barley rotation soil, rice/rape rotation soil was characterized by higher organic matter, undifferentiated nutrient storage and salinity/alkalinity, lower water accommodation and infiltration, and adverse groundwater conditions. Cotton/barley rotation had higher SQI values over rice/rape rotation (0.523 vs. 0.422). SQ indicators of SARe, ECe and WTg contributed the most to the overall SQI value for each rotation system. Plant biomass indices significantly correlated with the SQI values for both rotation systems, suggesting that the SQI values essentially reflected the status of soil quality. Such results allowed us to conclude that cotton/barley rotation system contributed more to the improvement of soil quality than rice/rape rotation system in coastal farming area. Also, we suggested SOCD, AK, ρb, WTg and ECg as the minimum data set for soil quality assessment, as they had potential in discriminating the effect of rotation systems on soil quality between the rotation systems used here.

Keywords：*Coastal; Crop rotation system; Cultivation; Salt-affected farmland; Soil quality*

O7-5

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Hydrostratigraphic Analysis Using Electromagnetic Induction Data and a Spatially-Constrained Algorithm for Quasi-Three-Dimensional Electrical Conductivity Imagi

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Efforts are being made to improve the irrigation efficiency in the Murray-Darling River Basin, Australia, to deal with predicted rainfall decline and to reduce the incidence of secondary soil and water salinisation. The latter commonly occurs as a result of locating water reservoirs upon relic drainage channels. To better manage irrigation, information is required about the spatial distribution of soil type and the stratigraphic features capable of redistributing deep draining water. In previous research, electromagnetic (EM) induction instruments (e.g. EM38 and EM34) have been used to map the distribution of soil type, hydrological processes (e.g. deep drainage) and vadose-zone features. The aim of this research is to demonstrate how a joint inversion of EM38 and EM34 data, using a one-dimensional spatially constrained algorithm for quasi three-dimensional (quasi-3D) electrical conductivity imaging, can be used to infer the areal distribution of soil salinity and physiographic and hydrogeological units. The quasi-3D modeling of true electrical conductivity provides a framework for future environmental monitoring and management to mitigate the hydrological processes that drive localized secondary salinization in the study area.

Keywords：*EM38, EM34, salinity mapping, 3-d inversion modelling*

O8-1

[C4.1-3] Soil Ecosystem under Climate Change

Climate Change Effects on the Suitability of an Agricultural Area to Maize Cultivation: a New Land Evaluation Hybrid System for Maize

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Climate change will cause significant effects on the suitability of agricultural areas to crop cultivation for food and feed, mostly due to the changes in rainfall distribution and water availability that will be limiting factors in most Mediterranean regions for some crops, included cereals.
Different approaches are used to examine the potential impact of climate change on crop yields able to evaluate the land suitability: (i) process-based crop simulation models, (ii) simple empirical approaches, (iii) expert-based approaches, (iv) crop-specific evaluation approach, (v) Land suitability evaluation and (vi) statistical model approaches. However every approach has limitations, given the complexity and the multi-facet nature of the problem and a universally recognized, best approach, doesn't exist.
It is clear that the study of climate change impacts on land crop suitability must consider the characteristics of environment and climate but also the crop intra-specific biodiversity (among hybrids or cultivars); the latter can be a tool for adaptation.
To this purpose, a Land Evaluation Hybrid System (LEHS) was proposed to evaluate the effects of climate change on land suitability for maize cultivation in an irrigated district of Southern Italy (Destra Sele, 20,000 ha). The system consists of three hierarchical steps: (1) Evaluation of thermal conditions for maize; (2) Environmental evaluation for maize cultivation, i.e. Land suitability for maize (LE)(qualitative approach); (3) Evaluation of adaptability options considering soil water availability (simulated by means of SWAP agro-hydrological model), the reference and future climate information, irrigation water resource, and different intra-specific yield responses of crops to water availability (quantitative evaluation).
The advantage of the methodology proposed is its hybrid approach which integrates: (i) the impact of single climatic variables on crop and its adaptation (e.g. temperature), (ii) the dynamic treatment of these ones in the soil-plant and atmosphere system by means of a physically based simulation model (iii) the evaluation of crop suitability in each STU considering the different responses of a set of maize hybrids at different levels of water availability (iv) the use of classic LE that allows to consider some land characteristics that could be not characterized through the simulation modeling and generally are not included in the studies of climate change impacts and on crop adaptation (e.g. flooding risk).
The work proceeded through the following steps:
- two climate scenarios were studied: “past” (1961-1990) and “future” (2021-2050), the latter generated through statistical downscaling procedures from general circulation models (AOGCMs)
- the yield response functions to water availability of 11 maize hybrids (Zea mays L., belonging to four FAO maturity classes) were determined from experimental data and scientific literature, identifying the hydrologic requirement of each hybrid.
- the agro-hydrological model SWAP (soil-water-plant and atmosphere) was used to determine the soil water regime (under optimal and deficit irrigation). A hydrological indicator was determined from simulation runs at landscape scale (in 25 soil units) in both climate periods.
- the hybrids’ hydrological requirements and the hydrologic indicators were compared and the crop adaptability in each soil of the study area, in both climate periods, was determined.
- the results of three steps of LEHS were compared, and the land suitability for maize to climate change assessed
The main results of LEHS approach have shown that in the study area:
- the evolution of thermal conditions during maize growing season have not affected crop adaptability;
- the main physical and chemical constraints of the study area were: pH, soil organic carbon content and flooding hazard (step 2, Standard Land suitability for maize, qualitative approach).
- from the quantitative approach (step 3, simulation of soil water regimes with SWAP model), only four hybrids of maize could be considered suitable for cultivation (NS640, Manuel, PP700 and Kaystar 890) if a reduction in water supply was accounted for;
- the quantitative and qualitative approaches showed the same weight as limiting factor in the final LEHS classification (30%) with an agreement in the 40% of cases.

Keywords：*Climate change, Land Evaluation, Food Security, Maize*

O8-2

[C4.1-3] Soil Ecosystem under Climate Change

Soil Organic Carbon Fractions, Aggregate Stability, Nutrient Availability and their Interrelationships in Tropical Cropping Systems

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Partial mitigation of global warming caused by accelerated emissions of carbon dioxide may be possible by the sequestration of atmospheric carbon in soils. Most field research programs associated with agriculture have attempted to sequester soil C primarily, by enhancing biomass inputs by tillage and residue management. Though studies are lacking in the tropics fertilizer types and their application management could also play a role in C sequestration of agricultural soils. C sequestration and post sequestration losses are reported to be influenced by clay and silt concentrations and microbial activity. Therefore more research is needed, especially for the tropics, to capture the impact of region-specific interactions between climate, soil, and management of resources on C sequestration, which are lost in global level assessments. In this study soil C stocks were estimated for 9 agricultural land uses that applied organic, inorganic and combined fertilizers. These annual crop land uses with different fertilizer applications were: organic fertilizer only (A-OF), inorganic fertilizer only (A-IF), both organic & inorganic fertilizers (A-O/IF) and agricultural field with perennial crops (PC), a home garden (HG), abandoned home gardens (AHG), paddy land with combined use of organic and inorganic fertilizer (P-O/IF) within the same soil type of calcic red yellow latasol and annual crop with organic fertilizer only (A-OFR) and uncultivated land in a sandy regosol (ULR). The effect of soil carbon storage on nutrient availability and aggregate stability was also studied in addition to the relationship between soil C stocks and clay content.

The study showed that land uses had significant variations in terms of soil organic carbon stocks, nutrient availability and aggregate stability. A-OF showed the highest soil organic carbon (SOC) fractions probably as a result of continuous supply of organic fertilizer for years. Conversely a lower SOC and other labile C fractions were recorded in A-IF probably due to greater decomposition of native soil organic matter without replenishment under mineral fertilizers. Aggregate stability value ranged between 0.17 – 4.11 and had highly significant positive trend with the carbon fractions studied. Micro and macro nutrients showed significant correlations with aggregate stability and C fractions.

Mg and Ca showed significant positive correlation with soil organic carbon fractions due to chelating effect of organic matter on Mg and Ca availability. P and K availability had highly significant correlation with soil organic C fractions. High level of organic matter mineralization and chelating effect of organic matter on Mg may cause higher availability in organic matter applied field and AHG.

Chelating effect of organic matter also resulted in positive correlations between micronutrients such as Zn and Cu and organic matter fractions. Fe, Zn, Mn and Cu availability had highly significant correlation with aggregate stability. Increased aggregate stability suggests the formation of strong bonding involving Ca2 + bridges. Fe increase aggregate stability as Fe oxides by forming Coarse-grained particles. In addition aggregate stability itself had a positive correlation with carbon fractions.

Though Fe availability shows a significant positive correlation with microbial and water soluble carbon fractions, Mn availability showd a significant positive correlation with microbial and total carbon fractions. The complexation of metals with soluble organic matter in the soil influences the solubility and mobility of these metals. Ca, K, Mg and Cu availability had highly significant correlation with clay content.

It is reported that tropical tree-based systems reduce net global warming potential compared to annual cropping and pasture systems. However from this study it is confirmed that tropical annual cropping systems also have a great potential in storing and maintain C in tropical soils and thereby increasing the availability of major nutrients.

Keywords：*Soil Organic C, Soil C sequestration, Soil Nutrient availability, Tropical soil*

O8-3

[C4.1-3] Soil Ecosystem under Climate Change

The Risk Assessment of Drought for Regional Upland Soil according to Rcp8.5 Scenario using Soil Moisture Evaluation Model (afke 0.5)

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In order to evaluating drought risk at upland according to climate change scenario (RCP8.5), we have carried out the simulating using agricultural water balance estimation model, called AFKAE0.5, at 66 weather station sites in 2020, 2046, 2050, 2084, and 2090. Total Drought Risk Index between the first month (f) and last month (l) (TDRI(f/l)) and maximum continuous drought risk index (MCDRI(f/l)) were defined as the index for analyzing pattern and strength of drought simulated by the model. Based on distribution maps of MCDRI(1/12), drought strength was predicted to occur the most severe in 2084 for all regions. Some regions showed severe risk of drought meaning over 20 days of MCDRI(1/12) in the other years, while MCDRI(1/12) in other regions did not reach 5 days. Even though maximum value of TDRI(1/12) in 2090 was greater than in 2050, more severe drought risk in 2050 than in 2090 was predicted based on MCDRI(4/6). It implies that drought risk should be assessed given each crop with its own growing season.

Keywords：*Scenario RCP8.5, Soil moisture estimation model, drought risk index (DRI)*

O8-4

[C4.1-3] Soil Ecosystem under Climate Change

Nitrogen Dynamics and Greenhouse Gas Emissions in Cropping Systems under Elevated Co_2: Face Experiments and a Meta-analysis

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Within less than 50 years, atmospheric carbon dioxide concentration [CO_2] is expected to double that observed in 1950. In this higher [CO_2] world, the sustainability of global crop production may be in jeopardy unless current nitrogen (N) management strategies are changed because of potential interactions between elevated atmospheric [CO_2] and soil N dynamics. However, these interactions are poorly understood especially in semi-arid cropping systems. In this paper, we present experimental results on the effects of elevated [CO_2] on crop N demand, fertilizer N recovery, symbiotic N_2 fixation, and greenhouse gas emissions from cropping systems in southern Australia and northern China using free-air [CO_2] enrichment (FACE) facilities. We also discuss the findings of a meta-analytic review of current literature which quantitatively estimated the effects of elevated [CO_2] on soil N dynamics in grain crop and legume pasture systems. Results of our experiments and meta-analysis suggest that under future elevated [CO_2] atmospheres (i) there will be an increase in crop demand for N; (ii) higher fertilizer N application rates and greater use of legume intercropping using locally appropriate agricultural management practices would be able to meet the additional crop N demand; and (iii) increases in the terrestrial C sink may be less than expected since there will be a significant increase in greenhouse gas emissions (CO_2-equivalent) associated with an increase in atmospheric [CO_2].

Keywords：*elevated CO_2, soil nitrogen, greenhouse gas, cropping system*

O8-5

[C4.1-3] Soil Ecosystem under Climate Change

Distribution of Photo-assimilated Carbon as Affected by Nutrient Addition to Soil

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The increasing level of carbon dioxide (CO_2) in the atmosphere resulting from carbon (C) cycling in terrestrial ecosystems is mostly dependent on the amount of photo-assimilated C translocated in the plant-soil system. Therefore, quantification of photo-assimilated C inputs to the soil through shoots, roots and exudates is important in the study of soil organic matter dynamics. Photo-assimilated C distribution in a wheat cropping system as it is affected by soil fertility was examined to identify the link between soil fertility, C partitioning and soil C sequestration. A novel pulse labelling experiment was conducted in which ^{14}C labelled CO_2 was introduced into the wheat plants using a pulse labelling chamber in a laboratory. Stubble and no stubble soils were collected from stubble retention and removal plots, respectively at Wirrabara, South Australia at 0-5 cm depth. Nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) were added as urea, triple super phosphate (TSP), muriate of potash (MP) and gypsum, respectively to both soils at 500, 80, 40 and 20 mg kg^{-1} soil, respectively to make four different nutrient gradient soils [(i) stubble soil + nutrient (High fertile: HF); ii) stubble soil + no nutrient (fertile stubble: FS); iii) no stubble soil + nutrient (Fertile no stubble: FNS) and iv) no stubble soil + no nutrient (low fertile: LF)]. Four wheat plants per pot were grown in a glasshouse. At three leaf stage (after seven days of germination), plants were taken in laboratory and labelled at 500 Kbq pot^{-1}. Wheat shoot, root and soil samples were taken after 1, 14 and 28 days of pulse labelling to examine the fluxes of ^{14}C in the plant-root-soil system. The distribution of ^{14}C in all pools was expressed as a proportion of total assimilated $^{14}CO_2$ i.e. sum of ^{14}C recovered in shoot, root and soil during the pulse labelling.

After 28 days of labelling, around 36.2%, 14.1% and 14.3% more shoot biomass was found in HF, FS and FNS, respectively over LF soils whereas in root biomass the increasing rates were only 16%, 6.1% and 7.2%, respectively for the HF, FS and FNS over LF soils. This indicated higher nutrient effect on above ground biomass production than that below ground. However, there was no significant ($P = 0.082$; $F = 14.33$) difference in root biomass between HF and LF soils indicating that soil fertility did not influence root growth in this study.

Although one day after labelling, the majority of the ^{14}C (80.4%, 81.4%, 81.6% and 82.8% in the HF, FS, FNS and LF soils, respectively) was in the shoot biomass, by day 28 the percentage of ^{14}C retained in shoots was highest in the HF plants and lowest in the LF plants (50.2%, 48.1%, 47.9% and 47.1% in the HF, FS, FNS and LF soils, respectively). Among the fertility treatments, however, a significant ($P = 0.021$, $F = 38.44$) difference was observed only between the LF and HF soils throughout the experimental period which was attributed by higher biomass production in HF soils.

At end of the experiment, photo-assimilated C distribution in roots in nutrient limited soil was higher ($P < 0.001$) (10.1%, 14.6%, 14.5% and 16.0% in the HF, FS, FNS and LF soils, respectively) whereas C distribution in above ground biomass was higher in nutrient rich soil. This indicated that low fertility soil provides a potential sink for the translocation of atmospheric C through root transfer. Although the amount of ^{14}C was almost similar (2.4% and 1.33%, respectively for bulk and rhizosphere soil) in all soils, ^{14}C in microbial biomass carbon in nutrient poor soil was higher ($P = 0.041$, $F = 28.85$) than nutrient rich soil which indicated higher root exudates in former soil. However, the total assimilated C was found to be greater in high- than low-fertility soil which was attributed to higher above ground biomass production in the former soil. Therefore, it can be concluded that in conservation cropping system with stubble retention practice, soil fertility can be an important factor by which C sequestration in soil may be potentially impacted.

Keywords：*14C pulse labelling, Carbon distribution, Soil fertility, Carbon fluxes, Carbon sequestration*

O9-1

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Quantifying Contribution of Ammonia-oxidizing Archaea to Nitrification in Acid Soils

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Microorganisms are the engines driving the biogeochemical cycles of soil elements. The nitrogen (N) cycle is one of the central processes of terrestrial ecosystems, and contains four main steps, i.e., biological N fixation, ammonification, nitrification and denitrification, all of which are driven by microorganisms. In the last decade, with the rapid development of culture-independent molecular techniques and high-throughput sequencing technologies, breakthrough progress has been made on the ammonia oxidation microorganisms. For over 100 years, ammonia oxidizing bacteria (AOB) were considered as the only group mediating the first and rate-limiting step of nitrification. Recent progress in ammonia-oxidizing archaea (AOA) studies suggested their putative contributions to the global nitrogen cycle by possessing the potential capacity to oxidize ammonia, and phylogenetic analysis categorized AOA into the Thaumarchaeota lineage, a novel archaeal phylum. We investigated the relative contributions of AOA and AOB to autotrophic ammonia oxidation in five strongly acid (pH < 4.50) soils collected from Zhejiang, Hunan and Yunnan provinces. A combined approach of 13CO2-DNA-SIP and application of the nitrification inhibitor dicyandiamide (DCD, C2H4N4) was employed to identify the ammonia oxidizing community responsible for the nitrification in the soils. It was found that significantly positive correlations between nitrate concentration and amoA gene abundance of AOA, but not of AOB, were observed during the active nitrification. 13CO2-DNA-SIP results showed significant assimilation of 13C-labeled carbon source into the amoA gene of AOA, but not of AOB. High levels of thaumarchaeal amoA gene abundance were observed during the active nitrification, coupled with increasing intensity of two DGGE bands for specific thaumarchaeal community. Addition of the nitrification inhibitor dicyandiamide (DCD) completely inhibited the nitrification activity and CO2 fixation by AOA, accompanied by decreasing thaumarchaeal amoA gene abundance. Bacterial amoA gene abundance decreased in all microcosms irrespective of DCD addition, and mostly showed no correlation with nitrate concentrations. Phylogenetic analysis of thaumarchaeal amoA gene and 16S rRNA gene revealed active 13CO2-labeled AOA belonged to groups 1.1a-associated and 1.1b. Taken together, these results provided strong evidence that AOA play a more important role than AOB in autotrophic ammonia oxidation in strongly acid soils. Acid soils are extensively distributed around the world, occupying approximately 30% of the world's total ice-free lands. Therefore, it is of great significance to understand nitrogen cycling in acid soils, thus providing possible strategies for managing the global nitrification process and mitigating nitrous oxide emissions and nitrate leaching.

Keywords：*Molecular technology, stable isotope probing, nitrification, ammonia-oxidising archaea, soil*

O9-2

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Innovative Approaches and Technologies to Assess N_2O Emissions from Forest Ecosystems, with Examples from South China

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Excess reactive nitrogen (Nr) in the biosphere, has become one of the most pressing global environmental problems, not only due to its impact on biodiversity, soil acidification and eutrophication, but also due to increased emission of nitrous oxide (N2O), a potent greenhouse gas (GHG), the concentration of which increases by 0.3% yr-1 in the atmosphere. So far, much of the N2O research has focused on agricultural soils and less attention has been given to forest soils.

In an ongoing Sino-Norwegian research project we assess the impact of elevated N deposition and climate change on ecosystem functioning and climate-ecosystem interactions in the N cycle of a representative Masson pine dominated forest catchment at TieShanPing (Chongqing, South China). In the initial phase of the project we focused on the mass balance of N, whereas the next phase emphasized process understanding and regional quantification of climate-change-induced perturbations of the nitrogen cycle. To this aim we combined classical biogeochemical methods with innovative approaches and advanced techniques. N balances studies indicate that N deposition at TieShanPing is about 50 kg ha-1 yr-1, a typical value for this part of China. Both, leaching of NO3-N in streamwater and N assimilation by Masson pine were important N sinks, each accounting for about 20%. The remaining 60% were most likely due to denitrification, but the emission of N2, the dominant gaseous denitrification product, is difficult to assess in the field.

N2O emissions were measured along transects on the hill slopes, dominated by acid Acrsols, and in the groundwater discharge zones, dominated by colluvium-derived Cambisols, using static chambers. We found large N2O fluxes on the hill slopes from April to October, especially during and after intensive rain episodes, when water filled pore space was temporarily high. N2O emission in wet years were as high as 5 kg N ha-1 yr-1, indicating that about 10% of the N sink at TieShanPing was due to N2O emission. Excess NO3 was transported downhill as interflow over the dense B horizon to the groundwater discharge zone, where it was largely denitrified before drainage water entered the ephemeral stream. Despite the large losses of NO3 presumably, due to denitrification in the groundwater discharge zone, the emission of N2O in this zone was surprisingly small. In a short-term field experiment on the hill slope using stable isotopes (15N), denitrification was found to be the dominant mechanism of N2O production. Stable isotopes (15N, 18O) were also used to study the natural abundance of 15N and 18O of NO3- in soil water, which was used to infer the degree of denitrification along the transects qualitatively. Prior to δ15N and 18O analysis by isotope ratio mass spectrometry (Finnigan XP coupled to a PreCon unit), NO3- is converted to N2O using a modification of the denitrifier method, which is now routinely used in our laboratory.

Because the total denitrification activity (i.e. the sum of gaseous NO, N2O and N2) cannot be measured directly in the field, we use laboratory methods to study inherent denitrification potentials and product stoichiometries along transects to explain contrasts in magnitude and dynamics of the observed N2O emissions. Specifically, we measured apparent enzyme kinetics (i.e. dependency of process rates on C-substrate and N-oxide concentrations), relative process rates (i.e. product stoichiometries) and taxonomic abundance and composition of the denitrifier communities. With respect to controlling factors we focus on soil pH and redox chemistry as many of the studied soils are acid and rich in iron (Fe). We found that the hill slope soils (with their low pH), but not the groundwater discharge zones, at TieShanPing, have low denitrifier gene expression rates and, especially, impaired functioning of the N2O reductase (N2OR), explaining the high N2O/N2 ratios and relatively large N2O emission rates. We also use high-throughput incubation robots coupled to gas chromatographs that allow quick and efficient screening of community denitrification phenotypes (CDP) on the basis of gaseous denitrification products. Combining the approaches allows us to assess site-specific metabolic patterns and help to scale up N2O emission fluxes across different ecosystems.

Keywords：*Forest soil, N saturation, N2O, denitrification, reaction kinetics, gene expression, stable isotopes*

O9-3

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

The North American Long-term Soil Productivity Experiment: Findings from a Long-term, Large-Scale Study

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The capacity of a forest site to capture carbon and convert it into biomass can be used to define fundamental site productivity. Protecting the inherent capacity of forest land to grow vegetation is a goal of modern forest management. To provide forest land managers with information to meet this goal, the Long-Term Soil Productivity (LTSP) experiment was established. Since its initiation in 1989, The LTSP program has grown to a network of more than 100 installations which address both short- and long-term consequences of site and soil disturbance on fundamental forest productivity.

The LTSP study is being carried out through a standard series of experimental treatments designed to create varying degrees of stress and to provide measures of biological response and soil recovery. Research centers on two key properties affecting a site's long-term productive capacity, site organic matter and soil porosity, each of which is readily influenced by management. Work is conducted on forest lands of the US Forest Service in the United States and dedicated sites in Canada, covering major forest and soil types. The Canadian sites are managed by the Canadian Forest Service in Ontario and the British Columbia Ministry of Forests. The experimental sites are protected from conflicting uses and are dedicated to long-term research.

Results after 10 years show that complete removal of surface organic matter led to declines in carbon concentration in soil to 20 cm depth and also reduced nutrient availability. The effect is attributed mainly to the loss of the forest floor. Total soil C storage was apparently undiminished, but this could be explained by bulk density changes following disturbance and to decomposition inputs of organic C from roots remaining from the harvested forest. The effects of soil compaction varied with a soil's initial bulk density. Soils with densities greater than 1.4 Mg m-3 resisted compaction. Recovery from compaction was slow, particularly on frigid soils. Biomass removal during harvesting had no influence on forest growth during the first 10 years. Total stand biomass was either unaffected or, with aspen, reduced by compaction. Forest productivity response to soil compaction depended both on soil texture and the degree of understory competition. Production declined on compacted clay soils, increased on sands, and generally was unaffected if an understory was absent. Vegetation control consistently enhanced planted tree biomass, regardless of climate, and also enhanced foliar nutrient concentrations on Warm Humid and Mediterranean sites. Vegetation control also increased total stand biomass on sites without abundant woody competitors, but decreased it on shrub-dominated Mediterranean sites. Most stands, however, have not yet reached canopy closure, and we will continue to follow treatment effects as they continue to evolve.

Keywords : *forest soils, organic matter, soil compaction, carbon, productivity*

O9-4

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Continuous Measurement of Vertical Distribution of CO_2 Concentration and Its Isotopic Signature in a Beech and a Pine Forest Soil

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Soil respiration is generally separated into root respiration, which is part of autotrophic respiration, and heterotrophic respiration, which is microbial respiration of both new and old carbon substrates. The rates of autotrophic and heterotrophic respiration may respond differently to variations in soil temperature, moisture, and substrates. As both fluxes vary dynamically it is highly important, but technically difficult to separate these. The $\delta^{13}C$ signature of soil CO_2 respiration may be used to separate these two components. Temporal fluctuations of $\delta^{13}C$ signatures of soil CO_2 efflux have been recorded but the underlying mechanisms and their environmental drivers have not yet been fully explained. Furthermore, only few studies to date provide vertical partitioning of $\delta^{13}C$-CO_2 signatures at different depths. Thus, needs for high-frequency, high-resolution spatial measurements of vertical CO_2 concentration and its isotopic signature in situ are evident.

Two forest sites were studied, (A), a beech forest located at Beerenbusch, and (B), a pine forest located at Kienhorst, both in Brandenburg, Germany. Soil CO_2 concentrations in the air-filled pores of soil were measured in -10cm, -20cm, -30cm and -100 cm depths (3 replicas each), as well as below the humus layer and on top of soil surface based on a closed cycle of hydrophobic, gas-permeable porous polypropylene tubing. At both sites, soil moisture and temperature (TDR probes) at the respective soil depths were detected. During a measurement campaign, a mobile CO_2 analyzer device, consisting of 16 pumps, 16 NDIR CO_2-sensors (1.000 - 50.000 ppm), a 16-position multiplexer, and a data logger was connected to an isotope CO_2 analyzer (CRDS, Picarro). Soil gas was circulated in a closed loop from the membrane tube passing a multiplexer system into the gas measurement setup. Thus, a new approach was applied for the in situ detection of vertical profiles of soil CO_2 concentrations and $\delta^{13}C$-CO_2 signatures, continuously. Special interest was directed to the assessment of temporal dynamics of soil CO_2 concentrations in combination with monitoring of soil temperature and moisture in order to explain the underlying mechanisms. Isotopic signatures ($\delta^{13}C$-CO_2) were monitored in order to trace sources of soil organic carbon. Furthermore, the effect of a root density gradient on soil CO_2 concentration was assessed.

Our results after one year of measurements at the beech forest site provided evidence for distinct vertical CO_2 concentration gradients with seasonal dynamics. Varying impacts of soil temperature and moisture on CO_2 concentration were revealed. Along distance from the tree trunk, increasing CO_2 concentrations were found in -10cm and -20cm soil depths. The $\delta^{13}C$ of soil CO_2 was variable over time, and displayed a gradient with soil depth. Further results will be presented, including latest findings at the pine forest site.

Keywords : *soil respiration, CO_2 profile, multi-layer approach, $\delta^{13}C$, beech, pine*

O9-5

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Stress Distribution under Forestry Machinery and Consequences on Physical Soil Functions

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In the last years the intensity of timber harvesting in Germany increased highly, combined with the increase of empty vehicle weights up to about 35 Mg. To be profitably harvesters and forwarders work also in very wet periods and cause heavy soil compactions. This degradation of soils could have lasting and sustainable effects on the health of forest soils.

This study simulates a typical workflow during the timber harvest on a skid trail with wheeled harvester (John Deere 1270e) and wheeled forwarder (Ponsse Buffalo) to figure out whether the influence on soil functions of the two machines is different. Furthermore opportunities to reduce stress impacts on skid trails are pointed out. Therefore trials with a conventional wheeled forwarder (Rottne F14) and a chained special forwarder (EMB Elliator) were carried out

The measurements took place in Lower Saxony on silty soils with John Deere 1270e & Ponsse Buffalo near Göttingen and on loamy soils with Rottne F14 & EMB Elliator near Bremen. To registrate stress impacts of these machines the state stress transducer system was installed in three different soil depths (20cm, 40cm, and 60cm). For each depth the stress tensor components can be quantified. To evaluate soil stability the current stress impacts are compared with the precompression stress (Pc) which was quantified for undisturbed soils in the known depths. Furthermore the saturated hydraulic conductivity (Ks), air permeability (Ka) and air capacity (AC) as a function of the stress impacts were applied.

In order to simulate a normal workflow the harvester (John Deere 1270e) crosses sensor heads once. Afterwards the forwarder (Ponsse Buffalo) crosses them five times. First results for harvester and forwarder show that the highest stress impacts were determined during the first wheeling of harvester. Any further crossing by forwarder reduces stress impacts, even though the weight of forwarder is much higher than the weight of harvester. Both machines reduce highly Ks, Ka and AC.

When comparing the two different forwarders Elliator and Rottne F14 both pass the sensor heads three times. The special chained forwarder Elliator is able to reduce stress impacts by about 50% in 20 cm depths with same loading. But the current stress impacts of both exceed Pc of soil and lead to instable soils. Although negative influences on Ks, Ka and AC can be pointed out for both forwarders.

Keywords：*stress distribution, precompression, forestry machinery, forest soils, compaction*

O10-1

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Biogeochemistry of Fe Acquisition by Phytosiderophores in the Rhizosphere

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Graminaceous plants (grasses, incl. staple crops like wheat, barley and rice) employ the so-called Strategy II for Fe acquisition. This Strategy II involves the exudation of phytosiderophores (PS), which are biogenic chelating agents with a high affinity for Fe. Upon release into soil solution, PS can bind and mobilize soil-Fe and the resulting Fe-PS is preferentially taken up at the root surface. PS are exuded in a 4-6 hour diurnal pulse release in the morning, after which there is no further release throughout the day. This pulse release initiates a window of opportunity (i.e. a time span during which the Fe concentration in soil solution is elevated as a result PS exudation) for graminaceous plants to take up Fe.

Despite the intensive research on Strategy II Fe acquisition, the biogeochemical processes restraining this window of opportunity are still poorly understood, amongst others, because most studies on the topic are carried out under conditions remote from those in the rhizosphere e.g. in hydroponic systems. Our present work aims to contribute to a quantitative understanding of these biogechemical processes and fluxes, in order to arrive at a coupled thermodynamic and kinetic model that will help to understand plant iron nutrition.

To examine how biogeochemical processes, including mobilization of Fe and other metals, adsorption of the PS ligand and PS-metal complexes, biodegradation of the PS ligand, and metal exchange from the PS ligand restrain the window of opportunity, a series of soil interaction experiments was done with the PS deoxymugineic acid (DMA) and several calcareous soils. In these experiments, metal and total DMA ligand concentrations in soil solution were examined as a function of time. The experimental conditions, including the added amount of DMA and the soil to solution ratio (SSR) were varied.

It will be shown and discussed that several simultaneous processes substantially limit the Fe-PS concentration in soil solution, and presumably plant iron uptake. The window of opportunity for strategy II Fe acquisition strongly depends on the exuded amount of PS and the availability of other metals in the soil.

Keywords：*phytosiderophores, Fe acquisition, deoxymugineic acid (DMA), Fe deficiency, Strategy II*

O10-2

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Siderophore Production by Soil Microorganisms

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Soil microorganisms play an important role in the biogeochemical cycling of mineral nutrients such as iron. In soil, microorganisms can synthesize siderophores with high affinities for metals as a strategy to overcome low bioavailability of mineral nutrients or as a tool to outcompete other microorgansims in the gain of mineral nutrients. Both bacteria and fungi can produce hydroxamate siderophores, which are very stable against hydrolysis and enzymatic degradation in the natural environment. The present study aims to answer several questions: a) What is the diversity of culturable siderophore-producing microorganisms within the different types of soil horizons of a podzol? b) What are the hydroxamate type siderophores and in what concentration can they be produced by the isolated siderophore producing microorganisms? c) Does the chemical characteristics of the soil horizon(s) from where the siderophore producing microorganisms were found have an effect on the production of hydroxamate siderophores?
Soil samples were collected from a podzolic soil in central Sweden (63°07′N, 16°70′E). Siderophore-producing bacteria/actinobacteria and fungi were isolated from O- (organic), E- (eluvial), B1- (upper illuvial), and C- (parent material) horizons. All the isolated microorganisms were genetically identified. The production of siderophores were studied in liquid cultures for each microbial isolate, and the hydroxamate type siderophores i.e. ferrioxamines, ferrichromes, fusigen and coprogens were detected and quantitated by HPLC-ESI-MS.
We found that the maximum counts of the isolated microorganisms were present in the E-horizon, whereas the minimum counts were found in the C-horizon. The molecular identification of the siderophore producing microorganisms showed that there was a high diversity of various fungal and bacterial/actinobacterial species throughout the soil profile. Streptomyces spp. was the most common taxa throughout the soil profile except in the C-horizon. In contrast, Pseudomonas spp. was sparsely detected within the soil profile. However, Micrococcus luteus was restricted to B- and C-horizons, whereas Penicillium spp. was only found in the O- and E-horizon.
The isolated siderophore producing bacteria/actinobacteria showed different abilities in their production of ferrioxamine (E, B, G and D) siderophores. All the bacterial/actinobacterial isolates could produce ferrioxamine D, except Micrococcus luteus (C-horizon). The maximum concentration of ferrioxamine D, 19 nM, was produced by Streptomyces olivaceus (O-horizon). Ferrioxamine G was the second most common hydroxamate type siderophore produced by most of the isolated bacteria/actinobacteria. The highest concentration of ferrioxamine G, 24 nM, was produced by Streptomyces nitrosporeus (B-horizon). Ferrioxamine B was produced in low concentration by most of the isolated bacterial/actinobacterial species. However, ferrioxamine B was completely absent for all the isolates from the C-horizon. In comparison, not all the isolated bacteria/actinobacteria had the ability to produce ferrioxamine E. Pseudomonas mendocina isolated from the B-horizon was found to produce the maximum concentration (11 nM) of ferrioxamine E.
The isolated siderophore producing fungal species showed a high variety in their ability to produce hydroxamate type siderophores, i.e. ferrichromes, coprogens and fusarinines. Most of the fungal isolates produced high concentrations of coprogen that ranged between 101 nM (Trichothecium roseum, O-horizon) and 1649 nM (Ustilago maydis, E-horizon). Neocoprogen II was also produced by many of the isolated fungi, especially those which were isolated from the E-horizon. In line with that were neocoprogen I (81 nM) and fusigen (lin.) (15 nM) restricted to be produced by isolate from the E-horizon, Fusarium sporotrichioides. Fe-dimerum acid was sparsely detected. Ferrichromes were found in much lower concentration compared to the coprogens. It was found that the fungal species isolated from the O- and B-horizon had the ability to produce most of the studied ferrichrome type siderophores, except for ferrichrome A. Ferrichrome A was restricted to be produced by Epicoccum nigrum (C-horizon); whereas ferricrocin was restricted to be produced by Thielavia terrestris (O-horizon).
The correlation between the distribution of siderophores, the chemical characteristics of each soil horizon, and the diversity of the siderophore producing microorganisms indicated that the characteristics of soil horizons from where the microorganisms were isolated strongly influenced the ability of the isolated microorganisms to produce siderophores. These findings may be explained by that the chemical characteristics of the soil horizons could influence the regulation of the expression of genes involved in the biosynthesis of the siderophores.

Keywords：*Actinobacteria, Bacteria, Coprogen, Fungi, Ferrichrome, Ferrioxamine, Fusigen*

O10-3

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

The Role of Root Exudates Released by Monocots and Dicots in Mobilizing Fe from Soil Minerals

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Iron (Fe) is an essential plant nutrient usually present in the soil mainly in insoluble Fe(III) forms. Particularly in well aerated soils at neutral to alkaline pH, inorganic Fe forms are scarcely available, such that plants rely mainly on Fe uptake from Fe-organic matter complexes or Fe that has been solubilized by organic compounds released by roots and/or microorganisms. In response to Fe deficiency, plants can be classified in two categories. Strategy I which is typical of dicotyledonous and non-graminaceous monocotyledonous plants, characterised by an increase in ferric (Fe3+) reduction capacity, acidification of the rhizosphere, and the release of organic acid anions and phenolic compounds into the soil solution. Strategy II is confined to graminaceous plant species (cereals and grasses) and characterized by an enhanced release of non-proteinogenic amino acids called phytosiderophores (PS) of the mugineic acid family.

In this research barley (Hordeum vulgare L.), tomato (Lycopersicon esculentum L.) and white lupin (Lupinus albus L.) were grown hydroponically in an Fe free (–Fe) nutrient solution using a plant-based biotest (RHIZOtest). After the first symptoms of chlorosis in Fe-deficient (–Fe) planst, were put in close contact with two different calcareous agricultural soils and root exudates were extracted from the soils (1:5, w:v) after 6 days. For the duration of the experiment, other –Fe and +Fe plants were continued to grow hydroponically and root exudates were collected at the beginning and the end of the 6-day period. Root exudates were determined quali-quantitatively using HPLC (High-Performance Liquid Chromatography) and colorimetric analyses, in order to determine the presence of phytosiderophores, amino acids, organic acids and flavonoids. The efficiency of the mobilization and acquisition mechanisms were evaluated measuring the accumulation of nutrients in plant tissues via ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometry) measurements after total acid digestion. Soil mineral modifications were assessed by XRD (X-Ray Diffraction) and SEM-EDX (Scanning Electron Microscopy coupled to Energy Dispersive X-ray spectroscopy). XRD quantitative analyses were carried out by using the Rietveld method and a highly crystalline corundum was used as internal standard.

In general, root exudates obtained by the hydroponic system were higher than those obtained from the soil extracts; plant uptake and adsorption by soil particles could be, at least in part, responsible of this result. After a 6-day soil contact the plants show a visible recovery from Fe deficiency symptoms at leaf level suggesting the efficacy, in this experimental conditions, of root exudate release in the mobilization of Fe into soluble soil forms and its uptake. Moreover, significant soil mineral modifications were observed; as expected, root activity induced the solubilization of calcite (approx. 15-20%). Beside this, as also confirmed by experiments carried out with an artificial mixture of soil minerals, the formation of additional smectitic phases is likely to occur. At last, organic ligands released in Fe-deficient soil conditions show very complex exudation patterns both in monocotyledonous and dicotyledonous plants. For instance, barley plants besides the dominant release of PS (epi-hydroxymugineic acid) also significant amounts of amino acids (Arg, Thr, Ala, Val, Ile, Leu) and traces of organic acids (citric and fumaric acids) were found. The results of this research will enable to better understand the soil influence on the release of root exudates, the dynamics of mineral weathering in the rhizosphere and the capability of plant species to mobilize and take up poorly soluble Fe forms.

This research is supported by grants from Italian MIUR (FIRB-Programma “Futuro in Ricerca” and Free University of Bolzano - TN5056).

Keywords：*root exudates, iron, mobilization, soil minerals*

O10-4

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

The Mechanisms of High Al Tolerance in Rhodotorula Taiwanensis Rs1

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Aluminum (Al) ions are toxic to most of plants, animals and microorganisms. Some microorganisms can tolerate several hundred mM Al, being much higher than the Al concentrations at which plants can tolerate (generally micromole grade). Compared with the deep and extensive researches on Al toxicity in plants, the mechanisms underlying the high Al tolerance of microorganisms are far from known. Here, we reported one microorganism which was isolated from acid oil-tea soils, and it can grow up to 200 mM Al (aluminium sulfate) at pH 3.5. This Al-tolerant microorganism belonged to the species Rhodotorula taiwanensis and was named Rhodotorula taiwanensis RS1. Secretion of organic acids into the growth medium and increase of medium pH were not involved in its high Al tolerance of R. taiwanensis RS1. Its cell walls were thickened by addition of Al and 78% of total Al of whole cells was present in cell walls in the presence of 100 mM Al. Proteomic analysis showed that the abundance of isocitrate lyase and malate dehydrogenase was decreased and increased by addition of Al, respectively. Correspondingly, addition of Al increased malate dehydrogenase activity and the accumulation of intracellular citrate. These results suggested that R. taiwanensis RS1 might adopt two strategies to tolerate higher concentrations of Al: 1) block the entry of Al into cell through increasing the thickness of cell wall; 2) chelate Al ion within cell by forming non-phytotoxic complexes with intracellular organic acids especially citrate.

Keywords：*Acid soil, Aluminum toxicity, Cell wall, Organic acid, Proteomics*

O10-5

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Effect of Nitrogen Fertilization on Zinc and Iron Uptake and Yield Components of Wheat

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Effect of nitrogen fertilization on zinc and iron uptake and yield components of wheat

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Abstract:

This study was performed to assess the role of nitrogen (N) rate and application time in combination with zinc (Zn) and iron (Fe) supplement in soil and foliage at booting stage of wheat (Triticum aestivum var. Krabat) for augmentation of protein, Zn and Fe in grain. Eighty four (84) plastic pots of wheat containing 8 plants in each pot were grown in a climatically controlled growth room. The rates of N supply were 28.57, 42.86 and 57.14 mg N^{kg-1} soil, equivalent to 80, 120 and 160 kg N^{ha-1}, respectively and for Zn and Fe, the rate was 10 mg $^{kg-1}$ soil and additional 30% through foliar spray at the designated N treatments, a total of 21 treatments.

Grain and straw yield $^{pot-1}$, 1000 grains weight, number of grains $^{pot-1}$, whole grain protein content, concentration and total uptake of Zn and Fe in grains were determined . Analysis of variance demonstrated that N application interacted often with Zn and Fe treatments. A tendency of higher yield was seen when increasing N rate at sowing was applied but the tendency was reduced at higher dose (160 kg N^{ha-1} in this study). Relatively higher grain yield, protein content and the uptake of Zn and Fe in grain were obtained at split N equivalent to 160 kg N^{ha-1} (applying 70% of allocated N at sowing and 30% at stem elongation). But lower N rates at sowing resulted in reduced grain yield with higher concentrations of Zn and Fe in grain. At soil plus foliar supply of zinc sulfate (ZnSO4) and ferric ethylenediamine tetraacetic acid (Fe-EDTA) together enhanced grain protein content, concentration of Zn and Fe up to 46% and 64% and their total uptake in grain by 35% and 42%. For the localization of Zn and Fe in grain, LA-ICPMS and MA-XRF were used. Scanning of half grain along the crease pointed co-localization of Zn and Fe at germ, crease and aleurone. Split application of N with sufficient dose at sowing and stem elongation or beyond in combination with soil plus foliar application of Zn and Fe can be a good agricultural practice to enhance protein, Zn and Fe content in wheat.

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Keywords：*Foliar application, grain yield, nitrogen fertilization, Zn and Fe uptake, Nutrient localization,*

O11-1

[C1.5-1] Validation of Soil Carbon Sequestration

Spatial Stratification in Design-based Sampling for Soil Carbon Auditing

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One of the biggest problems of assigning carbon credits in soil is the expense of verification as we are dealing with the inherent variability of soil in the landscape. A design-based method for sampling is the most appropriate for estimating the total C storage in an area (farm). The efficiency (in terms of precision and cost) of a sampling pattern is mostly determined by the distribution of the sampling units in the space-time universe. Appropriate stratification and allocation of sample sizes will lead to higher accuracy and lower cost of estimation. Here we will first review various stratification strategies: equal area, stratification by ancillary variables, and stratification based on predicted carbon distribution. Equal-area stratification works best if no information on the farm is available. However in most situations ancillary variables will be available for the farm. Here we can recognise the readily (and cheaply) available information: digital elevation models and aerial photography or satellite imagery or land use information. In addition, carbon prediction maps from digital mapping approaches can also be used. Here we define an optimum method for stratification which takes into account geographical coordinates, model predictions and its variances.

Keywords：*sampling, geostatistics*

O11-2

[C1.5-1] Validation of Soil Carbon Sequestration

Soil Carbon Sequestration in the Carbon Richest Region in the Conterminous USA

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Florida soils store the largest amount of soil organic carbon (SOC) among the conterminous U.S. states (2.26 Pg) due to its unique edaphic, climatic, topographic and hydrological conditions. During the past decades Florida, located in the southeastern USA, experienced rapid land use and land cover (LULC) change which may have had great influence on the large SOC pool. However, there is a knowledge gap on how SOC dynamics changed concomitant to LULC shifts along a distinct climatic trajectory stretching across this large region (~ 150,000 km2). Our objectives were to: 1) investigate the relationships between LULC change and SOC stocks in Florida, and 2) track the SOC change and investigate how SOC gains and losses interact with LULC change across a climatic and pedo-ecological gradient in Florida. We harmonized the historical SOC observations (n = 1251) from 1965-1996 and new SOC observations (n = 1080) from 2008-2009, identified spatial and temporal sequences of LULC, and characterized space-time patterns of climate showing maximum annual temperature variations from 24.2 to 30.5 °C and mean annual precipitation from 1022 to 1761 mm (Year 1981 to 2010).

Results showed that SOC stocks significantly differed across LULC classes – sugarcane (25.91 kg m-2) and wetlands (5.67 ~ 9.55 kg m-2) contained the highest SOC stocks, followed by mesic upland forest (3.37 kg m-2), pineland (3.54 kg m-2), rangeland (3.15 kg m-2), improved pasture (3.89 kg m-2) and urban while crop (3.53 kg m-2), citrus (2.38 kg m-2) and xeric upland forest (1.76 kg m-2) remained the lowest. We observed that significant SOC accumulation occurred between 1965-1996 and 2008-2009 and that LULC and LULC change had a significant effect on SOC change. In most of the LULC classes SOC stocks increased, except in sugarcane and citrus. Marked SOC losses were found due to the conversions of wetlands to other LULC types and opposing trends with profound SOC gains after wetland restoration. Urban soils contained moderately high SOC stocks and conversions of crop, pineland and barren land to other land uses resulted in significant SOC accumulation. The SOC sequestration rate was not only LULC dependent but also controlled by climatic factors interacting with LULC. Surprisingly, warm conditions tended to accelerate SOC accumulation, while high precipitation rates reduced the SOC sequestration rate.

Our findings provide insights into how LULC and its change have impacted SOC change over the past four decades, and have significance for SOC change under the influence of global climate change projected into the future. Our findings also underpin the importance to better understand cross-interactions between LULC, climate and SOC. This understanding is critical to assess the impact and vulnerability of soil carbon to act as a source or sink in one of the most carbon rich landscapes in North America that is expected to undergo major change under projected climate scenarios in the future.

Keywords：*Soil Carbon Sequestration , Land Use Change, Climate Change, Wetlands*

O11-3

[C1.5-1] Validation of Soil Carbon Sequestration

Quantification and Mapping of Vertical Soil Organic Carbon Distribution as a Function of Land Use and Soil Form, with a View to Carbon Accounting

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A study catchment was selected in the Midlands area of KwaZulu-Natal, South Africa, for the development of a decision-support system to optimize land use and decision making for ecosystem services provision. The project is part of the Green Landscapes approach towards development of South African agriculture and forestry within the Green Economy paradigm promoted by the South African government. Quantification and mapping of soil organic carbon (SOC) stocks is regarded as one of the pillars of this approach to promote sustainable soil management through conservation agriculture and environmentally-sensitive forestry practices.

One of the main challenges in soil organic carbon assessment and mapping is the lack of reliable and detailed information for modelling the vertical distribution of SOC stocks, as well as the absence of formal rules for spatial distribution of this property. In addition, SOC may be strongly dependent on soil stratification into horizons defined within soil classification, both at different landscape positions and under different land uses. The overall aim of this study was to quantify the vertical distribution of SOC in different catenary positions under different land uses to formulate rules for automated mapping based on point observations. The digital soil mapping (DSM) and extrapolation rules were refined using the soil survey report of the area conducted at 1:100 000 scale as well as the 1:10 000 forest soils spatial database provided by Mondi Forests (which contains both point and polygon layers).

The vertical SOC distribution sampled at short intervals and formalized as distribution curves was linked to soil classification polygons. The approach included the use of intensive soil sampling in conjunction with the spatial analysis of auxiliary variables such as terrain, geology and land use

The selected catchment is 317 km2 in extent with altitudes ranging from 950-1540 m. The average annual rainfall varies from 800 mm/annum at the bottom to 1600 mm/annum at the top of the catchment (according to on-site records kept by farmers and foresters in the area during the past 5 years). Complex topography is determined by frequent occurrences of dolerite (diabase) dykes, which pierce Karoo system shale, often forming isolated hills within the general incline of the Drakensberg escarpment. Agricultural land

uses are limited to maize and (to a smaller extent) sugarcane production, while forestry is represented by pine and eucalyptus plantations along with residual wattle stands in the process of conversion to eucalyptus stands.

A 20-m digital elevation model (DEM) was disaggregated into geomorphic units using e-Cognition software, with the broad topographic unit rules defined from the Land Type Survey data, maps and Memoirs (1:250 000 scale) available for the whole of South Africa. The Land Type dataset contained only 14 soil profiles in the selected catchment and additional soil profiles were needed to expand this data. The selection of 50 additional soil profiles and sampling locations was done by overlaying a geological map of the same scale (1:250 000) within the selected elevation class, expanded by 100 m above sea level on both upper and lower boundaries. Various interpolation techniques were tested and interpolated maps were compared to the existing map polygons. The 50 soil profiles were excavated up to 1m depth where possible, for soil classification and sampling at different soil depths. Approximately 400 core samples (5 cm depth) were collected in triplicate per soil depth (totalling about 1 200 samples), which included 5, 10, 15, 20, 30, 40, 50, 75 and 100cm depths for bulk density and SOC determination. In order to develop vertical distribution curves for SOC stocks, different analysis methods were applied to reduce the uncertainty in SOC pool distribution. Total SOC content was determined using the Walkley-Black and dry combustion methods, as well as near-infrared and mid-infrared spectroscopy. Density fractionation of soil organic matter was done on selected vertical soil profiles representing five land uses and two soil forms, with SOC subsequently determined using dry combustion.

Vertical SOC distribution was clearly affected by land use, with an increase in uncertainty of predicted vertical SOC content observed with an increase in soil disturbance (i.e. higher soil disturbance under crop production compared to forestry). DSM rules for spatial quantification of SOC stocks were defined and verified in the field using catenary sequences observed under different land uses.

Keywords：*Soil organic carbon, digital soil mapping, vertical SOC distribution, land use*

O11-4

[C1.5-1] Validation of Soil Carbon Sequestration

Soil Organic Carbon Stocks under Pasture Atlantic Forest in Rio de Janeiro State, Brazil

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The replacement of forest for other uses causes important changes in the soil carbon stock and also in the global cycling of this element. The objective of this study is to perform a comparative analysis of the soil carbon stock under pasture (Brachiaria spp) and semideciduous broadleaf Atlantic Forest fragments. The studies areas are located in two different municipalities in the state of Rio de Janeiro in southeast Brazil. The first study area is located in the municipality of São José de Ubá (21º 21' 27' S - 41º 56' 33' W) in the Northwestern of Rio de Janeiro state in the which has a hot and humid tropical climate and clearly defined seasons (Aw in the Kopen classification) in Chromic LIXISOLS. The second study area is located in the Trajano de Moraes (22º03'48'S - 42º03'59'W) in mountain regions in the which has dry subtropical climate humid with dry winters and rainy summers (Cwa in the Kopen classification) in Haplic FERRALSOLS. Data collection was carried out in January 2011 in the rainy summer season in Sao Jose de Uba area and in July 2011 in the winter dry season in the Trajano de Moraes area. Were selected contiguous and physiographical representative areas under forest and pasture. For this study in each area a number of three transects with 50 m each one were demarcated, situated at upper, middle and backslope from slope. In each transect three small trench around 1.0 m depth, 15 m distant from each other, with a total of the nine small trench in each area to quantify the carbon stock were opened. At small trench samples at depths of 0-10, 10-20, 20-30, 30-50 and 50-100 cm were collected, and carried out chemical analysis, particle size and density in order to quantify carbon stock in soils. Evaluating in terms of volume of soil (Mg ha-1) and correcting the levels of carbon in the variations detected in soil density for different depths, we observed a significant difference in carbon stock with the highest values for pasture. In Sao Jose de Uba area, the soil carbon stock is 70.8 Mg ha-1 under forest and 83.2 Mg ha-1 under pasture. In Trajano de Moraes area the soil carbon stock is 99.10 Mg ha-1 under forest and 132.83 Mg ha-1 under pasture. Despite environmental differences and the time of sampling in both areas the soil carbon stock under pasture was higher than under forests. The differences observed between the results of carbon stock in forest and pasture could be related to a number of factors, including the type of natural vegetation and its successional stage, characteristics and intrinsic and extrinsic variations among soil environments, the type forage plants, time and sampling protocol. The data analysis also showed the importance of topossequence studies, since the soil attributes usually vary depending on position on the slope, and the carbon stock is no exception, reducing their value in the direction of shoulder to footslope in the both areas. It was observed that for the conditions of this study, the assessment of carbon stocks only in backslope is an economic information and technically viable, allowing the reduction of sampling density without significant damage to the quality of information.

Keywords：*Land use soil, carbon stock, topossequence*

O11-5

[C1.5-1] Validation of Soil Carbon Sequestration

Soil Carbon and Nutrient Status of Soils under Secondary Forest Transformations in Leyte Island, Philippines

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Secondary forests are an important component of land cover in the tropics, and when transformed or converted into another land use, it is believed to have negative effects on some soil properties and the forest ecosystem in general. A paired-area/space-for-time substitution approach was conducted to determine the changes in soil organic carbon (SOC) stocks, total aboveground biomass (TAGB), and soil nutrient status of the soil due to land use change. The study was conducted in Silago, Southern Leyte and in Lake Danao, Ormoc City, Leyte. Adjacent to a secondary forest (< 1 km away) grassland and forest plantation land uses were chosen and sampled for possible changes in soil carbon and nutrient status due to land use change. Soil physical and chemical properties were characterized to assess changes brought by secondary forest transformation.

Conversion of forest to grassland and then to forest plantation decreased the organic carbon, exchangeable aluminum, exchangeable acidity, CECeff, TAGB while pH in H2O, exchangeable magnesium and CECpot increased when forest was converted to grassland and forest plantation in both sites. Meanwhile, in Silago, SOC stocks and total N increased while available P, base saturation, Ca, K, and Na decreased. In Ormoc, available P, base saturation, Ca, K, and Na increased while total N, and SOC stocks decreased when forest was converted to grassland and forest plantation. Results indicate that depending on soil types conversion of forest to grassland and to forest plantation could greatly affect the SOC stocks, TAGB, and soil nutrient status. However, contrary to common knowledge, improvement of some soil properties could also be observed. The study revealed that changes in soil properties were largely dependent on soil type and land use.

Keywords：*Carbon sequestratio, Carbon, Land use change, Land Conversion, Soil Carbon,*

O12-1

[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Colloid Formation and Transport along Hillslopes Modifies Erosion and Ridge - Valley Spacing in Post-orogenic Landscapes

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The spacing of ridges and valleys is controlled by physical erosion in tectonically active landscapes. In tectonically quiescent (i.e. post-orogenic) landscapes such as those on continental cratons, erosion is much slower, hence, soil residence times are much longer. In post-orogenic environments chemical erosion (weathering) can far exceed physical erosion, which allows colloid production and redistribution to produce feedbacks that determine: (i) the fate of soil properties along catenas, (ii) the length of hillslopes, and (iii) the spacing of hillcrests and valleys. Here we evaluate colloidal production and redistribution along a climate gradient of catenas in a granitic landscape in Kruger National Park in South Africa. Hillcrests are underlain by coarse-grained soils that are a long-term source of colloids, which are then deposited further downslope in a band that parallels contour. The clay-rich depositional zone in mid-slope to toe-slope positions slows through-soil water flow forcing it to the surface where it runs overland to the stream. The back-up of interflow creating seasonal reducing conditions at the end of the wet summer season followed by oxidizing conditions as the soils dry during the extended dry winter season. The location of colloid accumulation along the slope is determined by the amount of rainfall available to drive downslope colloid accumulation - more water moves colloids further downslope. Furthermore, 10Be measurements demonstrate that with increasing rainfall chemical erosion as a fraction of total erosion increases which means that a larger part of the hillcrests are leached and more colloid mass accumulates in the lower parts of the catena. A corollary is that water forced to the surface as it encounters the colloid-rich zone leads to a disproportionate amount of physical erosion occurring in the lower parts of the landscape, hence relief is being generated over time. Although weathering and redistribution of weathering products occur in all landscapes, it is in slowly eroding landscapes that we can clearly identify the role of pedogenic colloids in shaping Earth's surface.

O12-2

[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Hierarchy of Two Drivers of Soil Organic Matter Biodegradation: Microbial Habitat Properties Versus Microbial Communities

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Soil microbial communities live in a complex three-dimensional framework in which a range of microbial niches with a variety of properties exists. The importance of these habitat properties relative to the intrinsic properties of microbial communities in the regulation of SOM decomposition and so CO2 emissions is still unclear. Some studies suggest that abiotic processes dominate SOM decomposition, mainly through physical mechanisms (i.e. occlusion within aggregates, adsorption onto minerals) that limit the access decomposers have to organic substrates. Microbial habitat properties are therefore likely to profoundly affect microbial decomposition of SOM. In contrast, others studies have concluded that soil microbial communities acting as catalysts of biogeochemical cycles by converting organic material to inorganic substances play a dominant role in SOM decomposition. Most studies on the relationship between microbial diversity and SOM decomposition indicate that the lack of relationship between the two is due to a certain functional redundancy in microbial communities. However, the experiments on which this conclusion is based may always contain the same dominant microbial species and the same dominant active species.

In order to work with different soil microbial communities, we chose six contrasting soils from the same region (Ile-de-France, France), and under the same climatic conditions. These soils varied in texture, pH, OM status and we verified that microbial communities contained different dominant species (PLFA and T-RFLP). The effects linked to microbial habitat properties were uncoupled from those linked to microbial communities by sterilisation with gamma radiation and cross inoculation of the soils, resulting in 36 treatments (6 soils x 6 communities). An incubation study was established during which C mineralisation was measured and the degradation capacities and the structure of the microbial communities were analysed. The cumulative respiration curves were fitted with two-compartment first-order model, and the parameters were analysed to determine what affected the CO2 emissions. Microbial habitat was the dominant determinant of SOC decomposition and of microbial community structure. Nevertheless, the mineralisation rate of the native pool (β parameter) as well as the metabolic capacities were affected by the structure of the microbial communities.

Keywords：*Microbial habitat, Microbial communities, Cross-inoculations, Soil organic matter decomposition, Soil organic matter dynamics*

O12-3

[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Shedding Light on Soil Organic Matter-mineral Associations: Their Role in Carbon Cycling and Sequestration in the Terrestrial Environment

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Organic-mineral associations have been increasing recognized as key processes in the long-term stabilization of soil organic matter against microbial decomposition. Advances in understanding soil organic-mineral interactions requires non-invasive high-resolution imaging techniques that are able to disentangle the complex interactions between inorganic mineral surfaces, organic compounds, and biological organisms occurring in submicron geochemical environments. In a series of recent experiments, we have applied spatially resolved STXM-NEXAFS spectroscopy at the C 1s, N 1s, Ca 2p, Fe 2p, Al 1s and Si 1s edges to map micro- and nano-C distribution, and conduct submicron-level investigations of the compositional chemistry and the interactive features of C, metals and specific soil minerals in soils of diverse mineralogy and under different land use. Bulk techniques, including C and N NEXAFS, Fe K-edge EXAFS spectroscopy and XRD have been applied to provide additional insights. The findings in terms of carbon cycling and sequestration will be emphasized.

O12-4

[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Mercury and Sulfur Cycling in a Peatland Soil Warming and Carbon Dioxide Enhancement Study: Sulfur Speciation at Time-zero

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Mercury emitted to the atmosphere is deposited to the land at locations distant from the source. In terrestrial ecosystems such as peatlands, mercury converts to methyl-mercury through processes dependent on physical, geochemical, and biological conditions. The speciation and microbial processing of sulfur are major factors in mercury speciation and transport. Projected changes in climate for the north-central U.S.A. have the potential to stimulate the release of mercury to receiving water bodies. In the present research, the goal is to quantify how climate factors, primarily temperature and moisture, affect mercury biogeochemistry in peatland systems through co-cycling with sulfur. These processes are being examined in a 10 year study of enhanced soil temperature and atmospheric carbon dioxide at the Marcell Experimental Forest, U.S.A. Results from the time-zero field work for the "Spruce and Peatland Responses Under Climate and Environmental Change" or SPRUCE project will be discussed. Challenges with and insights from micro-probe and bulk sulfur 1s X-ray absorption near edge structure (XANES) spectra will be highlighted.

Keywords：*peatland, climate change, sulfur, mercury, XANES*

O12-5

[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

The Effect of Microbial Diversity on Soil Organic Carbon Mineralisation Highlighted by a ^{13}C-Labelling Technique

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Soil organic matter (SOM) represents the main pool of carbon within the biosphere, estimated at roughly twice that in atmospheric CO_2. In agrosystems, organic amendments are common to maintain soil C stocks. However, recent studies have revealed that these practices can lead to a priming effect, corresponding to enhanced release of CO_2 into the atmosphere, due to over-mineralisation of soil organic carbon. Therefore, appropriate decisions regarding organic input management require better understanding of the biogeochemical cycles related to SOM dynamics. As soil microorganisms are major actors in SOM turnover, their diversity is likely to influence SOM dynamics. In this context, the relationship between microbial diversity and SOM turnover should be characterised more precisely.

Three levels of soil microbial diversity (D1>D2>D3) were obtained by serial dilutions of a cropland soil suspension. Gamma-ray sterilised soil microcosms were subsequently inoculated with the three levels of microbial diversity to investigate the consequences of the erosion of microbial diversity. Wheat residues labelled at more than 95% with ^{13}C were incorporated into microcosms. Decomposition of these labelled residues and of indigenous organic matter was assessed during a 60 day-incubation experiment. The enrichment in ^{13}C was measured in CO_2 fluxes, pressurised hot-water extractable organic carbon (PH-WEOC) and soil organic matter (SOM) to obtain information about the mineralised, soluble and stable organic matter pools, respectively. During this study, we observed no difference in quality and quantity of PH-WEOC for the three levels of microbial diversity in the control experiment, when fresh organic matter (FOM) was not added into soils. In contrast, the input of ^{13}C-labelled FOM resulted in changes in the quality and amount of PH-WEOC in the amended microcosms, revealing the influence of microbial diversity on the labile organic matter pool. We observed that the evolution of ^{13}C enrichment in the PH-WEOC pool was synchronous with the priming effect mechanism. This finding highlights the close connection between this labile pool of C and the biodegradation of C in soils leading to mineralisation. Results also showed that the intensity of soil respiration as well as of the priming-effect induced by the addition of plant residues was strongly linked to microbial diversity, with the highest CO_2 production measured when microbial diversity was greatest. These results illustrate the importance of considering microbial diversity as a predictive variable for organic carbon storage/release in soils. The ^{13}C-labelling technique is suggested as a suitable technique for monitoring both the incorporation of FOM into labile and stable soil organic matter compartments, and the amount of carbon mineralised from FOM ($^{13}CO_2$) and SOM ($^{12}CO_2$). Lastly, this study clearly shows that the ^{13}C-labelling technique is highly relevant for priming effect prevision and quantification.

Keywords: *Microbial diversity, Priming effect, CO_2, Water soluble organic matter, ^{13}C tracer experiment*

O12-6

[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Fe/Al Oxides Can Act as Natural Anti-acidification Agents in Variable Charge Soils

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Variable-charge soils, such as Oxisols and Ultisols, are distributed widely in the tropical and subtropical regions around the world and represent an advanced stage of weathering. Thus, the usual mineral colloids in the clay fraction of these soils are kaolinite and sesquioxides, such as gibbsite, goethite and hematite. Kaolinite is a dual-charge soil mineral and carries a net negative charge above pH 4.0; while sesquioxides carry a net positive surface charge under acid conditions. Coexisting of oppositely charged particles in these highly weathered soils induces a different pattern of soil chemical behavior compared to a homogeneously charged colloidal system. Intensive leaching induces variable-charge soils to acidify naturally. The traditional acidification principle has assumed that highly weathered soils are characterized by low concentrations of exchangeable Na+, K+, Ca2+ and Mg2+, low ionic strength and relatively large contents of Fe and Al oxides. Subsequently, these soils should have a high degree of saturation of exchangeable acidity and thus become strongly acidic. However, a wide survey indicated that higher contents of free Fe oxides led to lower soil acidity of the variable-charge soils in south China. Some highly weathered and extensively leached soils showed weak acidity. The soils with different CEC and free Fe2O3 content were electro-dialyzed to simulate the natural acidification process and to induce them to reach their ultimate acidification state. Results indicated that soil pH was positively correlated with the free Fe2O3 content, and the exchangeable acidity and acid saturation of the soils were negatively correlated with free Fe2O3 content, which suggested that soils with higher contents of free Fe2O3 displayed weaker acidity in their ultimate acidification state. Therefore, the presence of free Fe2O3 inhibited natural acidification of variable-charge soils to some extent, which cannot be explained by the traditional acidification principle. Further study indicated that Fe oxides could inhibit the acidification of kaolinite and Alfisol subsoil mainly through charge neutralization when the soil or kaolinite was simply mixed with Fe oxides during electrodialysis. The charge neutralization occurred through overlapping of diffuse layers of the electric double-layers on negatively charged mineral particles and positively charged Fe oxides. Al oxides, when mixed with kaolinite or soil and then subjected to electrodialysis, could also decrease the corresponding effective negative charge and acidity through the overlapping of electric double-layers between oppositely charged colloidal particles as well as physically blocking on the phyllosilicates. Coated Fe/Al oxide could also decrease effective negative charge and inhibit acidification of kaolinite and Alfisol subsoil mainly through both mechanisms: diffuse double-layer overlapping between oppositely charged particles and physical blocking of kaolinite and Alfisol subsoil during electrodialysis. Therefore, Fe and Al oxides can act as anti-acidification agents in variable-charge soils. However, the traditional acidification theory did not involve the interaction between oppositely charged particles and its effect on the charge properties and soil acidity. Therefore, it cannot explain the phenomenon of soil acidification in variable charge soils. The mechanism of Fe/Al oxides in inhibiting natural acidification of variable charge soils through interaction of electric double layers and coating may offer an important supplement to the traditional theory of natural acidification of soils.

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Keywords：*Overlapping of electric double layers, physical blocking, Oppositely charged particles, Natural acidification, Variable charged soils*

O13-1

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Fertilisation with Pig Slurry Affects the Pore Size Distribution of Soils

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In Mediterranean climates any agricultural strategy that improves soil physical properties and increases its water-holding capacity, is positive to the crop yield. Soil structure is one of the most important soil physical properties, and the complexity and heterogeneity of the void space affects the physical quality of soils. Therefore evaluating porosity characteristics is important for the assessment of fluid transport through the soil profile, soil aeration, habitat availability for micro fauna and microorganisms and the aptitude for root growth. Applying pig slurry at appropriate agronomic rates is a way for the valorisation of livestock residues through the soil. Although it has been proved that this type of animal residue improves soil aggregate stability, the effects on the soil physical quality are still under discussion. The aims of this study are to analyze pore size distribution in order to draw relevant conclusions about the effect of the different fertilization strategies in the pore network. In Oliola, (Catalonia, NE Iberian Peninsula), seven pig slurry based fertilization strategies were tested. The experimental fields have been cropped with rotating rainfed winter cereals in a silty loam soil (Typic Xerofluvent, Fluvisol) since 2002. All these fields were maintained with conventional tillage and fertilized with different doses and sources of nitrogen (inorganic nitrogen, fattening pig or sows slurry). Furthermore the fertilization was applied at different moments (sowing or side-dressing). Undisturbed soil samples, from 0 to 6 cm depth, were taken on 2011 February 23th (three months after sowing and one year after last side-dressing fertilization). They were processed to obtain digital binary images from which the total porosity was statistically analysed. The surface horizons of eight treatments were sampled by triplicate in each plot, with 3 replications (blocks) per treatment (72 samples) for micromorphology. They were impregnated with polyester resin with a fluorescent dye (Uvitex ©). From each soil sample, a thin section 5 x 13 cm was obtained, and images 42 x 31.5 mm were taken from each field in three light conditions: parallel polarisers, crossed polarisers and incident UV light. Each image set was used to perform a pore-size distribution analysis based on an "opening" algorithm of mathematical morphology using the Quantim4 library (Vogel, 2008). The areas occupied by poroids at the following intervals (values in micrometers): <25, 25-35, 35-50, 50-65, 65-100, 100-200, 200-400 were obtained, and also to distinguish between microporosity (< 65) from the macroporosity interval 65-200 μm. Total perimeter was obtained for each image with ImageJ (Rasband 2008). The porosity data for each interval was transformed (X½) in order to normalize the original dataset. It was analysed with the GLM procedure using the SAS statistical package. Comparisons of means were done according to the Duncan's multiple range test. The results show that recent slurry application (3 months before sampling) at sowing increases microporosity (0-65 μm) when compared with mineral fertilizer and control (no nitrogen) plots, although these differences disappeared when slurry was applied one year before sampling. Total porosity significantly increased ($p<0.01$) up to 10% with respect to the control in the treatments with the highest slurry rates. As microporosity is associated to soil water holding capacity, pig slurry introduction in fertilisation strategies benefits porosity and water holding capacity. This fact is very important in dryland agricultural systems where water availability is a limiting factor.

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Keywords：*soil porosity, image analyses, organic amendments*

O13-2

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

The Use of Pb Labelling and Sem to Investigate Organic Matter in Thai Soil Microaggregates

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We studied soil organic carbon (SOC) concentrations for depths of 0-5 cm and 5-20 cm in soils under perennial (durian and rubber) and annual (maize, sugarcane and cassava) crop conditions. The study sites were located in the Southeast Coast and Northeast Plateau regions of Thailand. Soils under durian and rubber perennial agriculture conditions had the highest SOC concentrations that largely resided in microaggregates (2.20-3.92%). These microaggregates were stained with lead citrate solution which becomes attached to soil organic matter. Pb concentrations were determined via electron image and element X-ray mapping using a scanning electron microscope (SEM). Pb was much less strongly adsorbed by other soil constituents because Pb has a very high affinity for most functional groups in organic matter including carboxylic and phenolic groups. This novel application of scanning electron microscopy to map Pb-labelled organic matter in soils has helped to provide an understanding of microaggregate formation and stability in highly weathered soils and the effects of various types of land use on the carbon concentration in microaggregates.

Keywords：*soil organic carbon, Pb-labelled organic matter, microaggregate, scanning electron microscopy, land use*

O13-3

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Interactions between Soil Structure and Soil Organic Matter: Contribution of Pedofauna Activity

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Soil fauna plays an important role in the interaction between soil structure and soil organic matter. Burrowing and excretion activities induce new pore formation and stabilization of pre-existing ones modifying soil functioning also in its role of carbon pool. In this study we aimed to identify and quantify the contribution of different soil organisms on soil structure using soil image analysis techniques at soil micromorphology scale

Undisturbed soil sampling and soil micro- and macro-fauna identification were performed in sites characterized by different soil management and soil types in Valle Telesina, Benevento, Italy.

Different biological features (faecal pellets, organic residues, channels and chambers, etc.) have been identified by means of soil thin sections observation and their contribution to the soil pore and aggregate size distribution was quantified by means of image analysis procedures based on mathematical morphology.

The results of this preliminary study have allowed to observe that the combination of different biological activities in the same soil produce a pronounced multimodality in pore size distribution, and then an increase of the complexity and of the quality of soil structure. Moreover different organisms induce specific signals on soil pore size distribution, providing data useful to simulate the contribution of different biological activities in fluid and solute transport.

Keywords：*Soil structure, Pedofauna, Soil micromorphology, Soil image analysis*

O13-4

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Ectomycorrhizal Fungi in Association with Pinus Sylvestris Seedlings Promote Soil Aggregation and Soil Water Repellency

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Ectomycorrhizal fungi are ubiquitous and thought to be as important as arbuscular mycorrhizal fungi and saprotrophic fungi in contributing to soil structure, but there are seldom experimental studies on this topic. We quantified how nine ectomycorrhizal fungi inoculated into Pinus sylvestris seedlings affect soil aggregation and soil water repellency of a sandy loamy soil. Water-stable aggregates (>0.25 mm diameter) increased for L. bicolor, L. laccata, L. theiogalus, P. involutus and S. bovinus by 6 - 12 %. Mean weight diameter (MWD) also increased, primarily in the 2-4 mm diameter size class. However, S. granulatus increased water-stable aggregates but not MWD, conversely R. roseolus and S. luteus increased MWD but not water-stable aggregates. We also found L. theiogalus, R. roseolus and S. luteus promoted soil water repellency. Furthermore, hyphal length was weakly correlated to MWD ($R=0.27$, $P<0.05$), especially aggregate mass in the 2-4 mm size class ($R = 0.32$, $P<0.05$). However, we could not identify clear soil factors (soil pH, soil protein content) controlling either soil aggregation or soil water repellency. Thus, we conclude that interactions between fungi and soil structure are a species-dependent process based on fungal traits.

Keywords：*Soil aggregation, Soil water repellency, Ectomycorrhizal fungi, Hyphae, Pinus sylvestris*

O13-5

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Soil Aggregate Formation and Stability Induced by Starch and Cellulose

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Soil aggregate (SA) structure has fundamental functions in terrestrial ecosystem. Carbon (C) sequestration through storing as soil organic matter (SOM) within its structure is one of the major functions due to C dynamics between soil and atmosphere. The SOM is a parimary source of energy for the soil-organisms. According to the Monnier's model of SA structural formation and stability, decomposability of the SOM is one of the factors controlling SA structural formation and strength. Easily decomposable agents with low CN ratios have strong but transient effects on SA stability, while more recalcitrant binding agents with high C/N ratio may have weak but persistent effects. However, since the recalcitrant agents still contain some easily degradable substances, the relationships between the dynamics of SA and SOM with different decomposability need to be well clarified. Therefore, in this study, two different polysaccharides (starch and cellulose), of which molecular weights and structure are known, were used to investigate the effects of the organic matters of different decomposition rates on the soil aggregate formation and stability over time.

In this study, a tropical and sandy loam soil collected from southern Okinawa in Japan (26° 14′ N, 127° 73′E) was used. Fifty grams of the soil sieved through 2 mm sieve was pre-incubated to stabilize the soil microbial activity in a 125 mL plastic bottle for 11 d at 30℃. Pure water was applied to the bottle to maintain 50% of the maximum water holding capacity of the soil. After the pre-incubation, 0.5% (w/w) of starch or cellulose dissolved in distilled water was amended to the soil. The decomposition rates of the polysaccharides applied were estimated by measuring soil microbial respiration as the total amount of CO_2 from the soil, trapped by the NaOH solution over 42 d after the polysaccharide addition. The size distribution of water-stable soil aggregates was determined during the incubation by measuring soil weights passing through different mesh sieve sizes (<20, 100, 250, 500, 1000, and >2000 μm) after mechanical shaking in distilled water at 30 cycles min^{-1} for 5 min. The soil aggregate stability was expressed as the mean weight diameter (MWD) based on the proportion of soil weights in each size fraction.

The initial slopes of cumulative soil respiration rates with starch and cellulose addition until Day 6 were 23.1 and 7.1 mg CO_2 kg^{-1} soil day^{-1}, respectively. The slope was significantly different, indicating that starch was decomposed by soil microbes more quickly than cellulose was.

The fractions of the primary particles (PP: <20 μm diameter) and the meso-aggregates (MeA: 250-1000 μm) formed in the soils with both amendments significantly decreased from the size fraction before the amendment addition until Day 6, whereas the fractions of the macro-aggregates (MaA: >1000 μm) formed in the soils with both amendments significantly increased. These changes in the fractions of different aggregate sizes may indicate that the MaA were formed by binding the PP and MeA when both polysaccharides were applied to soil. After 18 d of incubation, the MaA fractions in the soils with both amendments significantly decreased, which may indicate the destruction of SA structure may have occurred.

The MWDs with both amendments significantly increased until Day 6, especially more in the soil with starch than cellulose, but on Day 18, became relatively equivalent with the MWD before the polysaccharide addition. The result may indicate that the soil with more easily decomposable substance may form SA more quickly than more recalcitrant substance, which coincided with the Monnier's model. However, the model did not support the result with more persistent agent such as cellulose forming SA with higher stability. Nevertheless, differences of SA stability induced by the polysaccharides with different decomposition rates may have been observed between 6 and 18 d of incubation.

The different decomposition rates of the polysaccharides may influence the soil aggregation differently as well as destruction rates, but not the SA stability.

Keywords：*Soil Aggregate, Soil Organic Carbon, Carbon Sequestration, Polysaccharides, Decomposition Rate, Soil Respiration*

O14-1

[IDS12] Development of Agricultural Technology and Contribution for World Food Welfare

The Critical Role of Soils in Preserving and Enhancing a Sustainable World

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In 1936, U.S. President Franklin D. Roosevelt signed an act to conserve the “natural resources of the land” and commented, “The history of every Nation is eventually written in the way in which it cares for its soil”. This quote could never be more relevant than now when we are facing major environmental challenges such as climate change, water quality and quantity, food security, land degradation, and contamination of air, soils, and water. Soils, and the discipline of soil science, play pivotal roles in all of these, and we as soil scientists must be leaders in helping to address these challenges. Our involvement is critical in preserving and enhancing environmental and agricultural sustainability. The world’s population is growing at a rapid rate, currently 7 billion with an increase to 9.5 billion by 2050. Such growth will necessitate increased food production, at a time when climate change, and accompanying severe weather events such as flooding, drought, and higher temperatures, is occurring at unprecedented rates. Additionally, the amount of land suitable for food production is shrinking. In 1900 there were 7.91 ha per person; by 2050 this will decrease to 1.44 ha per person. This presentation will discuss the paramount role that soils, and we as soil scientists, play in mitigating climate change, enhancing food security and food production, addressing land degradation and enhancing global sustainability.

Keywords : Sustainable world, natural resources, food, soil

O14-2

[IDS12] Development of AgriculturalTechnology andContribution forWorld Food Welfare

Earth Observation for Monitoring Agriculture: FAO's Global Information and Early Warning System (GIEWS)

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The Global Information and Early Warning System (GIEWS) of FAO monitors food supply and demand conditions for all countries in the world on a continuous basis and provides timely warnings of imminent food shortages, droughts, and hunger at individual country or sub-regional level. As part of its activities, the System collects and archives information from many different sources. It makes use of GIS and remote sensing technologies to identify regions experiencing unfavourable crop growing conditions and food supply shortfalls and to determine food insecure areas and/or populations. From 1988 GIEWS begun to operationally utilise low-resolution satellite remote sensing data to monitor vegetation and rainfall development over large areas in near real-time through the FAO Advanced Real Time Environmental Monitoring Information System (ARTEMIS). In particular, GIEWS made extensive use of the ARTEMIS near real-time satellite images such as the METEOSAT-derived Cold Cloud Duration (CCD) imagery providing a proxy for rainfall over Africa, and Normalised Difference Vegetation Index (NDVI) images for all countries, effectively providing GIEWS with important information on possible drought, crop growing and rangeland conditions. Initially, the focus of the ARTEMIS was on Africa. However, the range of products available through the ARTEMIS did increase drawing primarily upon new NDVI products derived from the VEGETATION Instrument aboard the SPOT-4 and 5 satellites including imagery at a 1 km resolution covering the entire landmass of the globe.

In 2013, FAO GIEWS and the Climate, Energy and Tenure Division (NRC) have developed an "Agricultural Stress Index System" (ASIS) for detecting agricultural areas with a high likelihood of water stress (drought) on a global scale using remote sensing data with the technical assistance and advice from the Flemish Institute for Technological Research (VITO-TAP); the Monitoring Agricultural Resources (MARS) unit of the Joint Research Centre (JRC) of EC; and the University of Twente. Data from NOAA-AVHRR and METOP-AVHRR (normalized difference vegetation index and brightness temperature) are used to calculate the per-pixel VHI on a global scale, averaged over the growing season. A phenological model, based on NDVI, is developed and employed to define the start and end of the growing season. Next, the averaged VHI over the growing season is aggregated over each administrative unit so the drought intensity can be assessed on a regional basis. The resulting data flow will provide timely and direct information on drought stress in all agricultural areas of the world. ASIS assesses the severity (intensity, duration and spatial extent) of the agricultural drought and indicates the final results at administrative level giving the possibility to compare it with the agricultural statistics of the country. Currently the ASIS database contains 30 years of agricultural hot spots data and information, starting from 1984.

From the global version of ASIS designed for detecting agricultural hot spots on the globe, standalone versions are to be developed for monitoring the agricultural drought at country or regional level. The standalone version would be calibrated with local agricultural statistics and it would run using specific parameters, coefficients and mask of the main crops of the country or region. This version could also be used for pasture monitoring and for other risk management activities such as crop insurance

Key Words: Early Warning, Drought and Crop Monitoring and Assessment, NOAA-AVHRR, METOP-AVHRR, vegetation health index, agricultural drought stress, phenology SPOTVEGETATION, NDVI, CCD

O14-3

[IDS12] Development of AgriculturalTechnology andContribution forWorld Food Welfare

The Role of Soil Scientists in Addressing Global Issues of the Anthropocene and Climate Strategic Agroecosystems

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Whereas the drastic impact of humans on transforming the Earth accelerated with the onset of the Industrial Revolution around circa 1750, human-induced gaseous emissions and global warming started millennia ago with the dawn of settled agriculture. Notable transformations during the anthropocene include: (i) conversion of natural to managed ecosystems and the attendant deforestation and biomass burning, (ii) depletion of the terrestrial carbon (C) pool and the emission of greenhouse gases and soot into the atmosphere, (iii) soil degradation by accelerated erosion (water and wind), salinization, structural degradation and depletion of nutrients and soil organic C stock, (iv) water contamination and non-point source pollution, (v) reduction in biodiversity, and (vi) decline in soil functions and services. Advances in agricultural technology during the second half of the 20th century, with drastic improvements in crop yield by biofortification to improve plant nutrition and use of irrigation along with improved varieties, hav been the driving force towards increase in human population estimated at 7.3 billion in 2014 and projected to be 9.5 billion by 2050 and 11 billion in 2100. However, sustainable intensification , producing more from less by minimizing losses and optimizing use efficiency of inherent and applied resources, is essential to protect native ecosystems and restore agriculturally marginal and degraded soils. In addition to recarbonization of the biosphere and restoration of degraded/contaminated soils to bridge the yield gap while improving the environment, it is also necessary to plan beyond “sustainable intensification” and identify innovative strategies (e.g ., the nexus approach) it is necessary for soil scientist to be pro active in protecting soil resources by working with policy makers and the public at large. The goal to promote adoption of numeerous innovations including urban farming, soil-less culture, recycling the grey water, using nano-enhanced chemicals, adopting soil-specific or precision farming and making soils a net sink for atmospheric C. It is prudent to invest in climate-strategic scientific innovations even with distant rewards for replacing the carbon civilization by low-carbon or no-carbon fuel sources. Sequestration of C in degraded soils, despite being cost-effective and with numerous co-benefits, is not sufficient to off-set anthropogenic emissions already estimated at 11-12 Pg C/yr. Nonetheless, the goal is to restore functions and services of soils already appropriated for agriculture and other uses through restoring soil C to above the threshold level and preserve those under natural ecosystems for nature conservancy and a range of ecosystem services. In addition to agriculture, soil scientists must also take a lead role in other global issues including space exploration, archaeology, oceanic and coastal processes, human nutrition ,urban planning , energy production and management, and governance of soils and natural resources.

Keywords : Anthropocene, climate change, agroecosystem, soil

O14-4

[IDS12] Development of AgriculturalTechnology andContribution forWorld Food Welfare

Strategy of Land Utilization for Environmentally Sustainable Agriculture

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Land and soil have four important ecological and cultural functions:
- the production of biomass (food, fibre and renewable energy)
- filtering, buffering and transformation between the atmosphere and the rock parent material, protecting the water resources and the food chain against contamination,
- sustaining biodiversity as the basis of all biological processes in terrestrial ecosystems, including land and soil,
- forming a cultural and natural heritage of great importance for the understanding of the history of human cultures and the environment.

Based on these four functions of land and soil, environmentally sustainable agriculture is providing goods and services for the increasing world population, not only targeting at food security but also at the protection of landscapes and of ground and surface water resources, at sustaining biodiversity, and at controlling climate relevant trace gases.

For reaching these goals any sustainable agricultural management must be based on the local ecological site conditions. However, the quality of land and soil resources is very differently distributed, not only at the local but also at the regional and global level.

A look at the global land and soil quality for sustainable agricultural production reveals that only 12% of the land surface is suitable for sustainable crop production, 24% can be used for grazing, 31% produce forests and 33% are unsuitable for any kind of sustainable use.

Distinguishing between 9 different land quality classes reveals further that the best class covers only 2.4%, and the next two quality classes 9.5%, altogether about 12% of the land surface on which about 25% of the world population produces all traded agricultural commodities, without considering agricultural subsistence farming. Two thirds of the best land quality classes are located in the northern hemisphere.

In view of the daily substantial losses of these most productive land surfaces through urbanisation, industrialisation, erosion and further adverse impacts, the future strategy of land utilization for environmentally sustainable agriculture must aim at “sustainable intensification” which means to produce more with less adverse inputs on the constantly decreasing land resources, by selecting soils with high resilience against adverse environmental impacts, e.g. through agricultural management, which have at the same time the best agricultural performance for producing enough biomass for satisfying the needs of a growing world population, maintaining at the same time the environmental services, which guarantee clean ground and surface water, biodiversity and the control of climate relevant trace gas emissions.

It will be shown that this can be reached by defining land and soil quality parameters for “sustainable intensification” of agriculture, based on topography, soil characteristics and climate.

Summarising it can be stated, that we dispose today of sufficient knowledge for defining strategies of land utilisation for environmentally sustainable agriculture at the local, regional and global level.

Keywords : Land utilization strategy, land and soil functions, environmentally sustainable agriculture, land quality, sustainable intensification

O14-5

[IDS12] Development of AgriculturalTechnology andContribution forWorld Food Welfare

Development and Utilization of Indicators to Manage Soil and Environmental Resources

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The framework of soil quality assessment has been proposed to evaluate the effects of varied soil use and soil managements on the soil environments in an integrated way. This approach can also be used to monitor the time trend of soil quality in certain soil-plant system. In last two decades, the concepts and the utilization of soil quality assessment has become an important issue and has been increasingly studied. In this abstract, we shared the constructive concepts and the methods of soil quality assessment and also illustrated the development and utilization of indicators for different soil managements or soil use decisions in several case studies in Asian and other countries.

Soil quality can be chiefly defined as the capacity of a soil to function. Therefore, to identify the soil functions those were highly related to the objectives of a soil quality assessment would be the first step. The most important objective to date was to develop the management strategies for sustainable agriculture which can be simply illustrated as the safe and economic production in a way that protects the natural environment resources and human health. Of these concern, soil functions can be identified such as crop productivity, water retention and availability, carbon source and sink, biodiversity maintenance, and soil-water conservation. Several soil properties or indicators can reflect the changes of selected soil functions. These soil properties are therefore chosen as a minimum data set (MDS) of soil quality indicators (SQIs). Each indicator can be monitored for the evaluation of soil quality alternation. According to this constructive concept, physical, chemical and biological indicators have been developed and mainly include soil organic carbon (SOC), soil structure, bulk density, soil pH, soil EC, available water content (AWC), available nutrient, aggregate stability, earthworm population, and microbial biomass carbon/nitrogen for general rural soils.

In the previous studies, the most interdisciplinary indicator may be SOC content or C stocks. SOC has a crucial effect on global carbon storage and also soil carbon sequestration rate can impact the global climate change and food security. In Indonesia and Korea, soil carbon has been monitored in last decades and the inference was brought out that long term rice cropping can sequester carbon in soils due to the increase of above- and below-ground biomass caused by fertilization. This also indicates that soil management effect on SOC sequestration may override the effect of increase in soil temperature due to warming climate. In Yangmingshan (YMS) National Park of northern Taiwan, we collected the soil C data from recently soil pedons and previous studies on volcanic origin soils. Our results indicate that SOC stock was not significant different between soil order (Andisols and Inceptisols with andic soil properties). Meanwhile, SOC stocks under silver grass and bamboo were significantly higher than those under secondary forests. Additionally, statistically significant linear regressions were found between the mean SOC stock and the mean of elevation classes. Climate, vegetation types and soil mineralogy varied along the elevation gradients in the complex terrain ecosystem.

The mobility of potential contaminants was also used recently as an indicator to reflect the soil function of conservation. The Arsenic (As) content of soil pore water was used as an indicator to evaluate soil water management for decreasing the As risk of

brown rice grown in different soils contaminated by As. We found that aerobic treatment inhibited the As mobility and could alter As content and change As species of brown rice. To increase the organic As ratio of total As in brown rice, aerobic after flowering was recommended. Rice would possibly accumulated cadmium (Cd) from Cd-contaminated soils, but the Cd uptake was quite different among different rice varieties and different soil characters. Various Cd uptake models were developed to efficiently predict the Cd accumulation when it was grown in the Cd-contaminated soils with different Cd extraction methods and soil characteristics. Two models were introduced which can predict the Cd concentration of brown rice and indicate the bioavailable extraction of Cd and Zn might be good indicators for safe production of rice grown in Cd-enriched soils. The regulation or indicators of As, Cd, Pb, and Hg are more concerned for food safety of crops grown in high potential contamination sites of the Asian countries.

For the health risk assessment, soil indicators can be illustrated by standard scoring functions (SSFs). Furthermore, a simple integrated value of soil quality index (SQI) can be derived from a SQI model which is calculated by weighted summation of the SSF scores of MDS indicators. We evaluated the indicators and the SQIs for reasonable and max-consumptive application of hog manure compost from 1997 to 2001. Since the manures or composts are generally contain high amount of Cu and Zn, the soil bioavailability of Cu and Zn was also included in the MDS for evaluation of soil quality, especially for long term application. Both of soil quality index and crop yield significantly increased at the application rate of composts up to 60 tons per ha per year. The framework of soil quality assessment is an useful tool to evaluate the effects of different soil managements on the soil resource relating to sustainable agriculture and environment conservation. The development and verification of indicators need to be continuously investigated.

Keywords : Soil, environment, resource, indicator

O14-6

[IDS12] Development of AgriculturalTechnology andContribution forWorld Food Welfare

Strategies to Prevent Soil from Pollution and Degradation

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With the world population increasing to greater than nine billion humans by 2050, there is an acute need to preserve, protect, and reclaim scarce soil resources. Soils across the world face eminent threats from a number of different stressors, including non-point and point source pollution, erosion, improper management strategies, expanding development, and climate change-related processes. A detailed understanding of the impacts of pollution on soil biogeochemical processes is required to develop management strategies to protect soil from pollution, mitigate damage to threatened soils, and reclaim degraded soils.

This talk seeks to provide a review of the biogeochemistry of soil systems that have been affected by pollution and how the function of these systems is affected. Soil serves as a critical nexus that partially regulates the global flow of biologically substances, such as water, nitrogen, and carbon. However, as such, soil is also a sensitive environment that can be impacted by pollutants, such as anthropogenic chemicals and potentially toxic metals. For example, contamination from metal ions can not only affect the composition of different soil components, but it can also disrupt the complicated web of interactions between biota, minerals, solutes, and organic matter. In some instances, management and remediation of soils may provide mechanisms by which to mitigate impairment of soil biogeochemical processes and strategies for improving soil function. As has been the case with subsurface remediation, future development of novel approaches for pollution mitigation and land reclamation may be driven by advances in our understanding of biogeochemical processes.

Keywords : Soil, pollution, degradation

O14-7

[IDS12] Development of AgriculturalTechnology andContribution forWorld Food Welfare

Reinforcing Agro-Material Industries to Maintain Soil Fertility and Crop Production

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In Japan, paddy fields account for 54% of the total arable land, making the fertility of paddy soil important for the country's food production. Recently, it was reported that the nitrogen (N) and silicon (Si) fertilities of paddy soil were decreasing. These decreases in fertility can be avoided by the application of appropriate materials so that the agro-material industry can play a key role in maintaining soil fertility. This paper introduces examples of agro-material production made from waste products of agricultural activities, which can reinforce agro-material industries and improve soil fertility.

A large quantity of waste is generated from livestock farming, which causes environmental problems in some areas. It is well known that application of compost made from livestock wastes is effective to improve the N fertility of paddy soil. However, the compost is not applied to most paddy fields, often because of the variability of its N efficiency. Recently, promising technologies promoting the use of chicken manure compost in paddy fields were developed by Murakami (2011). Available N in chicken manure compost was positively correlated with the content of uric acid and chicken manure produced from "windowless houses" had a higher uric acid content compared with those produced from other types of chicken houses. Chicken manure compost made in closed vertical fermenters also had a higher uric acid content than those from open stirred fermenters. Thus, procedures for making chicken manure compost with a high N availability were identified. The suitable moisture content for keeping this compost was also clarified and techniques for applying this compost to rice plants were also established. Because this compost can be used in a manner similar to chemical fertilizer but at smaller expense, it is a positive development for paddy rice farmers and agro-material producers, such as livestock farmers.

Silicon is one of the most important elements for rice plants and the application of Si materials to paddy field is recommended. Rice hull, a by-product from rice milling, has a high Si content and could be a potential Si material for paddy soil. However, the effect of rice hull application on Si uptake by rice plants is not significant so it has not been regarded as a beneficial Si material for paddy fields. Most rice farmers dispose of the rice hulls. Ito et al. (2004) developed a technology to make rice hull an effective Si source for rice plants. The availability of Si in rice hull became higher when it was processed by low-temperature combustion. The research group elucidated some properties of this low-temperature combusted rice hull which might be related to high Si availability and an incinerator for combusting rice hulls at a suitable temperature has been developed. This technology has converted a waste from rice production into a beneficial agro-material for paddy rice fields. Thus research and development into changing agro-wastes into beneficial agro-materials will reinforce the agro-material industry and maintain soil fertility.

Keywords : agro-waste, compost, fertility, paddy soil, rice hull

O14-8

[IDS12] Development of AgriculturalTechnology andContribution forWorld Food Welfare

Management of Soil and Nutrients Considering Soil Spatial Variation

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Future global population growth coupled with the growing demand for bioenergy will stress agricultural production to meet the escalating food and fiber demand. Because land availability for agricultural production is declining, obtaining higher yields is anticipated to result from intensification (producing more crops per seasonal cycle) practices that could potentially strain our critical soil resources.

To maintain agricultural productivity, fertilizer usage and agricultural management practices will be fundamental tools to ensure soil fertility and minimize secondary environmental impacts. Over the coming decades, fertilizer institutes and world food associations have predicted that fertilizer usage will increase significantly in attempting to meet the escalating productivity demands. Therefore, adopting agricultural management practices to obtain sustainable yields, will require balancing of soil nutrient inputs and outputs. It is apparent that different production systems will contribute to diverse forms of nutrient balances. For example, soil nutrient levels in many developing countries are being depleting due to cropping practices, low fertilizer and manure replacement rates. Consequently, depletion of nutrient levels in these soils is projected to be a serious threat for sustainable crop production.

On the other hand, in developed countries, agricultural production typically utilizes higher external inputs with inorganic fertilizer and/or animal manures. Over-application of inorganic fertilizers and manures coupled with rapid mineralization and off-field losses is a concern because of water quality impairment and other environmental consequences. Moreover, agricultural land quality can vary considerably across landscapes due to spatial differences in their pedogenic (i.e., organic matter content, texture, etc.) and geologic (i.e., parent material, mineralogy, etc.) characteristics. Thus, soil heterogeneity will confound our ability to manage soils in agricultural systems.

Clearly, nutrient management decisions need to account for soil spatial variability, and not solely uniform nutrient applications. This will require different approaches to restore fertility balances as well as maintain land and water quality. Moreover, nutrient management programs need to be developed at different scales (i.e., field, watershed, , etc.) to account for spatial heterogeneity and socio-economic differences. This presentation will: i) investigate the spatial variability in soil resources across landscapes, ii) examine how geo-positioning and spatial statistics can uncover critical geospatial relationships, iii) to discuss input and output management parameters for determining soil nutrient balances, and iv) to discuss future management options for maintaining sustainable soil fertility levels.

Keywords：Soil, nutrient, spatial variation

O14-9

[IDS12] Development of AgriculturalTechnology andContribution forWorld Food Welfare

Utilization of Korean Soil Information System - Heulg-To-Ram for Research-Extension-Network in Agriculture

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With the establishment of the Rural Development Administration (RDA) in 1962, the Korean agricultural scientists recognized the importance of soil survey and soil fertility improvement for food self-sufficiency. RDA secured the United Nation Aid in 1964 and has started a pivotal role in sharing vision and building capacity of researchers, extension advisors and farmers through the completion of the country's soil survey and fertility evaluation. RDA had operated demonstration plots all over the country utilizing the system to renovate rural agricultural landscape linked to Saemaeul Movement - the new community movement. The Korean people finally accomplished rice self-sufficiency in 1976 with new rice variety and soil fertility management, and felt self-confidence to get over any difficulty after that.

Notably, Korea had been through the severe financial crisis, such as the IMF crisis in 1997 wherein, the Korean government developed a variety of public enterprises to overcome the crisis. RDA performed a project on digitizing soil maps based on Korean soil survey data (1:5,000) and soil testing data from public works, consolidated in one web-based soil information service system called the Heulg-To-Ram in Korea. The web service system retains practical and useful soil and nutrients information that includes fertilization recommendation based on soil physico-chemical properties, land suitability, and irrigation guidelines for crops.

In 2010s, RDA launched AFACI and KAFACI as research arms with KOPIA as extension arm for sharing agricultural technologies with Asian and African member-countries. NAAS has also begun a project on management of soil fertility and water with the AFACI member countries. The Heulg-To-Ram system of RDA could be one of the good examples of decision-support information system which can be used for the research-extension-network and thus, will play a key role in providing Korean technical assistance to developing countries.

AFACI : Asian Food and Agriculture Cooperation Initiative

KAFACI : Korea-Africa Food and Agriculture Cooperation Initiative

KOPIA: Korea Project on International Agriculture

Keywords：Korean Soil Information System, Research-Extension-Network, Technology Transfer

O15-1

[C4.1-2] Environmental Management of Post-Epidemic Carcass Burial Sites

Disinfection Effects of Calcium Oxide (cao) on Pathogenic Microorganisms in Leachate from Infected Livestock Carcass Burial Sites

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Calcium oxide (CaO) as a disinfectant for the burial of infected animals has been extensively used to disinfect pathogenic microorganisms or viruses by inducing high temperature and pH.However, Calcium oxide is also known to inhibit and delay the biological decomposition of livestock carcass. In this study, two lysimeters(physical model simulating livestock burial site) were constructed to compare the effects of calcium oxide on decomposition of buried animal carcass. Six 100 kg-pigs were buried in lysimeter 1 (unit-1) with the addition of calcium oxide. Lysimeter 2 (unit-2) has the same condition with unit-1 except calcium oxide. The leachate was collected from the bottom of the lysimeters every two weeks. The experimental results for the biological monitoring showed there was insignificant difference between unit-1 and unit-2 for the concentrations of pathogenic microorganisms (salmonella, shigella, clostridium, campylobacter), sometimes unit-1 even higher than unit-2. The averages of pH during the monitoring period were 6.92±0.30 and 6.39±0.41 for unit-1 and unit-2, respectively. The reason for insignificant disinfection effect of calcium oxide is not clear, but $Ca(OH)_2$ transformed from the reaction of CaO and H_2O was expected to make more favourable pH condition for microorganisms in unit-1 than unit-2. As a result, the addition of CaO inlivestock carcass burial sites has the positive effects of decreases in contaminants concentrations and leachate volume produced, but insignificant disinfection of pathogenic microorganisms or viruses.

Keywords：*Animal burial site, leachate, calcium oxide, disinfection*

O15-2

[C4.1-2] Environmental Management of Post-Epidemic Carcass Burial Sites

Determining Leaching Possibility of Carcass Leachate in Groundwater

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Foot and mouth disease (FMD) and Avian influenza (AI) was widely spread in Korea at 2011 causing over 4,700 carcass burial sites around in nation. With this circumstance, concerns have increased for the groundwater contamination due to leachate from carcass burial sites. The main objective of this research was to determine leaching possibility of carcass leachate in groundwater with various chemical characteristics. Observation well in carcass burial sites and groundwater in agricultural field were compared for evaluating feasibility of chemical analysis to determine leaching possibility of carcass leachate. Concentration of ammonium nitrogen (NH4-N), chloride (Cl-), nitrate nitrogen (NO3-N), ninhydrin reactive nitrogen (NRN), and veterinary antibiotics (VAs) was analyzed. Result showed that concentration of ammonium nitrogen, chloride and NRN was high in observation well (59.8 - 61.5 mg/L for NH4-N, 179.0 - 181.7 mg/L for Cl-, and 47.0 - 52.2 mg/L for NRN) compared to groundwater (0.7 - 1.1 mg/L for NH4-N, 3.5 - 53.8 mg/L for Cl-, and 0.0 - 0.1 mg/L for NRN). Meanwhile, concentration of nitrate nitrogen was higher in groundwater (7.9 - 128.8 mg/L) than observation well in carcass burial sites (0.1 - 0.5 mg/L). For VAs concentration, higher concentration of sulfamethoxazole (SMX) in groundwater (2.80 μg/L) than observation well (0.07 μg/L) while higher concentration of chlortetracycline (CTC) and sulfathiazole (STZ) in observation well (3.40 μg/L for CTC and 3.59 μg/L for STZ) than groundwater (0.82 μg/L for CTC and 0.27 μg/L for STZ). Based on these result, selected chemical characteristics can be used to determine leaching possibility of leachate from carcass burial sites. Also, in-situ chemical analysis method, NRN, can be utilized to screen groundwater contamination. In conclusion, problems of carcass burial sites need to be resolved and especially, groundwater contamination from carcass burial sites should be prevented.

Keywords：*Carcass, Leachate, Groundwater, Ninhydrin reactive nitrogen, Veterinary antibiotics*

O15-3

[C4.1-2] Environmental Management of Post-Epidemic Carcass Burial Sites

Invasive Plant-derived Biochar Inhibits Sulfamethazine Uptake by Lettuce in Soil

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Veterinary antibiotics are frequently detected in soils posing potential contamination of food crops. This is the first study reporting the effects of biochar on veterinary antibiotic uptake by crop plants. Sulfamethazine (SMT) uptake was investigated by lettuce (Lactuca sativa L.) in the soils treated with/without biochar derived from an invasive plant, burcucumber (Sicyos angulatus L.) (BBC). Lettuces were grown in the soils contaminated with SMT at 5 and 50 mg/kg, and treated with/without 5% BBC (w/w). The lettuces were harvested after 30 days of cultivation and were analyzed for SMT by high performance liquid chromatography-tandem mass spectrometry after solid-phase extraction. With 5% BBC, the uptake of SMT was reduced by 86% in the soil spiked with 5 mg/kg SMT compared to the control whereas a 63% reduction was observed in the soil spiked with 50 mg/kg SMT. Application of BBC in soils can reduce the SMT uptake by lettuce. This work is supported by the Korea Ministry of Environment, as a Geo-Advanced Innovative Action Project (G112-00056-0004-0).

Keywords：*sulfonamides, black carbon, charcoal, pharmaceuticals, availability, soil amendment*

O15-4

[C4.1-2] Environmental Management of Post-Epidemic Carcass Burial Sites

Application of Woody Tree based Phytoremediation Technique to Remove N and P from Soil: Implication for Cleaning up the Livestock Burial Sites

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Contaminated plume containing a wide range of contaminants such as N and P originated from the livestock burial sites can be released into nearby soil and water body. Therefore, remediation technique is required to be applied at livestock burial sites for hindering contamination nearby environment. One of the possible techniques is phytoremediation. The current study was carried out to examine removal efficiency of two different woody plants including poplar and willow for plume, N, and P from soil. The experiment was conducted with pot trials. Sixty litter pots were filled with 40 kg soil followed by transplanting a year old seedlings for each plant. Then three different experimental treatments were applied by irrigating three different liquids as contaminated or non-contaminated plumes. These included full strength of liquid fertilizer, 1/2 strength of liquid fertilizer, and tap water. Liquid fertilizer was made of pig manure by aeration for 40 days. The prepared liquids were supplied to the pot soil from the bottom and daily based-decreases in volume of the liquids were monitored to estimate the plume removal rate by the woody plants. Removal rate for N and P by plants were estimated by subtracting the contents of N and P in soil at the end of experiment from the added amount of N and P through liquid fertilizers. The initial N and P contents in soils were considered for this calculation. All the experiments were conducted with four replications for six months.

Plume removal amount which was estimated by the decreased volume of irrigation liquids was 2.9 L day^{1} pot^{1} for both poplar and willow. Removal efficiency for N and P supplied through irrigation liquids was around 80% indicating the poplar and willow can effectively consume N and P originated from the contaminated plumes. The effective N and P removal rate by woody plants were supported well by the changes in N and P concentration in soil pore waters. For instance, decline of N concentration by 0.3～2.3 mg L^{1} in soil pore water was observed with plantation, while the concentration of N in soil pore water was elevated without plant as liquid fertilizers were supplied.

Keywords：*contamination, nitrogen, phosphorus, phytoremediation*

O15-5

[C4.1-2] Environmental Management of Post-Epidemic Carcass Burial Sites

Characteristics of Some Technosols Developed on Oil Refinery Waste Materials

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Technosols are newly introduced reference group of soils in world reference base for soils. There are not enough articles on their characteristics, classification and interpretation for different uses or managements. Some Technosols developed on oil refinery waste materials were described, sampled and analyzed for physicochemical and micromorphological properties. The obtained results showed that the polluted soils have got specific and different characteristics such as low pH, high organic matter in comparison with the unpolluted adjacent soils.

Technosols are modified soils affected by human activities with noticeable artifacts (manufactured or extracted materials from the earth by human), constructed geomembranes (impermeable layers) or technic hard rocks. These soils may result from wastes (sludge, cinders, mine spoils, landfills and ashes), pavements with their underlying unconsolidated materials, soils with geomembranes and soils constructed in human- made materials. Thus, cities, roads, mines, refuse dumps, oil spills and deposits and the like were considered as Technosols (FAO, 2006). The aims of this study are to characterize physicochemical properties and genesis of oil waste polluted Technosols around the refinery of Tehran.

The studied area (about 60 ha) is located on south of Tehran (between latitudes of: 35°30.299' to 35°30.814' N and longitudes of: 51°25.682' to 51°26.296' E) (Fig 1). Six pedons, including four Technosols developed on oil refinery waste materials (pedons no. 1, 3, 4, 6) and two reference pedons for comparison (pedons no. 2 and 5) were fully described and sampled. Totally 30 disturbed samples were prepared from the studied soil horizons. Soil moisture and temperature regimes were aridic and thermic accordingly. Regarding the diagnostic surface and subsurface horizons and aridic-thermic soil moisture and temperature regimes, the studied soils were classified as Gypsids (USDA, 2010). However, due to their parent materials that are comprising manufactured oil compounds and presence of an impermeable geomembrane in polluted pedons, they classified as Technosols in WRB system. The surface horizons of unpolluted soils were contained less than 2 percent organic matter with regular decrease by depth. While, in polluted soils, due to the added oil refinery wastes, soil organic matter in some horizons was very high (up to 12 percent). pH values were decreased by increasing organic matter (oil waste compounds) due to H+ dissociation from the petroleum compounds (Laurent et al., 2012). Electrical conductivity of polluted samples was lesser than unpolluted ones. Mineralogical studied showed that clay minerals such as smectite are capable to absorb oil compounds in their interlayer space and preserve from decomposition or mobility in soil. Micromorphological studies showed that oil compounds, due to their heavy molecule weights and high viscosities may form different micromorphological features in soil. Lower viscose compounds which easily penetrate into deeper soil layers, move soluble matters from soil matrix and the edges of aggregates and leave behind specific depletion zones. More viscose oil compounds may penetrate and stopped in some depths beneath the soil surface and soil pores. The results of these processes are hypo and quasicoatings alongside of pore walls inside soil matrix.

This study demonstrated that entrance of oil waste materials plays major role in soil formation and have left specific effects on physicochemical (soil texture, pH, organic carbon) and micromorphological characteristics. Mineralogical suit of soils is an important factor in holding and of oil compounds as surface and interlayer fixer.

O16-1

[C2.3-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Denitrifying Microbial Community in Agricultural Soil: Key Players involved in N_2O Generation and Elimination

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Agricultural field is a major source of nitrous oxide (N_2O) emission, one of greenhouse gases and ozone depleting substances. N_2O emission from agricultural field is mostly derived from microbial transformation of nitrogen contained in fertilizers applied to soil. N_2O emission is observed as a balance of its generation and elimination in soil. Information on the N_2O generating and eliminating soil microorganisms is essential to mitigate the N_2O emission from agricultural fields.

Rice is cultivated on 80% of Japanese arable land area. Among various types of agricultural fields, rice paddy fields are known to have low N_2O emission rates. This feature is likely related to the high levels of denitrification in flooded soil, during which nitrates and nitrites are completely reduced to N_2. However, the microbial populations responsible for the N_2-generating denitrification in rice paddy soils have not been well characterized. We used multiple approaches, stable isotope probing, nitrite reductase gene analysis, metagenomic analysis and a novel single-cell isolation procedure, to identify the key players in denitrification in rice paddy soil.

Based on the culture-independent analyses, bacteria in the orders Burkholderiales and Rhodocyclales were identified as the key players in denitrification in rice paddy soil in Nishi-Tokyo city under both laboratory and field conditions. In addition, Herbaspirillum and Azospirillum were identified as active N_2O reducers in the soil. We also performed a metagenomic analysis on Niigata rice paddy field soil. Among nearly two million reads generated by 454 GS-FLX, nosZ reads were selected. Most of them were homologous to those of Anaeromyxobacter, known as N_2O-reducing Deltaproteobactera. Anaeromyxobacter might be another important N_2O reducer in rice paddy soil.

Isolation of these key denitrifiers is important to examine the physiology of denitrification in these bacteria. We therefore developed a novel isolation procedure, a functional single-cell (FSC) isolation method, in which individual bacterial cells in soil responding to denitrification inductive condition were captured by micro-manipulator and cultivated. Diverse group of nitrate-reducing denitrifiers were isolated by the FSC method. Community composition of denitrifying populations was different among three soils at different locations in Japan. Strains capable of reducing N_2O to N_2, mostly Herbaspirillum, were also isolated by FSC method from Nishi-Tokyo soil.

In contrast to rice paddy field, N_2O emission from upland field soil is large. We observed large emission of N_2O after basal and supplement application of granular organic fertilizer in Niigata upland field soil. Antibiotics and acetylene inhibition studies revealed that bacterial (basal application) and fungal (supplement application) denitrification is largely responsible for the N_2O emission, whereas contribution of nitrification is small. Actually, significant fungal growth around granular organic fertilizer was visible several days after the surface application, when N_2O emission was active. By combination of culture-dependent and independent analysis, we successfully identified several fungal species responsible for the N_2O emission.
Our findings may lead to the establishment of microbial technology for N_2O mitigation from agricultural field soils.
This study was supported by BRAIN, eDNA project, JSPS and IFO.

Keywords：*N_2O emission, agricultutal soil, denitrification, soil microorganisms*

O16-2

[C2.3-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Biological N_2 Fixation and its Main Contributor in a Flooded Rice-soil System by a Novel Air-tight $^{15}N_2$ Incubation Technique under Natural Sunshine for 70D

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Abstract: Free-living biological N_2 fixation is an important process to provide N nutrient for terrestrial and ocean ecosystems. Rice field is a typical hot spot to fix N_2biologically,

but the direct evidence of N_2 fixation and the proportional contribution of heterotrophic and phototrophic N_2 fixation and its main contributor are difficult to assess. Here we report on the development and application of a novel field-based $^{15}N_2$ labelling technique in which a flooded rice-soil system was exposed to a $^{15}N_2$-enriched atmosphere to assess the biological nitrogen fixation (BNF) in paddy fields and $^{15}N_2$-DNA-stable isotope probing (SIP) to study active microbes to fix N_2. In this experiment, we were mainly concerned with rice planting and light effects on BNF. There were four treatments: no rice, with light on soil surface; no rice, without light on soil surface; rice, with light on soil surface; and rice, without light on soil surface. One month old rice seedlings (Oryza sativa L.) were transplanted to non N fertilized pots of flooded soil and exposed to a $^{15}N_2$-enriched atmosphere (approx. 7 atom% ^{15}N) in a gas-tight growth chamber for 70 days.

Results showed that the highest ^{15}N-enrichment 3.7551 atom% was observed in blue green algae in unplanted pots. After 70 days incubation, 49% of the total ^{15}N fixed in flooded rice-soil system was found in the plants, while 51% was found in the flooded soil. Rice planting enhanced both phototrophic and heterotrophic BNF and increased the proportion of heterotrophic BNF to phototrophic BNF from 0.50 in treatment without rice to 0.99 in treatment with rice.

Clear differences were observed in diazotrophic communities during the $^{15}N_2$-DNA-SIP study that a major proportion of $^{15}N_2$-fixers were affiliated with filamentous thermophilic cyanobacteria and geneus Aoarcus in rice-growing surface soils while the genera Geobacter and Desulfovibrio were dorminant in uncultivated soils. The main differences in diazotrophic community structure were related to light deprivation rather than rice-growing, and no significant differences in nifH gene abundance among treatments.

The findings suggested that rice benefit greatly from BNF processes and in turn rice growing can enhance both phototrophic and heterotrophic BNF significantly, and a major improvement for quantification of BNF and active diazotrophs exploration in flooded rice fields based on field $^{15}N_2$ labelling technique.

Keywords：*Rice; biological nitrogen fixation; ^{15}N labelling; heterotrophic; phototrophic; SIP*

O16-3

[C2.3-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Resource driven Community Dynamics of Assimilatory Archaeal Denitrifiers in Temperate Paddy Soils

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The involvement of archaea in soil nitrogen (N) cycling (i.e., immobilization, denitrification) of temperate paddy rice ecosystems is currently poorly understood. The central objective of this study was to unravel the effect of simultaneous application of rice straw and inorganic N under submergence conditions on N immobilizing archaea as regulators of their nitrous oxide (N2O) mitigation potential in a temperate paddy soil. Therefore, a typical paddy rice soil was incubated for 60 days under flooded conditions and treated with or without the addition of rice straw as well as with enriched (99 atom% 15N) and non-enriched (controls) (NH4)2SO4. Soil samples were obtained at defined time intervals and subjected to geochemical, stable isotope and molecular fingerprinting analyses to assess the response of active N cycling archaea involved in N immobilization (i.e., gdhA gene) and denitrification (i.e., archaeal arc-nosZ gene, prokaryotic nosZ gene). A higher abundance and distinct alteration of the community structure of nosZ, but particularly the arc-nosZ gene was determined in the no straw compared to the straw treatment. This finding was attributed to a promoted N immobilization as justified by the increased abundance and 15N-enrichment of active gdhA genes. Accordingly, the high abundance of both studied N2O reduction genes explained further the absent N2O emission rates in the no straw treatment. Our results showed that denitrifying archaea were able not only to switch their metabolism between different inorganic and organic N and C reosources, but also to immobilize fertilizer derived N under nutrient limitation conditions in flooded rice soils. Hence, this study demonstrated that N immobilization, as regulated by available mineral N and various C sources, was a critical precursor pathway of archaeal denitrification, highlighting their important role in mitigating N2O emission in temperate paddy soils.

Keywords：*archaea, arc-nosZ gene, gdhA gene, N immobilization, 15N-DNA-stable isotope probing*

O16-4

[C2.3-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Ureolytic Microbial Community Composition in Maryland Soils: a Missing Link in Understanding Landscape-scale Nitrogen Movement to Surface Waters?

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Urea is present in surface waters as a result of both natural and anthropogenic processes. In recent years, researchers in the Mid-Atlantic region of the USA studying the Chesapeake Bay estuary have measured unnaturally high levels of urea in regions of the Bay downstream from agricultural watersheds. These high concentrations have immediately preceded blooms of harmful algae, including dinoflagellates such as Alexandrium spp. that produce a toxin that poisons shellfish and causes paralytic shellfish poisoning. Studies of marine ecosystems in California, Florida, and the East China Sea have reported similar findings. Agricultural fertilizer may be the source of urea to these surface waters. However, numerous studies on the hydrolysis of urea in agricultural soils have shown that urea does not persist long enough to leach into surface waters. There is, therefore, a paradox in the published information on urea: urea appears to hydrolyze too quickly in agricultural soils to leach to surface waters, but concentrations of urea high enough to cause algal blooms are being measured in surface waters near fertilized fields.

Urease catalyzes the hydrolysis of urea to ammonium, and the enzyme exists both within cells and as a stabilized extracellular enzyme sorbed to soil colloids. Soil organisms that produce urease include plants, fungi, bacteria, and archaea. There are disagreements in the literature about optimum pH, temperature, and water content of the soil for urease activity. Some of this contrasting information may be a result of testing soils with inherently different microbial communities. Urease specific activity ranges from 14.5-180,000 μmol urea/min per mg enzyme. Little is known about the effects of microbial community diversity on this wide range of urea hydrolysis in soils.

The objective of this research is to determine how differences in pH affect urea hydrolysis in soils across a toposequence, and how landscape position and associated soil properties correlate with changes in the microbial community composition. Soils were sampled along a transect on the Coastal Plain physiographic province of Maryland that consisted of three points: an active agricultural field, within the grassed field border of that field, and in the riparian zone adjacent to surface waters. The soils were Typic Hapludults and Typic Endoaquults, and samples were taken in both the A and B horizons at each transect point. Subsamples of each soil were then equilibrated with HCl and $CaCO_3$ to achieve a range of pH values between 3.5 and 7.2. Triplicate soil samples at each pH were mixed with a urea solution, and the disappearance of urea was measured over a period of 48-96 hours, depending upon the treatment, to determine a rate of hydrolysis at each site. Soil samples were frozen at three time points to preserve the microbial community for genomic analyses: the day of field sampling, after equilibration to achieve different pH, and at the end of the urea incubation. Frozen soils were subsequently analyzed to characterize the microbial community by quantifying the presence of four genes: 16S rRNA to determine total bacteria, 16S rRNA to determine total archaea, the intergenic spacer region (ITS) between ribosomal subunits to determine total fungi, and ureC to determine bacterial urease gene quantity. Results from the urea hydrolysis rate study showed that pH explained 86-94% of the variability in the rate of change in urea hydrolysis in both A and B horizon soils. The change in urea hydrolysis rate with pH was affected by landscape position in both the A ($p = 0.062$) and B ($p = 0.056$) horizon soils. There was a significant correlation between the rate of urea hydrolysis and total bacterial urease gene copy numbers: the r^2 was 0.79 in the A horizon soil and 0.67 in the B horizon soil. Additional data will be presented on the bacterial:archaeal:fungal ratio and the total number of urease genes. In addition, we will present soil chemical data including extractable metals and available nutrients that help explain measured changes in urea hydrolysis and microbial community composition at different pHs and landscape positions. Knowledge of the soil chemical conditions affecting the ureolytic microbial community and rates of urea hydrolysis will improve our understanding of how modifications to agricultural best management practices and fertilizer timing or placement may reduce urea leaching from agricultural fields to surface waters.

Keywords：*urea, urease, enzyme, nitrogen*

O16-5

[C2.3-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Dna Metabarcoding of Fungal Populations in Restored Colliery Spoil Soils

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Fungi have an important role to play in ecological function and biochemical cycles in soils. We have used a novel high throughput (NextGen; Ion Torrent PGM) DNA sequencing system to assess differences in fungal populations on diverse colliery spoil restoration sites in Wales, UK under different afteruses. The broad aims of this study were to investigate environmental and temporal factors affecting the evolution of fungal populations in these developing soils and to explore links with stages in the development of soil C cycling. Samples were taken from restorations ranging from 13 to 30 years old and within these sites from grassland and mixed woodland. Comparisons were also conducted with semi-natural grassland sites reference sites (no ploughing or fertilizer addition for >50 yrs).

Conserved PCR primers amplified a 250bp region of the large ribosomal subunit of the rRNA operon. The resulting sequence data were quality checked, rarefied (at a sequencing depth of ca. 25,000 per site), and fungi identified to genus level (using the RDP pipeline), to provide an estimate of the relative proportions of each taxon. A range of soil chemical and physical were measured including estimates of soil C stocks and composition, and C respiration patterns.

Genera were sorted by ecological function to identify major shifts in fungal populations. Detrended correspondence analysis (DCA) revealed clear differences between the restored grassland soils and those planted with trees, and between restored and semi-natural grassland. For example, ectomycorrhizal species (Thelephora, Russula etc) were abundant in the restored woodland soils but absent from grassland areas. In another notable difference, arbuscular mycorrhizal fungi comprised ca. 5% of the total fungal population in restored grassland soils, < 1% in woodland soils and nearly absent in the reference grasslands. The semi-natural grasslands were dominated by basidiomycetes (eg. Hygrocybe spp. Clavariaceae. In addition genera containing pathogenic fungi were more abundant in restored soils than in semi-natural grasslands.

Several temporal trends in fungal communities were apparent. For example, in older restored sites there was a decreasing ratio of Basidiomycota to Acomycota ratio and an increasing relative abundance of AMF, indicating an increasing divergence from semi-natural sites over intermediate timescales. Some variations in the composition of fungal communities could be explained by edaphic characteristics including moisture and pH, as well as landscape data such as vegetation, slope and aspect. Rates of C accumulation in restored soils varied, as did the composition of these stocks; both factors were related to C respiration rates, and carbon stocks in restored grassland site were positively related to time since restoration. Links between fungal community structure and soil C parameters were also apparent.

This study of soil fungal populations demonstrates that whereas these populations quickly diverge (within 13 years) on restored land under differing land use, they are still after 30 years markedly different from those in semi-natural ecosystems. This points to a longer timeframe for recovery of soil processes and plant interactions that are fungal driven.

O17-1

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Degradation and Progradation of Soil Organic Matter Pools and Functions by Land Use

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Land use is the component of global change that the most strongly affects environment, especially soil fertility. Intensification of land use leads in the most cases to land degradation, despite high crop productivity may be achieved by use of fertilizers and optimal management.

Degradation processes related to C and N cycles, namely: decrease of input and stocks of soil organic matter, especially of fast pools, changes of microbial biomass content, composition and activity, as well as cycles of nutrients will be reviewed based on examples of land use in Africa (Kilimanjaro), China (Tibet) and Mediterranea. The degradation processes will be related to one of the key process groups: decomposition of organic matter, erosion, soil compaction and nutrient depletion. Losses of available organic matter pools lead to high stability of the remaining C in intensively used soils and narrowing of nutrient cycles on very small part of initial organics. Adaptation of microorganisms to less C inputs displaces microbial communities preferably by r-strategists with fast generation cycles and low carbon use efficiency. This causes further acceleration of C and nutrient cycles, discordance between nutrients mineralization and plant uptake and so, catalyzes further nutrient losses. Progradation of soil properties will be discussed on example of succession of natural vegetation on 45 Mio ha of agricultural lands in Russia abandoned after collapse of soviet farming system. This was the most widespread and abrupt land use change in the 20th century in the northern hemisphere. The average C accumulation rate in the upper 20 cm soil was 0.96 ± 0.08 Mg C ha-1 yr-1 for the first 20 years after abandonment. The progradation rates of several soil properties and soil organic matter pools will be discussed and compared with the degradation rates in various climatic zones.

Concluding, land use is the main anthropogenic factor leading to degradation of soil propertises and consequently ecosystem functions. However, careful management as well as periodic recovery to (semi)natural vegetation may enhance and progradate soil properties and increase C and N stocks, and so lead to long-term sustainability of soil functions.

Keywords：*Carbon sequestration, Degradation and progradation of soil properties, Microbial functions, Cycles of carbon and nutrients, Mitigation strategies, Land use changes*

O17-2

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Factors Affecting Soil Erosion on an Oceanic Island in Ogasawara, Japan: the Effects of Soil Chemical Properties and Landscape

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Introduction: Ogasawara Islands have been listed as Natural heritage by UNESCO since 2011 because the area sustains valuable ecosystems including many indigenous spices. Nakodojima Island and its peripheral reefs are also the important components of the heritage, but the area has been exposed to the influence of serious soil erosion which may damage the ecosystems. The soil erosion would be caused by disturbance by human and feral goat, but even after desolation and eradication of the feral goat since 1999 the soil erosion has been still serious and plant biomass has been low in some places on the Nakodojima Island at least in 2013. In the present study, we analyzed the relationship between the plant biomass as an indicator of soil erosion and chemical properties of the surface soils to clarify key factors controlling the soil erosion on the Nakodojima Island. In addition, several soil profiles were investigated to reveal the undisturbed and natural soil conditions of the Island.

Materials and Methods: Nakodojima Island (27º37'N to 27º38'N, 142º10'E to 142º11'E, 1.37 km2 in area) is a subtropical oceanic island in north-western Pacific. The mean annual temperature in the largest island of the Ogasawara Islands, Chichijima Island, was 23.1 °C and the mean annual precipitation (1969 - 2009) was 1234.9 mm. Field survey was conducted on the northwest part of the Nakodojima Island on June, 2010, where most of the area was covered with grass species or bare land. Eighty eight plots were randomly selected as study sites in the area using a statistical method. In each plot, plant species covering the ground of the plot were recorded, aboveground plant materials were sampled for the determination of plant biomass, and soil sample of surface layer (0 - 5 cm) was collected to analyze chemical properties.

Results and Discussion: Although the research area is very small, the chemical properties of the surface soils varied in wide range: pH(H_2O), 4.6 - 6.9; exchange acidity, 0.5 - 50 meq kg^{-1}; bioavailable phosphate (Bray II P), 4 - 1700 mg P_2O_5 kg^{-1}. The aboveground biomass was very low especially on soils with low pH and high exchange acidity. It has been well known that soils with low pH tend to release Al ions into soil solution, resulting in inhibition of plant growth. Therefore, in Nakodojima Island, plant growth on low pH soils is small because of the high level of plant toxic Al ions in the soils, and such place would have a high risk of soil erosion. To clarify the cause of the high variability of soil pH, soil pH profiles were analyzed for two natural forest sites and two grassland sites on the Island. All soil profiles exhibited higher soil pH(H_2O) values in their surface A horizons (5.7 - 6.4) than those in their deep B horizons (4.4 - 5.0), indicating that living organisms actively circulate essential cations such as Ca and Mg therefore soil pH has been kept weakly acidic in the surface horizons but in the deep B horizons such cations would have been leached out or absorbed by plant roots and transported to the aboveground parts. This implies that surface horizons having low pH values would have located in deep B horizons in the past but the upper horizons would have been lost by soil erosion under the influence of disturbance by human and feral goat. The plant biomass of such places would be low because of low pH and high level of Al toxicity. Furthermore, Nakodojima Island is an oceanic island, meaning that the number of plant species growing there is small and therefore the ability of ground cover on such low pH soils would be low. Actually, the number of plant species found in the present study was only 24. Interestingly, severe soil erosion was especially found in central valley area of the Island, not severe in the outer ridge area where seabird settlement has been observed after 1999. In these areas, the input of seabird feces would ameliorate soil acidity and increase soil bioavailable P, resulting in high ground cover by plants. In conclusion, soil chemical properties provide key information of the soil erosion on Nakodojima Island as affected by seabird activity and landscape.

Keywords：*Natural heritage, Nakodojima Island, Soil acidity, Exchange acidity, Seabird activity*

O17-3

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Study on Soil Eco-hydrological Function during the Degradation Process of Mountain Meadow

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By using mountain meadow in Wugong Mountain as the research object and comparing change tendency and correlation of characteristics of biomass, soil physical and chemical properties, soil water conservation capacity of different degradation degree and altitude, we analyzed the impact of meadow quality change on soil eco-hydrological function. The results showed that: ①Meadow degradation has affected the distribution of soil hydrology in the soil layer: For not degraded mountain meadow, soil water-holding capacities and infiltration capacities decreased with the soil layer deepening; as the meadow deteriorating, soil water conservation capacities changed in the vertical distribution of soil profile. The maximum water-holding capacities of the upper soil was lower than the subsoil in the mildly degraded and moderately degraded meadow of altitude of 1800 m and 1850 m; the changes of soil infiltration capacities mainly concentrated on the degraded meadow of different degree of altitude of 1900 m; especially on severely degraded meadow, the average infiltration rate of the upper soil was 23% lower than the subsoil; ②The maximum water-holding capacities on not degraded meadow ranged from 1282.47 g/kg to1735.41 g/kg, single-peak rule was presented with altitude rising, peaked at altitude of 1800 m. As the meadow deteriorating, the maximum water-holding capacities declined sharply, and fell on severely degraded meadow by 36% than it on not degraded meadow of altitude of 1800 m. ③the average infiltration rate on not degraded meadow ranged from 1.91 mm/min to 7.42 mm/min, declining with altitude rising . As the meadow deteriorating, the infiltration capacities declined at different degree. At altitude of 1800 m, the average infiltration rate on severely degraded meadow dropped to 35% of not degraded meadow. ④The results of the correlation analysis showed that the soil water-holding capacities were positively correlated ($P < 0.01$) with the soil capillary porosity and total porosity, but negatively with soil bulk density ($P < 0.01$) . These results indicated that during the degradation process of mountain meadow, increase of soil bulk density, decrease of total porosity and capillary porosity were the direct reasons for the decline of soil water conservation capacities .While the soil infiltration capacities were positively correlated ($P < 0.01$) with above-ground biomass, this result indicated that the decreases of vegetation coverage were the main reasons for decline of soil infiltration capacities . Our findings can be used to provide guidelines and basis for water conservation function monitoring and assessing in mountain meadow.

Keywords：*Mountain Meadow Degradation*；*Soil Eco-hydrological Function*；*Wugong Mountain*

O17-4

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Confounding Effects of Climate Change and Livestock Grazing on Pasture Land Degradation in Mongolia

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In arid and semi-arid regions, changes in precipitation regime and summer thermal stresses can do significant effects on ecosystem functions and water resource dynamics. Increased livestock populations since early 1990s are currently characterizing Mongolian pasture landscape more vulnerable to land degradation. It is important concern of understanding mechanisms on combined-effect of climate and grazing on pasture land degradation in Mongolia. In this study, we propose a new approach to understand the confounded land degradation mechanisms by applying hydro-ecological remote sensing techniques. Net primary production (NPP) and evapotranspiration (ET) of Mongolian pasturelands was estimated over the last decade since 2002 using satellite remote sensing data. The Livestock grazing pressure map was produced from geo-location data of herder's seasonal camp and their livestock inventory data for two contrasting river basins: Tamir river basin from wetter and cooler and Tuin river basin from drier and hotter climate regions in central Mongolia. The satellite-driven NPP and ET were used to estimate ecosystem water use efficiency (WUE) to characterize ecosystem property of vegetation photosynthetic and evaporative response to water limitation. Inter-annual variation and spatial differences in ecosystem WUE can reflect ecosystem-level signal of land degradation or land rehabilitation. We compared the NPP and WUE with water balance and livestock grazing pressure. It was considered livestock grazing pressure and NPP as demand and supply variables, respectively. Precipitation-ET balance was used as controlling factor for drought limitation. Our analyses indicates increase of livestock populations during 2000s and more scattered distribution of herder's winter camp than summer camp, which implicates more increased and intensive grazing demand during summer. Because NPP increase was marginal only for few years (e.g. year 2003), considerable imbalance between livestock demand and vegetation supply has been met frequently for the last decade. The ecosystem WUE generally showed higher values in drier years and in areas with high livestock pressure, which implicate ecosystem WUE is useful indicator of confounding effect of climate and livestock grazing on pasture land degradation vulnerability in Mongolia. We discussed socio-ecological mechanisms of pasture land degradation with respects to links between natural carbon and water processes and pasture management practices in Mongolia.

Keywords：*net primary production, grazing, drought, satellite remote sensing*

O17-5

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Sustainable Peatland Management for Mitigating Greenhouse Gas Emission from Acacia Crassicarpa Plantation in Sumatra, Indonesia

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Global warming is currently receiving considerable attention worldwide. In Indonesia, land use change and forest contribute to CO_2 emission as much 53%, which 47% of those are from peatland ecosystems. The objective of this assessment was to determine the potential of sustainable peatland management practice for mitigating CO_2 emission from *Acacia crassicarpa* plantation in Riau, Sumatra, Indonesia. Sustainable peatland management practices in this assessment included no burn land preparation and eco-hydro practices. The landuses applied were rubber (*Hevea brasiliensis, Hb)*, *A. crassicarpa (Ac)*, hydro buffer plant (*Hbp*), mixed peat swamp forest (*Mf*), and tall pole forest (*Tf*). The peatland site depths were 4 to 9 m. It turned out that CO_2 emission from bare peatland (open area) which measured 30 minutes continuously by Li-Cor 8100A was fluctuated, and the lowest value occured at the highest rainfall. The yearly average of CO_2 emission from bare peatland was 56 kg CO_2 $ha^{-1}yr^{-1}$. Emissions of CO_2 across the landuses which measured using close chamber method were strongly influenced by the type and age of plants. Before assessment, CO_2 emission from natural forests of *Mf*, and *Tf* were 16, and 18 ton CO_2 $ha^{-1}yr^{-1}$, respectively. Emission of CO_2 from older *Ac* plantation was higher than younger plantation, but was similar to the natural forest. Emission of CO_2 average (2011-2012) of *Ac* was the highest among landuses (59 ton CO_2 $ha^{-1}yr^{-1}$); while CO_2 emissions from *Hb*, *Mf*, and *Tf* were 33, 28, and 27 ton CO_2 $ha^{-1}yr^{-1}$, respectively. Compared to business as usual value, the CO_2 emission from *Ac* was 44% lower, but 5% higher than that of bare peatland. The carbon sequestration of *Ac* biomass was also measured in this assessment. With total carbon sequestration equal to 97 ton CO_2 ha^{-1} yr^{-1}, *Ac* plantation had potentially positive carbon balance ($_{+}$38 ton CO_2 $ha^{-1}yr^{-1}$). With measuring both GHG emission and carbon sequestration, it can be concluded that with no burning land preparation, and with implementing eco-hydro, *Ac* plantation has capacity to mitigate GHG emissions in degraded tropical peatland such as in Sumatra, Indonesia. Those CO_2 emissions were related to water table of the peatland. Yearly water table averages of the land uses of *Hb, Ac, Hbp, Mf,* and *Tf* were 28, 70, 21, 23, and 31 cm, respectively. Peat subsidences average of three year bases which measured using *Permanent Point Water Table* at *Hb, Ac, Mf*, and *Tf* land uses were 1.6, 0.9, 0.3, and 0.2 cm/yr, respectively. In contrast to those of other land uses, there was no peat subsidence at *Hbp* land use, even there was an accumulation of litter at the rate of 0.2 cm/yr. Finally, soil moisture within surface layer throughout the year was still under pF=4.2, soil temperature was less than 30°C and relative humidity was higher than 70%. With sustainable peatland management practice, therefore, *A. crassicarpa* at Kampar Peninsula, Riau, Sumatra can mitigate greenhouse gas emission, and reduce fire risk better than that of business as usual management. Further researches on carbon budget, and belowground biodiversiy in different peatland landscapes and locations are needed.

Keywords：*CO2 gas emission, eco-hydro technology, no burn land preparation, tropical peatland, peatland management.*

O17-6

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Reduced Tillage Systems for Sustainable Arable Farming in North-west Europe - an integrated Assessment of Soil Properties, Soil Ecosystem Services, and Socio-economic Aspects

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In response to soil structural degradation and soil organic matter decline associated with arable crop production, alternative approaches including no tillage or reduced tillage systems have been developed. Farmers, researchers and policy makers in Europe are increasingly interested in exploring the possible benefits of these systems. Many studies worldwide have analysed the impact of tillage systems on soil properties and crop yields. However adaptation of reduced tillage systems and optimization of the benefits according to the agroecological and social context is required. We aimed to analyse and document the development of reduced tillage practices in North-West Europe (Brittany, France and the Netherlands) and to evaluate the impacts on soil biodiversity, chemical and physical soil properties, soil functions and ecosystem services such as crop yields. In addition impact on ecosystem services and socio-economic sustainability are being assessed through the development of novel approaches for data integration and modeling. The social analysis gives tools for a better understanding of the will and also the resistance of farmers for changing their agricultural systems. Both conventional and organic arable farming systems are included in our research. This information, as well as the selection and monitoring of soil indicators, is crucial to guide practical implementation and policies and future research. Developed within the European SNOWMAN programme, the SUSTAIN and ECOSOM projects allow for international and interdisciplinary collaboration, required to develop an integrated approach. More specifically the following aspects have been studied and integrated: (i) how reduced-tillage systems impact on the biodiversity of soil functional groups and soil functions such as soil structure maintenance, organic matter and nutrient cycling, water regulation and soil filtering; (ii) effects of reduced tillage systems on ecosystem services such as food and fodder production, soil erosion and greenhouse-gas mitigation; (iii) socio-economic drivers and impact of reduced-tillage systems,(iv) development and dissemination of monitoring tools, such as soil-disturbance indicators and evaluation methods for system sustainability

Data have been collected from long term experimental (LTE) fields within conventional and organic farming systems (from 5 up to 13 years). These data are complemented with data from commercial farms in the same region through close collaboration with farmer networks. The impact of different reduced tillage systems are analysed (reduced tillage, non-inverse tillage, direct seeding, superficial ploughing) and compared to conventional ploughing. Measurements (biological, chemical, physical, agronomical) have been done at several dates which allow an overview of the evolution of the soil properties according to climate variation and crop rotation. All data are formatted and integrated in a database. Via path-way analysis (such as GLM), biological, chemical and physical data are analysed and combined to agronomical data; this approach allows the identification of the main drivers impacting on the different ecosystem services. A scoring approach is developed in order to integrate also data on sociological and economical aspects.

The study will present forthcoming results of this collaborative work, thereby shedding light on the benefits and trade-offs related to reduced tillage systems in North-West Europe.

Keywords：*reduced tillage, soil biodiversity, soil functions, food production, sociological approach*

O17-7

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Soil Degradation, Hunger, and Sustainable Development in Subsaharan Africa: Critical Assessment of the "African Soil Crisis" and Illustrative Case Analysis in Southern Mauritania

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In recent years, soil degradation has emerged as a major cause of concern in several parts of the world. Perhaps nowhere is the problem perceived to be more acute than in Subsaharan Africa, where massive famines are forecasted for the coming decades, unless food production is increased drastically. The current prevailing perspective is that this threat is intimately linked to the poor productivity of soils, which are often considered severely degraded. In Africa, as on other continents, the question of the extent to which soils are degraded is related to the use one envisages for them ultimately. If the use is basically agricultural, the severity of soil degradation depends on the type of agricultural practice that one wants to carry out to increase crop production. None of these questions are trivial, as various authors have shown in the past decade. When it has been determined that indeed, for their intended purpose(s), soils of a particular area are degraded, the next questions that need to be resolved are how to identify the process(es) that led to the degradation in the first place, and how this degradation can be reversed and sustainably avoided in the future. In this talk, we shall illustrate with a concrete example in Southern Mauritania that the actual processes that lead to degradation of the soil resource are not easy to identify precisely. A lack of nutrients in a soil would seem to be a clear-cut indication that local farmers have not been supplying enough fertilizers to their fields to sustain crop production at a reasonable level. The logical solution appears equally straightforward; farmers would just have to be provided with fertilizers to amend their fields. There have been thousands of projects that have done just that over the last few decades, and by and large they have all failed in the long run. As soon as the foreign aid disappeared, fields were left once again unfertilized, and in some ways, the local populations, which in time had become dependent on foreign aid, were worst off than before. The conclusion of our experience in Mauritania is that, to make any significant progress toward alleviating the soil degradation problem there, one has to not only identify the nature of the degradation and its seriousness relative to anticipated ('ecosystem') services one expects from the soil, but also to carefully determine the underlying causes of the degradation. In some cases, these causes are strictly physical, chemical, or biological, for example if farmers do not understand the salinization or acidification that may result from certain agricultural practices. But in other situations, what caused the physical, chemical, or biological degradation may be predominantly socioeconomic, political, or cultural. In these instances, the role of soil scientists, while still very important in the diagnosis of symptoms and the proposal of ways to address them, needs to be integrated to a wider effort, more encompassing and holistic. This type of effort is much more difficult, because it requires the development of a common language among specialists of different disciplines, which have not always communicated well in the past.

Keywords：*land degradation, mapping, socioeconomic factors*

O18-1

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Will Reliance on Bioenergy Affect Climate-regulating Services of Ecosystems?

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Biomass has low energy density relative to fossil fuel; consequently, transitioning to bioenergy will incur large changes in land use. Agricultural practices have the potential cause extensive changes in the net exchange of greenhouse gases between the land surface and the atmosphere, and to further alter climate-regulating services by changing albedo and latent heat flux. My research group has employed three approaches to address how land use change associated with expanding production of bioenergy crops affects of the climate regulating services of ecosystems: 1) experimental manipulation of agro-ecosystems; 2) process-based modeling of land use change; 3) theoretical considerations of the climate regulating value of ecosystems. Comparative measurements revealed that replacing annual row crops with perennial bioenergy feedstocks in the Midwest US increases cumulative soil respiration, but this increase is derived primarily for autotrophic respiration associated with the extensive root systems of perennial grasses. Corresponding increases in belowground carbon allocation by perennial grasses, suggest that bioenergy crops will have a climate benefit beyond the displacement of fossil fuels. The application of a process-based model indicates that replacing corn acres for ethanol production with high-yielding perennial grasses will transition the rain fed Midwest from a source to a sink for greenhouse gases. This transition is not limited to replacing annual with perennial crops, as an analysis in the southeastern US indicates that displacing pasture with energy cane has similar greenhouse gas benefits. To determine global consequences of land use change caused by the expansion of bioenergy crops, a metric that quantifies the climate regulating value (CRV) of ecosystems was developed. CRV is strongly related to total carbon stocks, therefore displacing high carbon systems with low carbon systems typically degrades ecosystem CRV. Judicious use of bioenergy crops can potentially increase the CRV of land surfaces, but raises the specter of competition with food supplies. Resolving the appropriate allocation of land to food/fiber versus fuel remains a critical concern.

Keywords：*bioenergy, greenhouse gas, soil carbon, climate*

O18-2

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Farming Strategies to Feed People, Facilitate Essential Soil Services, and Fuel the Economy

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Perennial cellulosic biomass and food crop residues are important on-farm resources, which have become potential valuable sources of income as a harvestable commodity contributing to biofuel production demands. Inputs of carbon embedded in above-ground plant biomass are a key biological energy source for the soil surface - a zone of great importance in the success of food-feed-fiber production and ecological processes essential to environmental quality. This review of literature looks at how above-ground plant biomass contributes to soil properties and processes, water conservation and quality, on-farm forage availability, and as a harvestable biofuel component. Competing needs for this resource could cause serious environmental or economic consequences without sufficient knowledge of their potential impacts. Perennial forages and crop residues are critical for providing surface cover to protect soils against erosion, provide the organic inputs to support below-ground ecosystems, and provide the building blocks for soil organic matter. The amount of biomass required to maintain soil organic matter and various ecosystem services linked to this key soil property may, in many cases, exceed that needed for simple erosion control. Achieving a balanced outcome will require scientific evidence, as well as well-designed government policies, for crop residue utilization schemes to contribute to a sustainable agricultural approach.

Keywords：*Greenhouse gas emissions; Nitrogen mineralization; Soil organic carbon; Soil quality; Water quality*

O18-3

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Soil Properties and Corn Yield Response to Residue Removal, Tillage, and N Rates

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As research in alternative energy advances, corn stover is one of the leading candidate feedstocks for cellulosic ethanol production. Before residue harvest is considered a viable option, long-term effects of residue removal on soil fertility and crop yields must be better understood. The interaction of crop management practices such as tillage and N fertilizer application could further affect soil and crop responses when residues are removed. Thus, our objectives were to determine the effects of residue removal, tillage, and fertilizer N application on 1) soil chemical and physical properties and 2) corn yields after 8 years since establishment of research plots. The experimental layout was a split-split-plot, randomized complete block design with four replications at each of four sites in Illinois, all with highly productive soils: DeKalb (Flanagan silt loam), Monmouth (Muscatune silt loam), Perry (Clarksdale silt loam), and Urbana (Flanagan silt loam). Main plots were levels of residue removal (full, partial, or none); subplots were assigned one of two tillage levels (chisel tillage,T, and no-tillage, NT) whereas sub-sub-plot treatments consisted of 4 N rates: 64, 134, 201, or 268 kg /ha applied as UAN at or right after planting. Soil samples were taken in spring 2013 for the determination of total carbon (TC, g/kg), total nitrogen (TN, g/kg), exchangeable K (mg/kg), available P (mg/kg), soil pH (1:1 in water), bulk density (BD, g/cm3), water aggregate stability (WAS, %), and microbial biomass C and N. Results on the effect of residue removal, tillage and N rates and their interactions on soils and corn yields will be discussed.

18-4

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Changes in Land Use of Contaminated Agricultural Soils from Annual Crops to Perennial Bioenergy Crops Impact their Trace Element Availability

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Increased global energy demands have lead to a shift of land use of non-contaminated fertile agricultural lands towards cultivation of non-food bioenergy crops especially in developed countries. But this practice is being criticized because of the threat of food shortage for increasing world population. On the other hand a large area under food crop production globally is contaminated due to anthropogenic activities which is causing food chain contamination and resulting to severe health hazards. In this scenario a solution is to use such contaminated agricultural lands for non-food energy crops to keep their agricultural vocation. Such non-food bioenergy crops (for example miscanthus) are mostly perennial. No-tillage and changes in vegetative cover type under perennial crops are known to modify the soil organic matter quality and quantity, which in turn can modify the trace metal bioavailability. The perennial bioenergy crops like miscanthus are seldom studied in a context of phytomanagement of the contaminated agricultural soils and the possible consequences of such cropping systems on trace metal availability in contaminated soils are rarely addressed. The objective of the present work was to assess changes in trace metal availability in contaminated soils when annual crop system is replaced by a perennial crop system.

A strategy of studying availabilities of Cu and Pb at two sites differing in the soil texture and origin of pollution was adopted. One site was of Metaleurop (North of France) with silt loam soils contaminated by atmospheric metal fallout and second site was of Pierrelaye (Paris Region) with sandy soils contaminated through long term untreated waste water input from city of Paris. They differed in the degree of metal pollution (for Cu, Pb, Cd and Zn) and in the quantity and nature of organic matter (different C/N values). The samples used for this study involved one land parcel at each study site. Each land parcel was divided to be cultivated in two parts; one part under annual crops and the other part under perennial crop i.e. miscanthus. At the time of the soil sampling, miscanthus was three years old. We investigated the trace metal availabilities of the soil samples through a combined approach of chemical metal extractions with EDTA and metal localization study in different soil size fractions. Chemical extractions of metals were first performed at equilibrium (24h) to quantify the soil metal supply. Then, kinetic extractions were performed at 10 time steps (5 min to 24 h) to determine labile metal fraction (supposed to be immediately bioavailable) and less labile metal fractions (supposed to be bioavailable on long term) to mimic dynamic feature of bioavailability. Metal localization in different soil size fractions was studied by determining the metal contents of the fractions separated through wet sieving. Statistical differences between means were determined according to Tukey's test.

The results for the soil under miscanthus compared to annual crop soil showed that the changes in land use influenced the trace metal availabilities at both sites. For the Metaleurop site, the availability of Cu and Pb was decreased by 4% and 13% respectively, with an increase in their localization in soil finer fractions (4% for both metals). For the organic matter rich sandy soils of Pierrelaye the impact was less apparent where the labile and slowly labile pools of only Pb were changed while Cu was not impacted. Pb localization in soil finer fractions was decreased by 9% in the soil under miscanthus compared to annual crop soil while Cu localization was increased by 4% in coarser fraction. These results showed an impact on trace metal availabilities at the earlier stage of changes in land use (3 years after conversion). However, more studies on longer terms after the changes towards perennial bioenergy crops are required to further highlight the potential role of the bioenergy crops for the phytomanagement of trace element-contaminated soils.

Keywords: *Trace elements, , availability, , miscanthus, Chemical extractions, physical size fractionation*

O18-5

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Impact of Agroforestry Plantings for Bioenergy Production on Soil Organic Carbon

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Tree windbreaks are an attractive multiple-benefit land use through their ability to mitigate climate change by modifying the local microclimate to improve crop growth and by sequestering carbon in the soil and tree biomass. Recently, such agroforestry practices are also being considered for their bioenergy potential as the wood could be harvested for direct combustion, cellulose to ethanol conversion, or pyrolysis to bio-oils. The objective of this project was to use detailed soil profile descriptions and spatially-distributed soil sampling to determine the soil carbon sequestration potential of tree plantings across climatic gradients in the Central Russian Uplands and the U.S. Great Plains. Three Russian sampling locations, Streletskaya, Yamskaya, and Kamennaya spanned a gradient of mean annual temperature from 5.3 to 5.8 °C and precipitation from 480 to 580 mm. Three U.S. sampling locations, Reynolds, North Dakota; Huron, South Dakota; and Norfolk, Nebraska; had ranges of annual temperature from 3.9 to 9.2°C and precipitation from 450 to 690 mm. Tree species at the sampling sites included black poplar (Populus nigra), silver birch (Betula pendula), box elder (Acer negundo), English oak (Quercus robur) and balsam poplar (Populus balsamifera) in Russia and green ash (Fraxinus pennsylvanica), redcedar (Juniperus virginiana), Siberian elm (Ulmus pumila, L.), mulberry (Morus rubra, L.), and cottonwood (Populus deltoides) in the U.S. Trees ranged in age from 19 to 70 years. Soil core samples (30 cm depth) were taken in a grid across each windbreak and subdivided into 0-15 and 15-30 cm sections. Soil pit and auger samples to 1.2 m or greater were collected in each land cover (tree, crop, and undisturbed grassland as reference). Samples were analyzed for organic (SOC), inorganic (SIC), and permanganate oxidizable (POXC) carbon as well as for stable carbon isotope signature (del 13C, natural abundance). Soil pH and total nitrogen (TN) content were also determined. For all six sampling sites, SOC content in the surface 30 cm beneath the trees averaged 22.4% greater than the adjacent cropped fields. Stable carbon isotope and POXC data indicate that a significant proportion of this accumulation could be attributed to tree sources. Changes in soil pH and TN were also observed with implications for soil chemical and physical quality and nutrient cycling dynamics. Windbreaks from more cool and moist climate conditions were found to be more favorable for SOC accumulation in the surface soil layers. The relationship between SOC accumulation and climate as characterized by the hydrothermal coefficient of Selyaninov (1928) enables the estimation of soil carbon stocks in existing windbreaks and the potential to predict carbon sequestration in future plantings.

Keywords：*soil organic carbon, agroforestry, tree windbreaks, carbon sequestration*

O18-6

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Soil Carbon Dioxide Respiration in Switchgrass Crops: Assessing Annual, Seasonal and daily Flux Patterns in East Tennessee

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Switchgrass is a highly efficient bioenergy crop cultivated to reduce greenhouse gas (GHG) emissions via fossil fuel displacement. Assessments of carbon (C) offsets generated by switchgrass are necessary for evaluating its value in C mitigation programs. Detailed data for soil carbon dioxide (CO_2) respiration, a primary mechanism for soil C emissions, is crucial for accurate assessments of GHG offsets. Quantifications of annual soil CO_2 respiration rates in switchgrass systems are, however, limited to the growing season or coarse-scale temporal sampling. Consequently, flux rate trends during cooler seasons and episodic events, such as precipitation, are excluded from annual soil flux estimations. This study evaluates daily, seasonal, and annual soil CO_2 respiration trends in switchgrass croplands in East Tennessee. Hourly measurements were taken for soil CO_2 flux, soil temperature, and soil moisture from June 2010 to August 2011 at sites with switchgrass crown cover (Cover) and inter-row bare ground space (Bare). Although both soil temperature and moisture were positively correlated with soil CO_2 flux rates, soil temperature was the primary driver of soil respiration throughout the majority of the year. During Winter, lower soil temperatures corresponded with significant decreases in average daily CO_2 flux rates, however, CO_2 pulses associated with precipitation events increased flux rates up to three times the seasonal daily average. Soil temperature influenced both daily and seasonal flux patterns where the highest flux rates, up to 31.0 kg CO_2 ha-1 h-1, were observed during the warmest hours of the day (13:00 to 15:00) and during the warmest season (Summer). The total annual CO_2 emission from the switchgrass plot was 73.8 Mg CO_2 ha-1, where Cover and Bare were representative of 75% and 25% of the total land area, respectively. Summer and Spring emissions combined accounted for 80.1% of annual flux, indicating that exclusion of non-growing season time periods may result in an underestimation of total annual CO_2 efflux. Our results indicate that inclusion of the non-growing season and a fine-resolution temporal sampling approach (i.e. hourly) captures episodic events and cool season soil respiration patterns and provides more accurate quantifications of total annual CO_2 emissions in switchgrass croplands in East Tennessee.

Keywords：*soil carbon, soil CO_2 respiration, switchgrass, annual flux, soil temperature and moisture*

O18-7

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Environmental Impact of Growing Herbaceous Perennials for Bioenergy

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A number of herbaceous perennial grasses have been evaluated for their bioenergy potential. Switchgrass (Panicum virgatum) is one of the most extensively studied but some others include Miscanthus x giganteus, energycane (Saccharum spontaneum), big bluestem (Andropogon gerardii), prairie cordgrass (Spartina pectinata), reed canarygrass (Phalaris arundinacea), and mixtures of various species such as is often found on Conservation Reserve Program (CRP) land. The use of perennial species for biomass has environmental implications, including their effect on greenhouse gases, water quality, soil quality, wildlife, etc. There is debate as to whether perennial species will most likely be grown in monocultures stands or as polycultures, at least in part due to environmental considerations. Various research groups have evaluated the environmental impacts of some of these species and mixtures. Some of the key environmental measurements associated with production of perennial energy crops have included the potential to 1) reduce pesticide inputs (e.g. herbicides, insecticides), 2) reduce synthetic fertilizer requirements, particularly N, and possibly utilize manure as a replacement source of nutrients, 3) improve ecosystem services (e.g. wildlife habitat, C sequestration), 4) reduce wind and water erosion, 5) improve soil and water quality, and 6) utilize, and possibly reclaim, marginal land (e.g. high saline areas or low-lying seasonal wetlands). Specific species will be highlighted from the Regional Feedstock Partnership, a collaborative research effort between the Sun Grant Initiative (through Land Grant Universities), the US Department of Energy (DOE), and the US Department of Agriculture. Because of some of the environmental considerations listed above, various herbaceous energy crops are being investigated at diverse locations throughout the USA. Specifically, the goals of the Regional Feedstock Partnership are to: 1) assess the potential of genetically diverse, dedicated perennial energy crops and CRP land for sustainable biomass production in environmentally diverse regions of the country; 2) identify critical management issues such as harvest timing and soil fertility for sustainable biomass production; 3) evaluate opportunities to expand production of herbaceous biomass crops and resources throughout the USA; and 4) evaluate the environmental impacts of some of specific species. This paper will address some of the key research findings in some of these areas and help demonstrate the potential for various perennial species to serve as dedicated bioenergy feedstocks and the the effect they may have on the environment.

O19-1

Surface Soil Resources Inventory and Integration: Soil Value and Erosion

Crop Productivity, Ground Cover and Wind Erosion Likelihood - Modelling and Mapping Surface Soil Protection for In-Season and Long-Term Risk Management

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Wind erosion is an insidious degradation process that is likely to occur on cropping land in South East Australia, particularly in the period between harvest and establishment of the following crop (December till June) . In Victoria, soil and landform units interpreted for their relative susceptibility to various forms of degradation have been used in a GIS based model incorporating data and information on land use practices, to create maps of likelihood and, in some instances, risk. The model logic follows a recognised approach to formulating risk as a product of likelihood and consequence. Likelihood is ranked according to a matrix that scores the degree of susceptibility of the soil/landform against the relative impact of the current land use practices (for example, type of tillage, stubble management, grazing practices). Consequence has been ranked as a product of value and sensitivity of the soil resource or of an associated natural asset. The logical structure of the risk framework used in the Land Use Impact Model (LUIM) is sound, the challenge is to find data and information to populate its components, particularly those affecting estimates of value and sensitivity. Generally, expert opinion has been used to select criteria and to create the rankings in the model. Research in the wheat growing regions in West and NorthWest Victoria is showing promise for a consistent and reliable method for mapping likelihood of wind erosion annually, using ground survey and satellite data. Evaluation of 40 year trends by analysis of satellite data is assisting in identifying the higher value soil assets as well as those more likely to have been consistently affected by wind erosion.

Key words: Land use practices,susceptibility, likelihood, consequence, risk,wind erosion

O19-2

Surface Soil Resources Inventory and Integration: Soil Value and Erosion

What is the Cost of Soil Erosion in Europe?

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The consequences of soil erosion for society are relatively severe, estimated by Pimentel et al. (1995) to cost $44 billion each year in the USA. In Europe, erosion has been estimated to affect 115 million ha which is around 12% of Europe's total land area (Jones et al., 2012; Kibblewhite et al. 2012. European Union Thematic Strategy for Soil Protection (EC, 2006) alerts policy makers of the need to protect soil and proposes measures to mitigate soil degradation. Soil erosion is a major process of degradation that has been identified as a key priority for action within the Soil Thematic Strategy of the European Commission. In response to the recent developments in soil policy at the European level, the European Soil Data Centre (ESDAC) has been established at the Joint Research Centre, Ispra (I) (Panagos et al. 2012), to provide a mechanism for reporting critical information on soil in the European Union (EU) Member States.

The impact assessment included in the proposed Soil Thematic Strategy estimated the cost of soil degradation. Based on estimations done in 13 countries including the major Member States where erosion occurs, the cost of soil erosion was estimated to a range 0.7 – 14.0 Billion Euros (EC, 2006). For the rest 15 states (European Union has 28 states), no data were available. The soil erosion cost has such a big range due to uncertainties in quantifying the impact of soil erosion at long term.

The consequences of erosion for soil fertility and ecosystem services are substantial, as soil is a non-renewable resource. It is worth noting that natural soil formation is extremely low, as losses over 1 or 2 tons ha^{-1} $year^{-1}$ are considered as irreversible. The main consequences of soil erosion are: loss of soil, loss of fertile land due to disrupted nutrient cycles, loss of organic carbon and biodiversity, destruction to infrastructures due to excessive sediment load, diffuse pollution of surface water, negative effects on aquatic ecosystems and biodiversity, restriction to land use impeding redevelopment and reducing the area for agricultural, forestry and recreation activities, depreciation of land value, flood risk and transfer of sediments to ports.

The on-site costs of soil erosion attributed mainly to land owners include the yield loss of fertile land and the impact to recreation and tourism. The off-site costs paid mainly by public administrations have to do with sediment removal, infrastructure damages (roads, dams, water supply), treatment of clean water and damage of ecosystems. The major part of soil erosion cost are off-site ones.

At European Union, a series of models (RUSLE, PESERA, G2) have been applied in order to identify areas under high risk of soil erosion (hotspots) and seasons where the threat is higher. The hotspots and high risk seasons are treated with care by policy makers and anti-erosion measurements are also proposed in the post 2013 Common Agricultural Policy (CAP).

One of the main components in EU Common Agricultural Policy (CAP) for the 2014–2020 are the Good Agricultural and Environmental Condition (GAEC) standards. Through the GAEC scheme, soil erosion protection, soil structure maintenance and soil organic matter levels are recognised as minimum requirements to achieve a good condition of agricultural land (EC, 2009).

O19-3

Surface Soil Resources Inventory and Integration: Soil Value and Erosion

Soil Erosion Status and Management Strategies in Taiwan

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In Taiwan, Soil and Water Conservation Act was developed and announced in 1994. Taiwan is located at the collusion of Euroasian plate and Pacific Plate, therefore earthquakes, landslides, and soil erosions were very general events and occurred in high potentials soil erosion region, especially in mountains area. Detailed soil survey project and digital soil information system of rural soils, hill lands and high mountain forest soils were developed on 1:25,000 scales. There are about 65% of hill lands and mountains and only 35% of total Taiwan for crop production. Some of hill lands, which the elevations ranged 100-600 meters, are still for agricultural productions, especially for tea, citrus, pear and other high economic crops. Most soil erosions were occurred in the hill lands. The total precipitation ranged 2500-3000 mm/yr, but most rains are in the rain seasons, May to October, especially on the summer with typhoon season (3-4 times per year) or special storm, 2000-3000 mm rain falling in 3-7 days. The soil erosion rate is <5 tons/ha/yr of natural soil formation process with good surface cover or natural forest ecosystem. Some hill lands with different land uses, such as citrus, tea or orchards production, had very serious soil loss ranged 50-100 tons/ha/yr, during the typhoon seasons and provided a 200-300 mm/day for 3-7 days. The soil loss reached the highest level (>200-500 tons/ha/yr) produced by a strong storm owing to climate changes in last decade. The main consequences of soil erosion in Taiwan are soil and nutrients loss, loss of soil carbon and soil biodiversity, excessive sediments loading on the rural soil surface, diffuse pollution of surface water discharged from industrial park, and negative effects on aquatic ecosystem and natural biodiversity. The best management practices (BMPs) have been successfully developed and applied to the field in last 3 decades in Taiwan, major including surface leveling operation of slope lands, land surface covering by mulching of crop residues, weed and vegetation covering on soil surface with different special grass species, and also set up a buffer zones (30-50 meters width) along the river. Some important indicators are recognized as minimum requirement to maintain the crop production and soil quality in Taiwan, including the practices of soil erosion protection, maintenance of soil organic matter levels at least 2-3 %, good soil structure maintenance, and efficiency water uses and nutrient managements. In Taiwan, two major soil loss models including revised universal soil loss equation (RUSLE) and soil loss index model (SLIM) have been applied and identify the high risk area of soil erosion during the heavy storm seasons. Emergency anti-erosion management strategies are also developed for reducing the soil loss and landslides. Soil and water conservation education programs were conducted by the government bureau in April every year. More than 25 outdoor classrooms and more than 200 soil monoliths exhibition were developed and demonstrated for rural soil farmers, association farmers of high economic crops and also for student and people in different regions of Taiwan.

O19-4

Surface Soil Resources Inventory and Integration: Soil Value and Erosion

ArcGIS-based SATEEC (SATEEC 2014) for Soil Erosion Estimation

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Soil loss has increasingly received national and international attentions as an economic resource and a source of natural disasters. In this regard, many countries have looked for solutions to prevent soil loss from water erosion. The Universal Soil Loss Equation (USLE) has widely been used to estimate soil loss over the years because of its simple approach and data availability. However, the USLE has a limitation to estimate soil loss at a watershed scale because it is a field scale model. To overcome this limitation, the Sediment Assessment Tool for Effective Erosion Control (SATEEC) ArcView system was developed and used in many countries to evaluate sediment yield and effects of various Best Management Practices on sediment reduction at a watershed. However, the needs for a upgrade of SATEEC ArcView system have been requested because the ArcView is no longer supported and sometimes it is not feasible to process bigger dataset under 64-bit operating system. In addition, numerous hydrology and water quality models have been integrated with ArcGIS because of various advantages over the ArcView. In the ArcGIS 10.1 version, ArcPy and other Python modules were provided. Thus in this study, ArcPy and ArcMap 10.1 were used to develop enhanced SATEEC system. In this study, the Add-in type of SATEEC system was developed with ArcPy and Python programming. In addition, simple BMP tools were developed and added to the SATEEC Add-in toolbar, and segmentation in the real field was considered. The SATEEC Add-in was applied to the study watershed to evaluate its effectiveness in soil erosion studies. The improved SATEEC will give a significant contribution to accuracy and convenience in estimating soil loss.

Keywords: USLE, SATEEK, Soil loss, Best practice management, ArcPy

O19-5

Surface Soil Resources Inventory and Integration: Soil Value and Erosion

Best Management Practice for Preventing Soil Loss in Highland Agricultural Field

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Soil loss from highland agricultural field has been a critical problem in Korea especially during rainy season. Since highland agricultural field has steep slope and soil texture is mostly sandy or sandy loam, soil loss during rainfall cannot be avoided. For this reason, main purpose of this research was i) to predict loading rate of soil loss from highland agricultural field based on cultivation area including illegal cultivation area and amount of soil cover ii) to estimate efficiency and cost of best management practice (BMP) for reducing soil loss from highland cultivation area, and iii) to analyze benefit and cost of BMPs in highland agricultural field. Study area was upstream of Han-River and four different locations of highland agricultural area were selected. Calculated total soil loss amount was ranged from 47 – 2,464 ton/ha/yr and cultivation area and slope were the main parameters for soil loss. Riparian buffer strips, sediment basin and bypass ditch were applied to estimate reduction efficiency of soil loss and approximately 22-49% of soil loss can be reduced depending on geological and environmental circumstances. In order to reduce 30% of soil loss within 10 years in study area, total estimated cost was approximately 930 million dollars and result of B/C analysis showed that efficiency of BMPs will be positive 5 years after BMPs are constructed. In conclusion, significant high cost and labor will be necessary to prevent soil loss from highland agricultural field and more research is necessary to minimize adverse effect of soil loss from highland area and at the same time to increase efficiency of BMPs.

Key words: Soil loss, Highland cultivation, BMPs, B/C analysis

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O19-6

Surface Soil Resources Inventory and Integration: Soil Value and Erosion

Effect of the Countermeasures for Prevention of Soil Erosion in Korea and DPRK

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Soil erosion, because of the slop land and intensive rainfall, is the principle nonpoint contaminant of the water system in Korea. Soil erosion is a function of the rainfall, soil characteristics, land slope, vegetation and soil management. The amount of soil erosion in agriculture area was estimated by USLE as 102.1 ton ha-1yr-1 at bare soil. This study was conducted to evaluate the effect of the countermeasures for prevention of soil erosion in Korea and DPRK. The effect of reducing soil loss according to the countermeasures in Korea was 90%, 82%, 86%, 80~84%, 33~83%, 83%, 34~86% and 37~41% by contouring waterway, waterways, gravel belt, grass belt, contouring cultivation, terrace field, straw mulching and vinyl mulching, respectively. On the other hand, the effect of reducing soil loss according to the countermeasures in DPRK was 19.5%, 21.8%, 24.9%, 29.1% and 69.7% by protective plowing, intercropping, double cropping, waterway and straw mulching, respectively. In conclusion, we can reduce the soil erosion more than 80% by the aid of the countermeasures like as contouring waterway, waterways, gravel belt and grass belt.

Keywords: Soil erosion, waterway, grass belt, contouring cultivation, mulching

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This study was carried out with the support of the “GAIA-project (Development of the Korean model to estimate surface soil erosion)”, KEITI.

O19-7

Surface Soil Resources Inventory and Integration: Soil Value and Erosion

Spatiotemporal Variation of Erosion and Deposition using the Catchment-scale Soil Erosion Model (C-SEM)

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Increasing rainfall intensity and frequency due to extreme climate change and haphazard land development are aggravating soil erosion problems in Korea. A quantitative estimate of the amount of sediment from the catchment is essential for soil and water conservation planning and management. Essential to catchment-scale soil erosion modeling is the ability to represent the fluvial transport system associated with the processes of detachment, transport, and deposition of soil particles due to rainfall and surface flow. This study applied a physics-based erosion model for flood events due to typhoons and then assessed the impact of topographic and climatic factors on erosion and deposition at a catchment scale.

Keywords: catchment-scale, deposition, erosion, flood events, soil erosion modeling,
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O19-8

Surface Soil Resources Inventory and Integration: Soil Value and Erosion

Towards Sustainable Topsoil Management in South Korea

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The OECD report (2008) shows that annual soil loss in agricultural land area of South Korea was 32 tons/hectare/year for the period 2002~2004 and over 20% of farm land classified as having moderate to severe risks. Since the enactment of Soil Environment Conservation Act (SECA) in 1995, Korea's soil conservation policy has made much progress, however, focusing only on contaminated soil remediation. As it became necessary to establish a systematic plan for a shift toward a policy for sustainable soil management, the Ministry of Environment began to establish legislation and policies on topsoil conservation in 2011.

The first step was to survey the actual state of topsoil erosion, so the Act was amended to include the provision on ‘Survey on Actual State of Topsoil Erosion’ in 5 April, 2011. To provide a detailed survey method, the Public Notice, Survey on Actual State of Topsoil Erosion and Countermeasure, was published in 19 March, 2012. The Universal Soil Loss Equation (USLE) was used for the prediction of long-term average soil erosion. The investigation at the regional level is being undertaken on factors of the USLE equation by Korea Environment Corporation (KECO).

Then the Ministry of Environment established the ‘five year master plan for topsoil preservation (2013-2017)’ in 31 December 2012 to prevent loss of topsoil, and to maintain environmental function of soil ecosystem. The main contents of the plan are as follows:

- Building in research and evaluation system of topsoil erosion
  - Survey on actual state of topsoil erosion
  - Introduction of soil quality assessment
  - Development of the Korean model to estimate topsoil erosion
- Preventing soil erosion and implementing countermeasures
  - Conservation area designation
  - Topsoil erosion prevention and countermeasures
  - Topsoil management in development works
- Building the infrastructure
  - Amendment of legislation and policies
  - Technical capacity building
  - Industry development

Investigation severe loss of topsoil in North Korea and cooperation between international organizations

Since 2012, the GAIA Project (Geo-Advanced Innovative Action Project) for topsoil management has been implemented by the Ministry of Environment and managed by the KEITI (Korea Environmental Industry & Technology Institute). Studies about evaluating multifunctional soil quality and developing a monitoring system have been completed or are in progress. As part of the

GAIA Project, the SSORII (Surface SOil Resources Inventory & Integration) Research Group was founded in April 2014 and will receive a total of 3.6 billion won for four years to study on environmental and economic value of topsoil, the Korean investigation model, medium & long-term topsoil erosion assessment technique, and environmental impact assessment technique.
The introduction of progressive legislation and policies of topsoil preservation will change a paradigm of soil environment conservation for improving the status of the soil resource and sustainable development.

Keywords: Topsoil, Erosion, Sustainable Management, Soil Quality, Master Plan
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O20-1

[IDS2] Global Soil Partnership

The Intergovernmental Technical Panel on Soils (ITPS)

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The Intergovernmental Technical Panel on Soils (ITPS) was established at the first Plenary Assembly of the Global Soil Partnership held at FAO Headquarters on 11 and 12 of June, 2013. The ITPS is composed of 27 high-level soil experts representing all the regions of the world. The main function of the ITPS is to provide scientific and technical advice and guidance on global soil issues to the Global Soil Partnership primarily and to specific requests submitted by global or regional institutions. The ITPS will advocate for addressing sustainable soil management in the different sustainable development agendas.
The ITPS have the following functions:
- Provide scientific and technical advice on global soil issues primarily to the GSP and in relation to specific requests submitted by global or regional institutions.
- Advocate for the inclusion of sustainable soil management into different development agendas.
- Review and follow up on the situation and issues related to soils in the contexts of food security, use and management of natural resources, ecosystem services provision, climate change adaptation and mitigation, and other relevant areas.
- Review and endorse from a technical viewpoint the GSP Plans of Action.
- Follow up on the implementation of these Plans of Action with due attention to their impact and contributions to different global policies and initiatives related to sustainable development, MDGs, food security, climate change adaptation and other subject matters.
- In exceptional cases, when complex technical matters arise, request the Plenary Assembly and the Secretariat to form technical committees aiming to gather specific advice

The first meeting of the Intergovernmental Panel on Soils (ITPS) of the Global Soil Partnership (GSP) was held at FAO Headquarters (Rome) on 22-26 July 2013. At its first meeting the panel elected its chairperson and approved its programme of work. At the core of the activities of the ITPS is the final approval of the plans of action for the 5 pillars of the GSP. At its first meeting the ITPS finally approved the plan of action for pillar 4 (Soil data and information), while the plans of action for the remaining 4 pillars have been discussed at its second meeting held 7-11 April 2014. Additional items on the ITPS agenda are the revision of the World Soil Charter, the development of the soil related goals and targets for the post 2015 Development Agenda and the compilation of the Status of World Soil Resources Report.
The mandate of the ITPS members will expire in 2015, when a new ITPS will be nominated at the GSP plenary for the following two years.

Full details are available at http://www.fao.org/globalsoilpartnership/intergovernmental-technical-panel-on-soils/en/

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O20-2

[IDS2] Global Soil Partnership

A 10-Year Plan Of Action for Pillar 1 of the Global Soil Partnership to Globally Promote Sustainable Soil Management for Soil Protection, Conservation and Sustainable Productivity

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The Global Soil Partnership (GSP) was formally endorsed by the Food and Agriculture Organization (FAO) of the United Nations in December 2012, based on five (5) pillars of action towards the global improvement of soil management. This presentation highlights the global Plan of Action (POA) developed for Pillar 1 of the GSP aimed at promoting sustainable management of soil resources for soil protection, conservation and sustainable productivity. Soil is a non-renewable natural resource with large variation in space and time, a reality which, until the recent past, was not sufficiently recognized and addressed in the global political arena. Soil protection and its sustainable management needs to be addressed as a cross-cutting principle in a variety of environments including agricultural and environmental policies, and spatial planning for a diversity of land uses. Furthermore, improved global sustainable soil management (SSM) is needed to support at least a 60% increase in food production by 2050, and contribute to climate change adaptation and the Sustainable Development Agenda.

Within this context the POA considered regional priorities and national diversity in soil management, with a view to the Plan's implementation over the next 10 years. An overview of state-of-the-art SSM methods and technologies was provided, as well as indicators related to regional soil management challenges, to be used for monitoring purposes. Such methods and technologies include conservation agriculture, climate smart agriculture, integrated farming systems, efficient plant nutrition, proper irrigation, integrated soil and water management at watershed level, relevant biotechnologies and pest management and others. Indicators associated with monitoring soil management include regional areas under sustainable soil management, potential agricultural production areas not currently used, and areas of soil degradation.

In order to promote SSM, information exchange is essential through awareness, extension services and effective partnerships. Awareness regarding soil as a finite natural resource, its use and its protection is needed from ground level up to global level. Current global efforts to improve such awareness include the GSP's establishment of the annual World Soil Day on 5 December and the International Year of Soils during 2015. Large variation exists in the quantity and quality of extension services worldwide. The need was identified to improve underperforming extension services through participatory learning initiatives. Effective partnerships at national, regional and global level are essential to the successful implementation of this Plan of Action. The impetus for successful implementation thereof lies not only with the GSP Secretariat, but with the GSP Partners. The above mentioned channels of information exchange are strongly linked to GSP Pillar 2 which focuses, amongst others, on education awareness and extension in soil. The successful implementation of this plan of action will require a number of actions that are complementary and fully integrated by other GSP plans of action.

Current national, regional and global policies related to SSM were discussed, gaps identified, and actions suggested to address these gaps. Since the GSP does not have the mandate to enforce policy development, adaption or implementation, the proposed approach should be driven by the regional GSP partnerships to increase the implementation and regulation of sustainable soil management. However, the World Soil Charter and the Sustainable Development Goals (SDG) process could contribute to the enforcement of some general actions towards SSM. The importance of including the societal impacts of environmental policies was highlighted and should be addressed in future policy and guideline development. Monitoring of the Plan's implementation over the next 10 years at regional level is discussed. Effective implementation will depend on the strength of the regional GSP partnerships, buy-in into the process by national level GSP Partners, and funding acquired for regional implementation.

Keywords: *Global Soil Partnership, GSP, Plan of Action, sustainable soil management, soil protection*

O20-3
[IDS2] Global Soil Partnership

Changing Soil Science Education for Confronting Challenges

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'Soil Science' has efficiently served the human society through generating fundamental and applied knowledge, and human resource in the fields of fertilizers, irrigation, fertigation, soil and natural resource management for better understanding of production resources and technology generation and assessment for enhancing agricultural productivity. Soil is a natural foundation on which our activities pertaining to overall food security rest. Once we recognize a soil, it cannot be a waste and its productivity will oscillate between near to zero and approaching 100 and move through an act of management, which is just a means to minimize risk or uncertainty or doubt or any type of limitation. Soil is mainly responsible for (i) serving a quality food, (ii) pure water (iii) clean air, (iv) congenial ecosystem, and (v) sustainable soil biodiversity so that soil may contribute to its critical zone in order to sustain the gross happiness in the societies. To attain these objectives, there is need of revolutionary updating in global soil science education. Over the last about two decades, the agricultural scenario has tremendously changed in several ways and as a result 'Soil Science' has started showing signs of fatigue and has clearly lost its sheen and charm with students, teaching faculty, policy makers and research funding agencies.

With the fast changing trend from `enhancing' crop production to `sustainable production' while safeguarding the environment, it has become increasingly necessary that the thrust of teaching, research and extension of 'Soil Science' should be just as much about sustaining productive, non-toxic, and non-pathogenic soils and environmental safety as it is about crop production (Sharma and Aulakh, 2009). Keeping abreast of fast changing demands of the human society in general and farming community in particular, several departments, institutes, colleges, and universities around the globe, especially in developed countries, have either changed their names, created/carved new departments or started new degree programmes. It is pertinent to note that main emphasis is on 'natural resource management' and 'environmental science'. Lal (2007) observed that in an era of budgetary constraints, dwindling faculty positions, declining enrollment, and the ever-looming threat of extinction to 'Soil Science' departments within the Land Grant University systems, 'Soil Science' must be taught as a business.

Significant changes have occurred globally in the recent past in agriculture sector as a whole and university education per se that have impacted university teaching. It also has to respond to technological changes in the areas of space technology and geometrics, information technology and instrumentation. As the eco-system is becoming a fundamental functional unit, 'Soil Science' has to be reoriented to provide training and solutions to the problems from a holistic angle rather than from a sub-system approach that had been currently followed. Similarly, mere listing of factors that control various soil properties or soil processes, these could better be explained in terms of a system and its driving variables. Major academic and industrial projects related to environment, largely deal with analysis of soil and water. If 'Soil Science' curriculum focuses on environmental issues, the trained personnel could get accepted in this ever-expanding employment arena. Continuing with classical thermodynamic approaches in the curriculum at Master and Doctoral levels is restricting the vision of personnel working in the field of 'Soil Science'.

Ecology teaches us that species that are unable to adapt to changes in their environment get extinct. Soil Scientists should learn from ecology, and adapt their teaching, course curricula and research activities as per the changing needs and expectations of the society. 'Soil Science' teaching must train students for jobs in both the public and private sector. We must expand our present boundaries to embrace other disciplines to further our own cause. Soil Scientists must become proactive in educating and convincing the research funding agencies and policy makers about the indispensability of 'Soil Science' research in solving several agriculture- and non-agriculture-based problems.

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Keywords：*Soil Science, Education*

O20-4
[IDS2] Global Soil Partnership

Pillar Two of the Global Soil Partnership, from Concept to Endorsement

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The Global Soil Partnership (GSP) was formally endorsed by the FAO Council in December 2012 and has five important pillars as its foundation, this paper deals with Pillar 2: 'Encourage investment, technical cooperation, policy, education, awareness and extension in soil'.

Unlike the other Pillars, as its title indicates, it covers mostly cross-cutting themes which are all important in the fight to raise global awareness on the importance of soils for food security, provision of ecosystem services and sustainable development in general. The other pillars are more specific in their objectives and this adds to the challenge that this Pillar presents.

Soils and soil science have a low (but not necessarily poor) public image, particularly in the developed world. The grouping of, on the surface, diverse themes in this Pillar is based on the presumption that the current lack of investment reflects lack of public awareness, and low interest of decision-makers, which is, in its turn, a result of the deficiencies in soil education at all levels as well as in soil extension services for farmers. Awareness raising and education are seen as prerequisites for the achievement of the other strands in this pillar and this connectivity will be demonstrated.

The Action Plan has been developed with what we consider to be an unrefuted argument that we need a significant shift in policy and investment into soils. This shift would have three main applications:
• Facing the need for increasing food production
• Facing the issues of degrading ecosystems
• Facing global environmental change

The plan has been developed by soil scientists (mainly) with colleagues whose skills lie in investment and communication. Each component of the Pillar has been analysed and a number of recommendations were produced. Among the underpinning principles that the Action Plan follows are:

Education: Soil science education should not be viewed in isolation from education in related disciplines such as water conservation or ecology. Only by demonstrating synergy with other sciences will we demonstrate our relevance. Education should also not just be about the accumulation of knowledge but also the application of that knowledge to move forward.

Awareness raising: The need for this varies in different parts of the world but we need to use new technology and novel techniques to capture the attention of decision makers' and the public who also have influence. This aspect needs serious investment and employing professional communicators and advertising agencies

Policy: Convincing this audience is key to the success of the GSP. There is a clear link with the education and awareness raising strands and specific high profile events are needed to attract politicians. We must make the most of World Soil Year 2015 as an important component of raising the profile of soil at governmental level. Soil needs to be at the heart of environmental and sustainability policies, rather than on the fringes; again soil needs to demonstrate its vital role in the energy, water, food security, biodiversity, environmental change nexus.

Extension: Soil extension services provide a link between farmers, land managers and other users and the science community. Extension services need to interpret and present relevant research-based knowledge to stakeholders in an understandable and usable form. For good reasons, extension services have traditionally focussed on the production function of soils and this should be expanded to reflect and protect the multi-functional services of soil.

Technical cooperation: This aims at assisting in mobilizing resources for soil-protective agriculture, rural development, food security, nutrition and resilience (in particular for technology transfer and capacity building). In this context technical cooperation involves mutually beneficial collaboration rather than a direct donorship from one partner to another. This might include for example FAO and multiple partners, where FAO acts as a coordinator of joint activities, which could not be organized in the frames of Regional Soil Partnerships or other schemes.

Investments: These are tangible products of growing awareness of the importance of soil resources. Thus, the growth of investments will reflect our effectiveness as the promoters of soil through the other strands in the Pillar. Coupled with this, we need to prepare databases of 'problems', 'solutions', 'partners' and 'donors' to help develop the necessary links between these strands

Keywords：*investment, technical cooperation, policy, education, awareness,extension*

O20-5

[IDS2] Global Soil Partnership

The Challenges for the Eurasian Soil Partnership

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The Eurasian region in GSP is considered to include almost all the post-Soviet countries plus some neighboring states, which face similar challenges in soil management, degradation, and reclamation. The common feature of all the Eurasian countries is that they are supposed to have somewhat excessive soil resources, and thus historically the agricultural development has been extensive rather than intensive. An illusion of richness in soils was one of the reasons why the productivity of agricultural lands was relatively low in spite of the presence of extensive areas of Chernozems, which are believed to be the most productive soils in the world. Of course, there were also socioeconomic reasons (planned economy) and natural limitations (severe climatic conditions in Russia and some other countries) that caused the gap in agricultural production between the most developed European states and the countries of the Eurasian region. After the revolutionary transformation of the Eurasian space in the 1990th the agriculture in most of the post-Soviet countries suffered a shock: it failed to compete with intensive agriculture of Europe and other developed countries. In Russia the total area of lands transformed to fallow during 1990-2005 was 48 million ha, i.e. the area that almost equaled the area of Spain. Actually the area used for agriculture is growing in all the countries, including Russian Federation. Actually there are two possible ways for the development of agriculture in the Eurasian region. One of them is to follow the Western intensive technologies, increase the doses of fertilizers, and use advanced agricultural machinery. The other way is to use an opportunity given by the presence of vast areas of unused fertile land in Eurasia and to practice organic agriculture. The intensive and organic agriculture may be developed simultaneously in different parts of the region; for example, intensive agriculture in the areas with the best climatic conditions, and the organic agriculture in marginal lands. Also combined techniques may be developed, like landscape-adaptive agriculture approach. Soil scientists should take part in the discussion on the perspectives for agricultural development in the region, and give an advice to the decision-makers on the regional planning for the development of agriculture. In the case of the intensive agricultural development soil scientists should ensure sustainable intensification, soil conservation and environmental protection by developing rational system of soil use and management. In the case of organic agriculture soil science can help in the increasing of soil productivity and in the application of soil-friendly technologies. The regional soil partnership in the Eurasian region should be aimed at trans-boundary studies, intensification of the technology transfer and encouraging the dialog between the farmers and soil scientists. The nearest goals will be the formation of a bank of ideas and a marketplace of agricultural technologies adapted to the natural and socioeconomic conditions of the Eurasian region.

Keywords：*soil management, sustainable intensification, orhganic farming, soil conservation*

O20-6

[IDS2] Global Soil Partnership

Globalsoilmap's Oceania Node: Towards the First Node Version of a Finescale Soil Grid

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The GlobalSoilMap project is developing fine-resolution soil functional information as a response to the need to meet the challenges of food security, environmental degradation and climate change – at scales from the farm to the globe. This work has been organised through Nodes which aim to provide a local focus to establish collaboration, coordination and joint development of the new soil grid. The Oceania Node of GlobalSoilMap was launched on Feb 7th 2011in Bogor, Indonesia. It includes Australia, New Zealand, Indonesia, Timor Leste and the 22 nations within the Pacific community. It has developed a workplan across the Node to produce the first version of new information over the next three years: a comprehensive raster map covering the lands of Indonesia, Timor Leste, Australia, New Zealand and Pacific at a constant fine resolution (3 arcsec) with the key soil attributes needed to better model food production dynamics, environmental processes and climate change adaptation and mitigation.

The Node has developed capability through training, focussed workshops, increased and wider engagement, and cooperation in information management and connections based on an agreed set of principles for the Node's operation. A set of pilot projects has built confidence that the grid can be produced through this collaborative model. These projects include:

New Zealand: The New Zealand strategy for national GlobalSoilMap coverage is to integrate GSM into the national soil mapping and soil database development. Three precursor stages are being pursued. The first stage is the development of S-map, the new national soil maps programme providing national coverage at 1:50 000 scale; the second is redevelopment and modernisation of the National Soil Database and the third the development of a SoilML (soil information model) with Australian colleagues. The resultant integrated system will allow the derivation of the GlobalSoilMap system.

Indonesia: The Indonesian plan is built around the modernisation of a soil data system for Java, Sumatera and Kalimantan; digital soil mapping and GlobalSoilMap estimation in Nusa Tenggarra and Sulawesi. New approaches will be needed for west Papua and the Moluccas. This approach has been built around a comprehensive training program on the suite of methods needed for data compilation and estimation, in partnership with the University of Sydney.

University of Sydney: The University has provided a research and training foundation for the Node. Notably, it has developed (and tested with other Australian colleagues) new approaches to disaggregation of legacy soil maps.

Australia: In building the continent's first version of the complete GlobalSoilMap product, the Australian team has refined disaggregation techniques, developed new approaches to estimation, imputation and uncertainty measurement and has extended the GlobalSoilMap reach to other attributes including the regolith depth.

Information systems: A notable feature of the Node's developments has been the implementation of information systems approaches to data sharing and system interoperability.

The paper illustrates key aspects of the Node's progress.

Keywords：*Soil information, Soil estimation*

O21-1

[IDS7] The Soil Health: Human Health Nexus

The Soil Health-human Health Nexus

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Soils can beneficially or adversely affect human health, and likewise human activity can improve or destroy soil health. In the new anthropogenic era, it is worth examining the soil health-human health nexus. To do this, we can evaluate soil from the perspective of what infects us, what heals us, what contaminates us, what we eat, what we drink, and what we breathe. Likewise, we can examine the impact of humans on soil using a similar matrix and suggest strategies to improve human health by maintaining or improving soil health. This presentation will provide an overview of the soil health-human health nexus, and provide a framework for subsequent presentations in the symposium.

O21-2

[IDS7] The Soil Health: Human Health Nexus

Urban Agriculture-ground Zero for Soils and Human Health

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There is a current renaissance in urban agriculture manifesting in multiple forms. These include peri -urban agriculture, community gardens, and individual plots ranging in size from m2 to hectares. Crops from these 'farms' have the potential to meet a significant portion of growing demand for food. Urban agriculture may also alleviate food security problems for a subset of populations and increase general health through improved diet and increased exercise for all participants. In many cases these efforts represent the first or most significant contact that urban residents have with soils. Much of the research efforts on urban soils has focused on potential for contaminants in these soils to cause harm to farmers and their families. This emphasis fails to consider other critical factors for urban agriculture and may have unintended negative consequences. In addition to potential enrichment by lead and other contaminants, urban soils are typically neglected with high bulk density and low nutrient statues. Urban 'farmers' are typically ignorant of basic soil principles. Emphasizing hazards associated with urban soils may serve to discourage fledgling farmers. Instead, working to integrate education of basic soil principles and practices, including water collection and reuse and residuals collection stabilization and reuse have the potential to increase soil tilth and so associated yields as well as reduce the hazards associated with any contaminants that may be present in these soils.

Keywords：*urban agriculture, contaminants, residuals, food security*

O21-3

[IDS7] The Soil Health: Human Health Nexus

Relevance of Soil Climate Variations and Microclimate for the Distribution of Ticks and Tick Borne Diseases in South-west Germany

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In South-West Germany, the tick Ixodes ricinus is an important transmitter for pathogens causing diseases such as Borreliosis or tick borne encephalitis. During its life cycle the tick is developing from an egg to an adult and fertile organism via a larva and a nymph stage. After eclosion, for each transformation a blood meal from mammals is necessary. Here, ticks are not differentiating between human beings and other mammals, and use human beings as hosts if available. Consequently, very often it is assumed in the public that ticks are mainly waiting for human beings along forest trails or on meadows. However, human beings are not the main host of Ixodes ricinus that also can use other mammals like mices, but also larger ones like wild pigs and deer. Thus, high frequencies of ticks typically occur in forests providing a moist microclimate necessary for the water balance of the tick. Longer periods of higher saturation deficits can cause higher tick mortality. Therefore, relative air humidity and air temperature are reckoned to influence the activities of ticks. Low temperatures and relative air humidity are generally reducing ticks activities. However, ticks are living on the soil surface and consequently soil climate will influence the tick's vitality as well, but only little knowledge is available on this issue. Therefore, in 2012, we installed microclimate stations at 25 different locations across Baden-Württemberg in South-West Germany considering different altitudes and forest types. Twenty of these stations record soil moisture and soil temperature in 5 cm depth as well as air temperature and relative air humidity in 50 cm height. Five of them are intensive measurement stations also recording these parameters in 2 m height and in the litter layer. Furthermore, the soils were investigated for soil water budget relevant parameters such as grain size distribution, field capacity and permeability of the two upper soil horizons. Monthly, ticks were collected by the flagging method at every site and counted and main pathogens for Borreliosis and tick borne encephalitis were determined. First results show that the microclimatic influence on tick abundance in the different development stages depends on variation of local climate as well as on general climatic effects expressed by an average decrease of tick abundance with altitude. Furthermore, evidence was obtained that microclimatic influences are different on the activities of larva versus nymph and adult living phases of ticks. Water availability for ticks also depends on the soils' capacity to store water. First results show evidence that field capacity and grain size distribution, which are connected to the soil water budget, influence the tick frequency at the specific sites. Connections between tick transmitted pathogen bacteria and viruses and the microclimate are under current investigation. Here, local variations are at least partly even more evident as for tick abundance patterns. Conclusively, it can be stated that beside the availability of hosts, air and soil microclimate have a complex influence on the abundance patterns of Ixodes ricinus needing further detailed and long term investigations.

Keywords：*tick, tick born encephalits, Borreliosis, soil climate, microclimate, soil water balance*

O21-4

[IDS7] The Soil Health: Human Health Nexus

Relationship of Soil Cadmium Content and Wheat Grain Cadmium Concentration in some Wheat Cultivated Regions of Iran

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Wheat as the main food source has a main role in producing the proteins, and calories of the city and village societies of Iran. Today, the specialist's interest is toward the production and supply of the healthy food. Therefore, the wheat production with the high nutrient values (full of proteins and micronutrients), should be considered which have no pollutants such as cadmium. In this study, meanwhile, investigating the soil cadmium content and it's concentration in the wheat grains, the relation between the soil cadmium content and it's adsorbed value by wheat crop was investigated in some of the wheat farms of Fars, Khorasan and Mazandaran provinces. Keeping in mind, with the wheat crop area information of the related farms of each of the above provinces, in some of the farms with different characteristics (especially the P, Zn, and EC values), the soil and wheat grains samples were taken. The cadmium concentration in the soil and the wheat grains were measured with the standard methods. Using the statistical analysis, the correlation between the some of the soil and plant parameters, including the cadmium concentration in the soil and the wheat grains were determined. The results obtained showed that, the mean soil cadmium concentration in the Fars, Khorasan and Mazandaran provinces were in the order of 320, 187, and 323 μg/kg (p.p.b), and the mean wheat grains concentration in the Fars, Khorasan and Mazandaran provinces were in the order of 303, 250, and 263 μg/kg (p.p.b). The correlation between the wheat grains cadmium with the cadmium and other characteristics of the soil including the amount of Cl, P, and EC values were not significant statistically. Overall, we conclude that the cadmium concentration in the soil and the wheat grains were not passed the normal pollution rates. Therefore, the adsorbed and stored values in the wheat grains were not of such importance, and meanwhile there is no hazard in using the wheat crop produced, and the possibility of cadmium existence in the food chain (animal-plant) were not followed.

Keywords：*Cd, Wheat, Soil, Phosphorous, EC, Cl*

O21-5

[IDS7] The Soil Health: Human Health Nexus

Escherichia Coli O157:H7 Deposition, Survival and Toxic Genes Expression on Soil Clay Minerals in a Flow System

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Understanding bacterial pathogens deposition and survival processes in the soil-groundwater system is crucial to protect public health from soilborne and waterborne diseases. However, mechanisms of bacterial pathogen-clay interactions are less well studied, particularly in dynamic systems. Also, little is known about the viability of bacterial pathogens when attached to clays and their effects on toxic genes expression. In this study, a parallel plate flow system was used to determine the deposition kinetics and survival of Escherichia coli O157:H7 on montmorillonite, kaolinite, and goethite over a wide range of ionic strength (IS) (0.1-100 mM KCl). E. coli O157:H7 deposition on the positively charged goethite is greater than that on the negatively charged kaolinite and montmorillonite. Although the zeta potential of kaolinite was more negative than that of montmorillonite, kaolinite showed a greater deposition for E. coli O157:H7 than montmorillonite, which is attributed to the chemical heterogeneity of clay minerals. Overall, increasing IS resulted in an increase of E. coli O157:H7 deposition on montmorillonite and kaolinite, and a decrease on goethite. Interaction energy calculations suggest that E. coli O157:H7 deposition on clays was largely governed by DLVO (Derjaguin/Landau/Verwey/Overbeek) forces. The loss of bacterial membrane integrity was investigated as a function of time using Live/Dead BacLight viability assay. During the examined period of 6 h, E. coli O157:H7 retained its viability in suspension and when attached to montmorillonite and kaolinite; however, interaction with the goethite was detrimental. The toxic genes expression of bacteria when attached to clay minerals was studied ongoing. The information obtained in this study is of fundamental significance for the understanding of the fate of bacterial pathogens in soil environments.

Keywords：*Escherichia coli O157:H7;deposition;survival;gene expression; clay minerals*

O21-6

[IDS7] The Soil Health: Human Health Nexus

Current Status of Soil Contamination in E-waste Recycling Sites in South China

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Although banned by many countries, the informal recycling activities of electrical and electronic waste (e-waste) are still influencing the surrounding environments. As an important sink for pollutants, soil is severely contaminated by several kinds of organic pollutants and toxic heavy metals, such as PCBs, PBDEs, lead, zinc, copper and cadmium. This survey monitored the above-mentioned pollutants in soils contaminated by informal e-waste recycling activities in two areas in south China. The distinguished extents and constitutions of contamination caused by different treating activities are illuminated and compared. Results show that the pollution is reduced by forbidding informal recycling workshops. Nevertheless, effective remediation techniques are urgently needed for the reuse of soil and land in these areas.

Keywords：*e-waste; organic pollutions; heavy metals*

O21-7

[IDS7] The Soil Health: Human Health Nexus

Influence of Environmental Factors on Ecology of Soils of Shirvan Region of Azerbaijan

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Ecosystems of Shirvan are exposed to strong anthropogenous influence which amplifies by instability of the climatic conditions accompanied by periodic droughts. The basic anthropogenous factors of biogeocenosis changes are drainage and flooding of territories; agricultural land development, set of agrotechnical actions for increase of soils fertility, cutting down of woods and bushes, building of roads and industrial targets. One of problems which the region faces is desertification problem. It inseparably linked with a soil erosion, salification, chemical pollution and as a whole soil degradation.

The region climate is non-uniform: climate is damp in high-mountainous and middle- mountainous parts, in foothill-hilly - droughty, warm, in low-flat - dry and warm. The mountain zone of area is rich by mineral waters of medical and resort value. The springs rich basically by sulphur and hydrocarbonates are used as a source of medical and potable water. The mountain part is located at height of 700-3000 m over level of sea level.

Soil resources of region differ by variety. Mountain-meadow soils are generated on the alpine and subalpine meadows under wild motley grasses, on 1800-3000m above sea level. Brown mountain-wood soils (600-1800(2000)m above sea level) meet in middle-mountain zone under broad-leaved beechen and hornbeam mezophill forests. Korichnezem wood soils were generated in arid conditions climate (600-1200m above sea level). Mountain chernozems settle down on 550-800m and 1200-1500m above sea level. Distribution to a wood zone of mountain chernozems in the form of a relief plateau confirms their wood origin. Chestnut soils mostly are extended at height 200m in foothill and low-mountain zone. Grey soils meet on flat sites at height 150-200m above sea level. Meadow soils are generated in the conditions of a dry and semidesertic climate. Saline soils, solonetzic and marshy soils widespread local stains in low territories. Territorially, these soils are extended in the conditions of roast and an arid climate of the Kur-Araz lowland in a grey soil zones.

7 basic rivers proceeding in region: Kur, Goycaychay, Turyanchay, Girdimanchay, Agsuchay, Pirsakhatchay, Gozluchay, their chemical, bacteriological structure influences an ecological condition of a soil-vegetative cover of Shirvan. Pollution of the rivers occurs both superficial and sewage where get a waste and products of live ability of the person. Deterioration of physical and chemical properties of soils are observed, has amplified water and wind erosion. Unsystematic, intensive and all-the-year-round pasturage of cattle, absence of corresponding care of pastures have led to strong oppression and loss from structure of herbages of valuable fodder plants.

The basic industries of region are food-processing industry, processing local agricultural For today the ecological condition of Shirvan is regarded as satisfactory. Instability of Shirvan ecosystems negatively affects on it biogeocenose and there is actual a working out of measures on its preservation. Constant monitoring of a soil and vegetative cover gives the chance monitoring of an ecological condition of region. The full and all-round information is necessary for decision-making on protection of Shirvan environment.

Keywords：*soil ecology, environmental factors, Azerbaijan*

O22-1

[WG6] Urban Soils-Properties, Functions and Evolution

The Economics of Soil in European Urban and Peri-urban Contexts

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The study 'The economics of soil in European urban and peri-urban contexts' is prepared for the European Environment Agency. Soil is a key resource that needs to be well-managed as Europe develops a Green Economy. It supports a range of ecosystem services accessed by urban communities. However, its allocation and management within the wider land system is complex. A tension exists between a need to conserve fully-functioning soil systems that are essential for food production, an efficient water cycle and biodiversity, while meeting the demand for land for development of the built environment, which causes sealing and other irreversible degradation of soil. The economic assessment of alternative uses of soil will inform options for the future management of soil in urban and peri-urban contexts

Accordingly, the study reports, explores and develops an economic assessment of the services provided by soil resources to urban communities, including in the peri-urban zones that surround urban centres. First, it describes the role and explores the 'essentialness' of soils in supporting the provision of services vital to sustainable development. Second, it investigates how soil is exploited by urban communities to support a range of ecosystem services (e.g., platform for buildings, regulating water and temperature), and gives an appreciation of the economic importance of these resources through the relative costs and benefits associated with different uses and management. Third, it also describes and critiques the governance of soil in the urban and peri-urban contexts, including aspects of spatial planning; and thus contributes to the evaluation of options for soil governance.

Two relatively recent developments, the ecosystem services framework and the green infrastructure development, provide an appropriate intervention framework for appreciating and promoting the economic contribution of the soil resource, and its use and management.

Keywords：*soil, economics, urban and peri-urban, Europe*

O22-2

[WG6] Urban Soils-Properties, Functions and Evolution

Assessment and Monetization of Ecosystem Services of Soils in Urban Regions for the Example of Karlsruhe

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The general concept of ecosystem services was presented by the Millennium Ecosystem Report from 2005. Here, supporting, regulating, provisioning and cultural services of ecosystems were distinguished providing security, goods, health and good social relation to human beings to ensure their freedom of choice and action. Beside self-developing ecosystems without controlled action of human beings such as coastal or tropical ecosystems, agricultural, forestry and urban ecosystems only exist due to impact of man. The development and maintenance of these ecosystems controlled by man already caused larger material and chemical element fluxes as natural systems created without human activities. Soils in urban regions are exposed to manifold anthropogenic actions. Here, soils are sinks for pollutants, fundament for constructions, sealed by buildings and roads, transformed to gardens and parks, used as playgrounds, shifted from one place to another, or even excavated and finally abolished. Besides that, every new artificial surface exposed to weathering is initial parent material for new soil development. However, soils take over important ecosystem functions even in urban systems and thus serve for the benefit of the urban dwellers. Soils are storing water and contribute to allay the development of the urban heat island. Lawns, parks and gardens need the soil for plant growth. Trees in cities even often rely on the soils sealed by pavements. Soils on roofs (isolatic Technosols) improve indoor climate. Soils of cemeteries allow the safe degradation of corpses. Furthermore, soils store pollutants and protect the groundwater body, clean percolating rain water and reduce surface run-off with the positive consequence of an increased groundwater recharge. From the view point of biodiversity, soils are important parts of ecosystems providing the biotope for many species. Development activities are endangering all these positive ecosystem functions of soils. Economically, soils are only monetized according to the respective land prices or the costs for remediation actions in cases of legacies of pollution. The manifold ecosystem services soils provide in urban regions are mostly neglected. These ecosystem services of soils were assessed and partly monetized in the City of Karlsruhe on the basis of a biotope mapping for nine selected urban quarters. Karlsruhe is located in the Federal State of Baden-Württemberg in South-West Germany. Soil services were evaluated for biodiversity, food and wood production, recreation, climate regulation, flood water retention, nutrient regulation and groundwater recharge. According to the high land use diversity of urban systems the soil services identified in the urban quarters investigated extremely vary. Nevertheless, the ecosystem services of urban soils easily account up to several thousands of Euro per hectare. More and extended detailed analyses of the monetary value of soils within urban systems are urgently needed to support argumentations to protect inner urban non-sealed soils against further development.

Keywords：*urban soils, ecosystem services, monetary value, urban systems, urban development*

O22-3

[WG6] Urban Soils-Properties, Functions and Evolution

Carbon Capture in Urban Soils

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Urban soils represent a significant sink for atmospheric CO2 (Washbourne et al., 2012), as a consequence of carbonation reactions that take place through the weathering of calcium silicates, mostly derived from concrete. We have previously shown that the amount of inorganic, carbonate, carbon within urban soils can reach 300 tonnes C/ha to 3 m depth (Renforth et al., 2009), greater than the organic C content of agricultural soils. Here we present evidence for the rate of accumulation in urban soils of inorganic carbon in carbonate minerals to 0.1 m soil depth.

Newcastle Science Central is a 10 ha development site in city-centre Newcastle, with an artificial soil (made ground) surface composed of material derived from demolition and superficial natural clays. Precisely located sampling (within 25 mm) of the top 0.1 m of soil at an interval of 18 months has been carried out, with determination of soil carbonate contents. These analyses have shown that the calcium carbonate content of the soil increased from 376 to 670 tonnes per hectare, corresponding to an increase of 16 tonnes CaCO3 per hectare per month to 0.1 m depth, or removal of 86 tonnes CO2 per hectare annually. In comparison with agricultural soils, the soil inorganic carbon stock increased from 45 to 80 tonnes C per hectare in 18 months, approaching values similar to those reported for organic carbon in arable land (84 tonnes C pre hectare; Smith et al., 2000).

Carbon and oxygen stable isotope data demonstrate that the carbonate is derived from the atmosphere, predominantly through hydroxylation reactions given the high soil pH and low levels of vegetation at the site. Calcium is derived from the weathering of silicate minerals within the soil, and from dissolution of the calcium hydroxide cement mineral portlandite.

The carbon capture potential of this site is limited by the availability of Ca derived from weathering of cement-derived minerals. However, related work on natural calcium silicates has shown that similar reactions take place (Manning et al., 2013). Overall, management of urban land by addition of artificial and natural calcium silicates that react to provide a calcium carbonate product provides the opportunity to design a carbon capture function into an urban soil. Extrapolating to 1 m depth, approximately 7000 ha land (a small proportion of urban land turnover in most countries) is capable of achieving removal of 1.0 Mt CO2 annually.

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Keywords：*Soil carbonate, carbon capture, cement, concrete*

O22-4

[WG6] Urban Soils-Properties, Functions and Evolution

Features of Soils of Abandoned Industrial and Mining Areas for Forestry

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In urban areas occur often abandoned industrial and mining sites. Many of them have the problem that they cannot be used again for development of industrial, commercial or residential areas. So the question comes up what alternative land uses are possible. Of interest would be a natural use of the sites. This opens the chance to use the sites for compensation and substitution measures for land lost by establishment of construction at other sites as required by the landscape act from 1994 of the Federal State North Rhine Westphalia (NRW), Germany

Urban areas have often a shortage of wood. Therefore it would be of interest to prove the suitability of the sites and their soils for establishment of urban forests. This was investigated in the old northern part of the city of Essen, Germany, which was heavily affected by heavy industry and hard coal mining before.

For the assessment of the sites the landscape act of NRW recommends a 5 step procedure based on the soil functions: habitat for soil organism, habitat for wood vegetation close to nature, body of balance for the water household and filter, buffer and transformer of hazardous substances.

The 5 sites and their soils investigated were (1) deposits of rubble which were vegetated by a 40 years old birch tree stock, (2) soils from rubble, hard coal mining spoil and ash which were vegetated by sycamore maple, (3) a heap from hard coal mining spoil vegetated by 80-100 years old robinia stand, (4) soil from mixture of not clearly identified material containing fly ash and some mining spoil residues which were vegetated by about 15-20 years old sycamore maple, hornbeam and small-leaved lime trees, (5) an about 30 years old waste tip from diverse materials such as ash, coal, bricks, brick grit, fine sandy loam, styrofoam, iron wires, iron girder. In a depth of 60 cm a liner from a plastic sheet occurred, which separates the waste from the underlying Stagnic Gley. The vegetation was from sycamore maple and few black alder trees.

With aid of the assessment of the above described 5 step procedure the soil from deposits of rubble (1) and the soil from rubble, hard coal mining spoil (2) were fit for the long term use for woods. They meet the minimum requirements of soil physical and chemical properties. They are eligible for substitution measures for lost land according to the landscape act of NRW

The results of the assessment of soil of the mining spoil heap (3) excluded the suitability for substitution measures. The soil was acid, had reductomorphic properties and adverse proportions of water and air household, low nutrient retention potential and low filter potential.

The not clearly identified material containing fly ash and some mining spoil residues (4) had low properties for filtering, buffering and transforming hazardous substances.

The soil from waste deposits above a Stagnic Gley (5) was due to the plastic sheet between the deposits and underlying natural soil assessed as not appropriate. The soil function body of balance for the water household was disturbed.

Although all investigated sites were afforested not all of them met the requirements for a proper use for substitution measures. But at least they are all an enrichment of landscape and an offer for recreation of the urban population

Keywords：*industrial areas, mining areas, forestry, compensation measures, landscape act NRW*

O22-5

[WG6] Urban Soils-Properties, Functions and Evolution

Ekranic and Urbic Technosols of Debrecen

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Debrecen is situated in the eastern part of Hungary, at a distance of 230 km from the Budapest. With an area of 461.65 km2 and a population of slightly above 200 000, Debrecen is the second largest and most populated city of the country. Through the centuries, the natural deposits have been overlain by younger anthropogenic and technogenic sediments, and today the original soil surface can be found at a depth of 2-3 m (Csorba 2008). Central area has the highest ratio of soil sealing − 75%. The areas surrounding the city centre are higher, therefore the cultural layer is usually thinner. Recently in the eastern part of Debrecen, were built districts of detached houses, and sealed areas represent there less than 50%. Whereas in the western part of the city, multi-storey blocks of flats dominate and the sealed soils cover between 50 and 75% (Szegedi 1999, 2003).
Regarding the urban soils of Debrecen, so far only few papers was published. Szegedi (1999) carried out research on the distribution pattern of heavy metals coming from the transportation and on its urban ecological effects. Sándor and Szabó (2013) examined soil features modified by technogenic factors, the vertical distribution of the toxic heavy metals and classification of the soils according to the WRB system. Many Technosols from Debrecen were presented in Technogenic soils atlas (Sándor et al. 2013).
The aim of the presented studies is to determine the properties of Ekranic Technosols and compare them with nearby not sealed soils (also urban) to assess the effect of sealing.
The field works were carried out in 2013. Three sites were selected. In each location two soil pits were made: Ekranic Technosol and reference one, devoid of sealing.
The analysed soils were characterised by increased pH values compared to natural soils Values of pH in sealed soils ranged from 7.5 to 9.0, in reference ones from 6.8 to 8.8 (in H2O). Increased pH is mainly caused by the occurrence of artefacts containing CaCO3.
The content of organic carbon (OC) highly varied in the analysed soils – from 0.07 to 2.76%. The vertical distribution of the OC content indicates a strong technogenic effect; layers of humus-rich lie alternately with humus-poor ones. The total content of nitrogen (Nt) has a similar pattern. Phosphorus soluble in 1% citric acid solution in the studied soils ranged from 35 to 541 mg•kg-1.
Total content of Zinc was from 7 to 92 mg•kg-1, of copper from 18 to 56 mg•kg-1, of lead from 25 to 104 mg•kg-1. The content of Pb, Cu, Zn and Cd in most layers didn't exceeded pollution limits, only in one layer content of lead was above Hungarian norms - <100 mg/kg (2009).
It can be concluded that soils of the centre of Debrecen are under strong technogenic influence. In all of the examined profiles artefacts was found, which were mostly building waste material, therefore the technogenic origin is evident. High content of artefacts in 5 out of 6 sites, fulfilling the WRB criteria allowed to use Urbic qualifier in classification of investigated soils.

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Keywords：*Technosols, Ekranosols, Ekranic qualifier, soil sealing, urban soils, Hungary, heavy metals*

O23-1

[DS3] Modelling of Soil Properties and Processes - Challenges and Opportunities

Molecular Simulation Techniques for Complex Soil Systems

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Molecular dynamics simulations give insight into molecular processes at a resolution that is often inaccessible by experiments. The structure and (thermo)dynamics of small molecules interacting with various media are commonly studied by computer simulations in material sciences and biomolecular sciences. However, extensive molecular simulations of soil constituents are hampered by ill-defined molecular systems and restrictions in the description of the relevant interactions.
Here, we present a library of building blocks for classical molecular simulations of humic and vulvic acids as relevant components of soil. An approach to establish condensed phase, amorphic systems will be presented, which can subsequently be used for extensive in silico experiments, e.g. addressing the structure of the systems, the their thermodynamic stability or the adsorption of small molecular pollutants. We will demonstrate the need for extensive sampling of the conformational space and suggest applications of modern simulation methods to soil components.

Keywords：*Molecular dynamics simulations; humic substances*

O23-2

[DS3] Modelling of Soil Properties and Processes - Challenges and Opportunities

Visualisation and Validation of the Water Release Curve using X-ray Computed Tomography

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Understanding how water is distributed in soil and how it changes during the redistribution process or from root uptake is crucial for enhancing our understanding for managing soil and water resources. The application of X-ray Computed Tomography (CT) to soil science research is now well established; however few studies have utilised the technique for visualising water in pore spaces due to several inherent difficulties. Here we present a new method to visualise the water content of a soil in situ and in three-dimensions at successive drying matric potentials. A water release curve was obtained for different soil types using measurements from their real pore geometries. The water, soil, air and root phases from the images were segmented using image analysis techniques and quantified. These measurements allowed us to characterise pore size, shape and connectivity for both air filled pores and water. The non-destructive technique enabled water to be visualised in situ and repeated scanning allowed wetting patterns to be analysed. The experimental results were validated against conventional laboratory derived water release curves and specifically developed mechanistic models of soil-water-root interactions. Micro-scale revelations of the water-soil-root interfaces enabled us to make macro-scale predictions on water movement in soil. It is envisaged that this research will inform interdisciplinary scientists and farmers to improve current mathematical models on root water uptake and soil management techniques.

Keywords：*image analysis: modelling; pore geometry; soil water; water release curve; X-ray Computed Tomography*

O23-3

[DS3] Modelling of Soil Properties and Processes - Challenges and Opportunities

Building 3D Soil Models Combining X-ray Ct and 3D Printing Technology. First Applications to a Loamy Soil

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The use of manufactured geometrically rough models mimicking soil structure allows to study bio-geochemical processes affecting the vadose zone (e.g. water movement, microbial competition and movement). So far, to assure reproducibility in the investigation of soil structure-related processes only simple and homogeneous packed columns of aggregates have been used. 3D printing technology is maturing today to overcome these limitations and reproduce the physical heterogeneity of the soils at high resolution. In fact, operating at small spatial scales is now possible even for complex porous structures, reconstructing the surface of the samples with 3D printing techniques.
The objective of this study was to evaluate the feasibility of using 3D printing technology coupled with X-ray microtomography (microCT) in order to create replicated structures of a loamy soil and compare different methods for optimizing their construction.

Undisturbed soil samples (2.5 cm diameter × 2.5 cm height) were collected in a long-term experiment on cropping systems located at the University of Padova, Italy. In two blocks, plots subjected to contrasting treatments with farmyard manure (60 t ha-1 y-1) and no-fertilisation were selected. Samples were scanned with an X-ray microCT (Skyscan 1172) operating at 100 kV × 100 μA with projections collected during a 180° sample rotation at 0.2° angular incremental step. Final pixel resolution was 40 μm. A 3D image dataset of each soil core was cropped to a region of interest corresponding to a cylinder of 625 pixels diameter (2.4 cm) and 625 continuous slices depth (2.4 cm) and finally binarized to differentiate between pores and soil matrix.
From the voxel data, the surface of the pore network was extracted in polygonal meshes with size of 0.5 and 10 million triangles and converted in stereo lithography file format (STL). Depending on resolution, meshes retained the bulk characteristics of the pore volume but introduced some smoothening of the surface walls compared to real soil.
The digital models were finally used to create a total of eight 3D solid prototypes (2 fertilisation treatments × 2 accuracy levels × 2 cleaning treatments) with a professional ProJet® 3510 HD 3D printer (3dsystems). The 3D printer deposed a curing resin mixture slices by slices at a resolution of 16 μm (Visijet Crystal®, roughly composed by 15-30% bisphenol A ethoxylated diacrylate, 20-41% urethane acrylate oligomers, 1.5-3% tripropyleneglycol diacrylate) and was supported by paraffin during the printing process. Once printed, the prototypes were opaque, white and rigid. Since the solidified paraffin was intruded in the samples and sealed the pores, two methods of cleaning were tested, i.e. (1) ultrasonic cleaning in a heated oil bath and (2) vapor steam cleaning. Finally X-ray analysis were performed on the prototypes to compare them with the original samples in terms of total porosity, pore size distribution, pore morphology. Pores > 40 μm were represented in the 3D prototypes. Results indicated that mesh size did not significantly improve the fidelity of pore reproduction although some smoothening was observed at 0.5 million triangles. Vapor steam cleaning favored the paraffin flush out while an higher fraction of occluded narrow pores was observed with ultrasonic treatment. As a result, in the latter pore connectivity was reduced. We showed that prototyping the soil structure heterogeneity with 3D printing is a promising technique, although advancements in resolution and cleaning treatments are key aspects that still need to be improved.

Keywords：*x-ray CT; soil structure; porosity; 3D printer*

O23-4

[DS3] Modelling of Soil Properties and Processes - Challenges and Opportunities

A Computerized Model of Soil Structure Integrating Biological and Physical Processes to Assess the Impact of Reduced Tillage

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The concept of soil structure is well-established in the field of soil science. It can be defined as the spatial arrangement of voids and solids in soil. However behind this simple definition is hidden a huge variety of solids depending on their size and of voids that are filled with various gas and liquids. Soil structure results from the pilling up of voids and solids which forms structures of various shape and continuity. To this "spatial heterogeneity" one has to add the temporal dynamics that is linked to agents' activity. Among these structuring agents, the best known are: (i) the mechanical action of soil tillage (ii) earthworms through their burrowing activity and faeces production and (iii) the climate impact in particular due to rain and temperature. Lastly, soil structure is very often studied because of its impact on soil functional properties, e.g. water percolation, soil water conductivity, soil oxygen supply. In a context of farming practices shift towards non-ploughing techniques, it is needed to evaluate impacts on soil structure and consequently on its functional properties

The study of soil structure and properties comes up against the opaqueness of soil. This is why, study techniques have to be building up: they are either direct (e.g. 2D thin sections, tomography) or indirect (e.g. bulk density, pore-size distribution). However they have their own drawbacks such as their cost in time and money or the destruction of the sample. Modelling is a way to bypass some of these drawbacks. A review of existing computerized models of soil structure shows that they may be split into two categories: (i) the one that simulates soil structure using measured parameters and (ii) the one that builds a soil structure by simulating processes that are its base.

The first category allows transposing a real soil structure into a computerized one by using a parameter, e.g. pore-size distribution, porosity, water retention curve. This computerization goes with various limitations such as a size limitation both up and down due to computer memory limitation or geometric limitations. But these models do not deal with the difficulty to access soil structure by itself because input measured parameters are needed. The second category groups models that start from either a virgin structure or a structure coming from category (i). By now, this starting structure is then altered according to only one structuring agent. At present, there is a need for a model of soil structure that is dynamic, explicit (3D) and that may be common for a large set of structuring agents. A first proposal, based on the strong assumption that soil is fractal, was proposed by Marilleau et al. (2008). Our model aims at helping to assess farming practices and notably the shift from ploughing to non-ploughing systems. Three structuring agents were chosen: tillage, earthworm's activity and solid particles settlement due to the climate. It first focuses on the building of a computerized soil structure which is a common base to simulate the agents. It aims at being as generic as possible by using an object-oriented structure. The concept of voxel is used to split the soil into elementary units and each of these voxels displays a state chosen within a pre-established list (e.g. fresh organic matter, voids). In order to manage memory footprint and to improve simulation speed, voxels are grouped into piece. This grouping allows reducing memory consumption by using an encoding algorithm which takes part of the recurring structure of the soil at small scales. As seen previously, models of category (ii) sometimes start from an existing soil structure, in our model this initial structure is defined using simple parameters such as porosity and fresh organic matter content. By doing so, one is able to account for: e.g. a dense plow-pan. The model is coded in both Python and C++ and has been coupled with a simulator of earthworm activity yet. This simulator accounts for faeces and burrows production of two ecological categories (anecics and endogeics). A simulator of tillage effect (ploughing vs non-ploughing) and settlement will be soon added.

To conclude the model produces various outputs such as the resulting soil structure, earthworm's trajectory that are analyzed to assess farming systems.

Keywords : *process-based, dynamic modelling*

O23-5

[DS3] Modelling of Soil Properties and Processes - Challenges and Opportunities

Does the Fractal Behavior of Surface Soil Water Storage Holds at Multiple Depths?

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Knowledge on the spatio-temporal behavior of soil water has important hydrologic applications. Data intensive measurement of surface soil water using remote sensing has established that the spatial variability of soil water can be described using the principle of self-similarity (scaling properties). This information can be used in deciding land management practices provided the relationship holds at deep layer. This study examines the scaling properties of soil water below the soil surface using intensive sampling, thereby allowing the information to be available to the plant root and vadose zone models. Soil water storage down to 1.4 m depth at seven equal intervals was measured along a transect of 576 m for 5 years. The surface soil water storage showed multifractal nature only during the wet period indicating the need of multiple scaling indices in transferring soil water variability information over multiple scales. However, with increasing depth, the soil water storage became monofractal in nature indicating the need of single scaling index to upscale/downscale soil water variability information. The dynamic nature made the surface layer soil water highly variable compared to the deep layers in wet period. On contrary to the wet period, all soil layers during the dry period were monofractal in nature may be due to the high evapotranspirative demand of the growing vegetation. Strong similarity between the scaling properties at the surface layer and deep layers provides the possibility of inferring about the whole profile soil water dynamics using the scaling properties of the easy-to-measure surface soil water storage data.

Keywords：*soil water storage, monofractal, multifractal, power law, vadose zone, scaling, self similarity*

O24-1

[DS2] A: Soil Development and Soil Properties and Functions

Evolution of Soil Functionality in Natural and Artificial Soil Systems

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Natural soils are complex systems with various interactions between mineral surfaces, organic matter (OM) and microorganisms resulting in highly heterogeneous structures that control soil functionality. Here we report about an experimental pedology approach combining investigations on the evolution and functionality of natural and artificial soil systems.
In a new experiment 'artificial soils' were produced by incubation of pure minerals, organic matter (OM) and a microbial inoculum from a natural soil under neutral pH conditions. The complexity of the C stabilization process was reduced to formation of organo-mineral associations and aggregates through microbial products interacting with mineral components with known composition and initial properties. The key technique for tracking the biogeochemical cycles of C and N was used by stable isotope labelling (13C, 15N) of added litter material. Nano-scale secondary ion mass spectrometry (NanoSIMS) enabled the direct visualization of 13C and 15N down to a lateral resolution of 150 nm and was used to identify organo-mineral associations by the simultaneous detection of ion species derived from the organic (C, N) and inorganic (Al, Si, Fe) components of the associations.
We tested (1) the effect of the mineral composition and charcoal as components on the long-term development of a soil-like system, (2) the formation of macroaggregates and development of organic matter, and (3) the response of natural and soil-like systems to OM addition (13C and 15N labeled) with respect to respiration and microbial communities established as a function of the soil composition. The results from these experiments show that there are redundant mechanisms of aggregate formation in soils, depending on the presence or absence of mineral materials. These aggregates are formed during the decomposition of the organic substrate by a microbial community that differentiates during incubation in dependence of the mineral composition. The results show that a microbial habitat developed during the first phase that allowed for a higher mineralizing activity in all artificial soils developed, but to a different extent controlled by the mineralogical composition. Our experimental approach offers a valuable model where the formation and interactions of soil properties and processes can be studied in a well-defined system.
Incubating a sieved (<2 mm) topsoil with labelled litter, we found that only some of the clay-sized surfaces bind organic matter. Surprisingly, less than 19% of the visible mineral areas showed an organic matter attachment. Our data show that only some of the clay-sized mineral surfaces, namely those with rough surfaces, react with OM and thus contribute to OC and ON sequestration. We demonstrated for the first time that small mineral particles with rough surfaces in organo-mineral clusters provide the essential reactive interfaces for OM sequestration. Our results clearly indicate that mineral particles with a smooth surface are not suited for substantial OM sequestration, presumably because they do not have etch pits, micropores or cracks. We could show that new organic matter is preferentially attached to already present organo-mineral clusters. These rough surfaces were found to be the nuclei for additional OM accumulation and therefore to control the C and N sequestration potential of soils. Our data point to the necessity for careful identification and quantification of the reactive mineral complexes that are responsible for OM sequestration and that control the OM saturation capacity of soils.
These findings have major implications for our understanding of fundamental soil functions that are controlled by the available soil interface and the surface reactivity of the fine soil fraction, such as cation exchange capacity, pollutant binding capacity, and physical properties.

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Keywords：*soil organic matter, soil formation, aggregate, organo-mineral associations*

O24-2

[DS2] A: Soil Development and Soil Properties and Functions

Changes in Soil Properties due to Afforestation of Former Agricultural Lands in the Boreo-nemoral Zone

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This chronosequence study focuses on forest succession and related changes in soil properties (morphological, physical and chemical) of former agricultural lands in the boreo-nemoral zone.

Soil sampling sites of each chronosequence were chosen to differ in age of forest landuse (25-167 years) and soil parent material (formed by Quatenary deposits – glacial till, glaciolacustrine deposits, Baltic Ice Lake and eolian sediments). Soil samples were collected from the genetic horizons of soil profiles and the following soil properties were determined according to USDA (2004) and FSCC (2006) methods:

• soil texture (sand, clay, silt content, %);
• soil pHKCl value;
• cation exchange capacity (cmol kg-1);
• base saturation (%);
• content (mg kg-1) of non-silicate (free) aluminium (Ald) and iron (Fed) compounds;
• content (mg kg-1) of crystalline non-silicate aluminium (Alpyr) and iron (Fepyr) compounds;
• content (mg kg-1) of amorphous non-silicate (reactive) aluminium (Alo) and iron (Feo) compounds;
• content (cmol kg-1) of exchangeable aluminium (Alex) and iron (Feex) compounds.

Magnetic susceptibility value (m3/kg SI) was measured using a Bartington Magnetic Susceptibility System MS2B Dual Frequency Sensor.

Soil groups of Luvisols, Albeluvisols and Stagnosols were determined according to WRB (2007) in sampling sites where soil parent material was formed by loamy sand and loam, and respectively - Arenosols and Podzols on sandy soil parent material.

Changes in soil morphological features, soil chemical properties and magnetic susceptibility were observed during the afforestation succession on abandoned agricultural lands

Previous studies show that secondary podzolization features could be observed within 100 years of the start of afforestation (Nikodemus et al., 2013).

With increase of forest landuse age, the development of the secondary E and B horizon was accompanied by a decrease in pHKCl value, cation exchange capacity and base saturation and leaching of aluminium and iron compounds from the mineral topsoil layer, irrespective of the genesis of soil parent material. Lower content of aluminium and iron compounds and magnetic susceptibility value were found in mineral topsoil layer in sampling sites where soil parent material was formed by sands, in comparison with loamy sand and loam.

In the former plough horizon (formed by loamy sand), during the first 70 years after start of afforestation, the following changes in

the most important soil properties were observed:

• pHKCl value decrease from 3.97 to 3.40;

• cation exchange capacity decrease from 5.31 to 4.52 cmol kg-1;

• base saturation decrease from 87.92 to 59.17 %;

• magnetic susceptibility value decrease from 39.29 x 10-6 to 37.32 x 10-6 m3/kg (SI).

Furthermore, in the illuvial B horizon (formed by loam) there was an increase in magnetic susceptibility value from 90.36 x 10-6 to 166.76 x 10-6 m3/kg (SI), which can be explained by an increase of iron compound content. However, an increase in aluminium compound content also was found in the illuvial horizon.

Higher accumulation of aluminium and iron compounds as well as increase of magnetic susceptibility value in illuvial B horizons indicates development of podzolization. Furthermore, relationships between clay content and magnetic susceptibility and content iron compounds indicated that development of podzolization depended on soil texture and soil parent material and origin of geological deposits. In general, effect of afforestation on topsoil properties was also established.

This study is supported by the European Social Fund No. 2013/0020/1DP/1.1.1.2.0/13/APIA/VIAA/066.

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Keywords：Land abandonment, Soil forming processes, Podzolization

O24-3

[DS2] A: Soil Development and Soil Properties and Functions

Effects of the Mound-building Termite (Macrotermes Bellicosus) on Iron (Oxyhydr) oxide Mineralogy in Highly Weathered Tropical Soils

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Termites (Isoptera) are regarded as one of the major ecosystem engineers which modify soil biophysicochemical environments and resource availability to other organisms in tropical ecosystems. It is well known that the termites manipulate soil material trough preferential selection of finer soil particles, but their influences on soil mineralogical composition have not been examined extensively. There have been several reports in the literature on this issue but most of them have assessed phyllosilicate minerals only and much fewer have addressed free iron (oxyhydr)oxides in the soil. In my previous paper (Abe and Wakatsuki, Pedobiologia, 2010), the selective dissolution analysis suggested that the mound-building termite (Macrotermes bellicosus) altered forms and composition of free iron (oxyhydr)oxides in a soil catena overlying the Basement Complex rocks of Southwest Nigeria due to altered moisture regimes in soil material incorporated into the termite mounds. However, detailed mineralogical analyses are still needed for further research. Therefore, differential thermal analysis, thermogravimetry, X-ray fluorescence analysis and differential X-ray diffraction analysis were performed to analyse iron (oxyhydr)oxide mineralogy deeply by comparing soils that constitute termite mound structures with those of surrounding soil horizons free of any visible sign of termite activities. Findings obtained from the present study will be discussed in this presentation.

Keywords：*Differential thermal analysis, Thermogravimetry, Differential X-ray diffraction analysis, X-ray fluo*

O24-4

[DS2] A: Soil Development and Soil Properties and Functions

Initial Stage Processes of Soil Development Processes observed by a Field Experiment

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Soil development is considered a slow process under a natural condition. We hypothesized that it can be facilitated by anthropogeneic disturbances such as tillage and organic amendment. A field experiment was established eight years ago, with the parent material of Mollisols dug out to the surface soil and used under two perennials and four cropping with the above-ground biomass partially or totally incorporated into soil. The structures of soil pores from aggregates to core scale (characterized by micro-CT), nemato and microbial communities (characterized by PLFAs) and mineralogies (characterized by decomposition of X-ray spectrum) were investigated to examine the effects of land use, soil depth and aggregate size and their interactions on soil organic carbon. The preliminary results demonstrated that soil physico-chemical properties were largely and linearly affected by the amount of organic C input under different land use and leached to deeper depth. The variation of mineralogical structure results from the interaction of weathering (particle size and leaching) and the amount of organic C input. The microbial community structure is affected by soil physical and chemical properties in two separated dimensions. Tillage seems to be the first driving force causing the contrasting separations from the parent material under the perennials and cropping systems. The quality and quantity of organic C input is the second driving force causing the separation from the typical Mollisol under cropping. Nemato structure is more related to trophic condition rather than soil physical condition. The results suggest that there is shortcut to facilitate soil development and recovery soil function for example by agricultural practices such as physical intervention and increasing the amount of organic matter.

Keywords：*Soil development, Soil Microbial community structure, Soil porous structure, Soil Mineral Structure; Soil organic C*

O24-5

[DS2] A: Soil Development and Soil Properties and Functions

The Parental Source of the Terra Rossa like Soils on the Liuchiuyu Island, Taiwan

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There are red soils overlying the coral reef of the marine terrace along the Liuchiuyu Island, a small offshore island of the southwestern Taiwan. They resemble the “Terra Rossa” of the Mediterranean region which formed by decalcification and silicate enrichment for the insoluble residuum of carbonate or limestone. There are examples show the Terra Rossa like soils may develop, instead of in-situ weathering from the parental limestone, from the deposits with addition of eolian material. The fact that modern dust storm may reach Taiwan casts a question of the eolian origin for the Terra Rossa like soils on the Liuchiuyu Island.

Field observation shows the sharp boundaries between the surface red soils and the underlain limestone strata, suggesting a different parent material and a complex pedogenesis for these soils is indicated. In this study, the soil morphology and the chemical properties are examined and analyzed to assess their degree of soil development. Sr isotopic data are applied to trace their parental sources. The result indicates the material of the “Liuchiuyu Mudstone” (the formation directly under the “Liuchiuyu Limestone”) serves as the major source with minor component input from the drift sand transported by longshore currents.

Keywords：*red soil, Terra Rossa, eolian, pedogenesis, coral reef*

O25-1

[C2.5-3] A: Mechanism Controlling Greenhouse Gas Emissions from Soils

Management Options to Control Methane Emissions from Rice Paddy Soils

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Paddy soils are recognized as one of the major anthropogenic sources of atmospheric methane (CH4). Because the harvest area of rice has increased significantly during last several decades, it is likely that CH4 emission has increased proportionally. Due to the large amount of the global emissions, the reduction in CH4 emissions from paddy fields is very important to stabilize its atmospheric concentration. In addition, because of the possibility of controlling the emissions by agronomic practices, rice cultivation must be one of the most hopeful sources for mitigating CH4 emissions.

Methane production in paddy soils is a process occurring in strictly anaerobic conditions. Like any other biogenic sources, CH4 is produced by the activity of methane producing archaea, or methanogens, as one of the terminal product in the anaerobic food web in paddy soils. After the soil was flooded, the redox potential of soil decreases rapidly by the sequential biochemical reactions. A part of produced CH4 is consumed by methane oxidizing bacteria, or methanotorophs, in aerobic zones in paddy soils such as surface soil-water interface and the rhizosphere of rice plants. The emission pathway of CH4 which are accumulated in flooded paddy soils are: diffusion into the flood water, loss through ebullition, and transport through the aerenchyma system of rice plants. In the temperate rice fields, more than 90% of CH4 is emitted through plants, while significant amounts of CH4 may evolve by ebullition, in particular during the early part of the season in the tropical rice fields. Therefore, it is concluded that the possible strategies for reducing CH4 emissions from paddy fields can be made by controlling either production, oxidation, or transport processes.

Since methanogens require highly reducing conditions for their activity, arresting the development of soil reduction is one of the most effective ways of decreasing CH4 production rate in soils. This can be accomplished by aerating soils during the flooding period with altering water management, or by inhibiting the progress of the sequential redox reactions with adding chemicals. This option may simultaneously enhance CH4 oxidation rate in soils. Reducing the amount of labile organic matter in soils by composting organic fertilizer or promoting aerobic decomposition of rice residue and other biomass is another effective way of controlling CH4 production in soils. Since rice plants also have a significant contribution on production/oxidation of CH4 in the rhizosphere and its transport to the atmosphere, selection of rice variety that emits small amount of CH4 may also be effective to mitigate CH4 emissions from paddy fields.

In various candidates of the mitigation options, water management is thought to be the most promising one because it has technical feasibility to irrigated paddy fields and has already extended to many countries as the alternate wetting and drying (AWD) system due to the synergy with water saving. A Japanese national campaign of field experiments across the country for two years demonstrated that seasonal CH4 emissions were effectively reduced at most sites by prolonging mid-season drainage (MD) beyond its conventional duration. Increase in the emissions of nitrous oxide (N2O), which is known as a trade-off of CH4 emission reduction, was much smaller than the reduction of CH4 emission in terms of GWP-based CO2-equivalent. Compared to conventional water management strategies, the seasonal net 100-year GWPs (CH4 + N2O) was reduced by 28.0±3.1% while maintaining grain yields as high as 96.2 ± 2.0% by prolonging MD. The results of field experiments were further analyzed with using simulations by a process-based biogeochemistry model, the DNDC-Rice, in order to estimate the mean effect of prolonged MD on CH4 emissions. As a result, a long-term (20-year) simulation calculated a mean reduction rate of 20.2±5.6% when acceptable prolonged MD practice was conducted.

Other options, especially organic matter management, have also been demonstrated their promising potentials to mitigate CH4 emissions from paddy fields. Understanding of the management options to control CH4 emissions from paddy soils has vastly improved during the past two decades. The next step should focus on developing social frameworks that can extend these technical options to local farmers. In general, any efforts to mitigate CH4 emissions from rice cultivation through changes in agricultural practices should attempt to achieve synergy between climate change policies and sustainable development.

Keywords：*greenhouse gas, methane, mechanism, mitigation, rice*

O25-2

[C2.5-3] A: Mechanism Controlling Greenhouse Gas Emissions from Soils

Greenhouse Gas Emission from Organic Amendments applied Soils- Emission Processes, Controlling Factors, and Mitigation Options

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The use of organic amendments including manures, crops residues, and biosolids as a source of plant nutrients and carbon (C) is rapidly increasing. For example, globally, about 32.2 million ha of agricultural land is managed organically using mainly organic amendments by more than 1.2 million growers. Oceania, Europe, and Latin America are the regions with the largest organically managed land areas. Substantial quantities of organic amendments such as plant residues (3.8×10^9 Mg/yr), biosolids (10×10^7 Mg/yr), and animal manures (7×10^9 Mg/yr) are produced worldwide. Land application of 7×10^9 Mg animal manures can contribute a substantial amount of nutrients approximately, 4.3 million Mg of nitrogen (N), 0.6 million Mg of phosphorus, 1.7 million Mg of potassium, and 0.4 million Mg of sulfur. Application of organic amendments is regarded as one of the most promising options to enhance plant growth and yield by improving soil physical properties including aggregate stability, water holding capacity, porosity, and water infiltration and percolation; chemical properties including, soil pH, electrical conductivity, cation exchange capacity, and soil organic C; and biological properties including increased microbial diversity and enzyme activities. Nevertheless, improper application of organic amendments possesses some disadvantages such as nutrient eutrophication (nitrate leaching) and greenhouse gas (GHG) emission.

Agriculture plays a major role in the global fluxes of the GHG including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Though CH_4 and N_2O are emitted in less quantity than CO_2, they are 21 and 310 times more powerful in global warming potential, respectively. Agriculture contributes up to 10–12% of total global anthropogenic emissions of GHG, and organic amendments provide a major source of all these gases. Organic amendments added for improving soil fertility and enhancing crop productivity, can lead to GHG emission by processes such as priming effect, methanogenesis, nitrification, and denitrification. Priming effect is the stimulation of soil organic matter (SOM) decomposition by the addition of organic amendments which can lead to CO_2, CH_4, and N_2O emissions. Methanogenesis is the production of CH_4 by microbes (methanogens) in soil under anaerobic condition. Nitrification and denitrification, the two contrasting microbial processes in soil N cycle can lead to N_2O emission. Globally, 10×10^7 Mg biosolids are produced annually which can result in the potential emission of 530 Gg of CH_4 and 60 Gg of N_2O. Greenhouse gas emission from land application of organic amendments is controlled by proximal regulators including N and carbon content in soil and organic amendments, oxygen (O_2) supply, soil water content, temperature, pH, and organic matter and by distal regulators including management practices, climate, soil type, and nutrient supply. For example, organic amendments contain high amounts of available C and N that often create soil anaerobic conditions due to high microbial growth and O_2 consumption thereby enhancing N_2O production through denitrification.

Proper and active management options will help to reduce GHG emission from land application of organic amendments and also enhance plant growth and yield. By managing C and N flow in agricultural ecosystems, GHG emission can be reduced. For example, an optimum application rate of organic amendments by considering all nutrient sources available to plant is an effective management practice to minimize nutrient loss and GHG emission. Also, lagooning of biosolids and stabilization process such as composting organic amendments minimize the risk of GHG emission by conserving nutrients and promoting their slow release. Recently, inhibitors (urease and nitrification) are used in agriculture to slow down N transformation and to reduce N loss as N_2O in organic amendments added soils. This paper examined organic amendment-induced GHG emission processes, factors controlling GHG emission, and also the management strategies employed to mitigate GHG emission from organic amendment applied soils.

Keywords：*Organic amendments, Greenhouse gases (GHGs), Emission processes,, Factors, Mitigation*

O25-3

[C2.5-3] A: Mechanism Controlling Greenhouse Gas Emissions from Soils

Life-cycle Analysis of Dryland Greenhouse Gases Affected by Cropping Sequence and Nitrogen Fertilization

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Little information is available about management practices effect on net global warming potential (GWP) and greenhouse gas intensity (GHGI) under dryland cropping systems. We evaluated the effects of cropping sequences (conventional till malt barley-fallow [CTB-F], no-till malt barley-pea [NTB-P], and no-till continuous malt barley [NTCB]) and N fertilization rates (0 and 80 kg N ha-1) on net GWP and GHGI from 2008 to 2011 in eastern Montana. The CO2 equivalent from farm operations was greater in CTB-F than NTB-P and NTCB, from N fertilization was greater with 80 than with 0 kg N ha-1, and from crop residue and soil organic C (SOC) sequestration were greater in NTB-P or NTCB with 80 kg N ha-1 than other treatments, but the equivalent from soil greenhouse gases (GHGs) varied among treatments and years. Net GWP and GHGI based on soil respiration were greater in NTCB with 0 kg N ha-1, but GWP and GHGI based on SOC were greater in CTB-F with 0 kg N ha-1 than other treatments. Because of greater grain yield but lower GWP and GHGI, NTB-P with 80 kg N ha-1 may be used as a management option to reduce global warming potential while sustaining dryland crop yields compared to CTB-F with 0 kg N ha-1 in the northern Great Plains. The management option also has been known to reduce the cost of N fertilization and control weeds, pests, and diseases effectively compared to NTCB with 80 kg N ha-1.

Keywords：*Greenhouse gases, Global warming potential, Tillage, Cropping sequestion, Nitrogen fertilization*

O25-4

[C2.5-3] A: Mechanism Controlling Greenhouse Gas Emissions from Soils

Eddy-covariance Measurements of CH_4 and CO_2 Fluxes from a Reed-covered Fen in Southwest Germany

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Carbon sequestration by terrestrial ecosystems buffers the increase of greenhouse gas concentrations.. Among terrestrial ecosystems, pristine peatlands are the largest sinks for carbon dioxide (CO_2). However, their role in the global C cycle can be ambivalent, since at the same time peatlands are the largest natural source for methane (CH_4), a greenhouse gas with 25 times the global warming potential of CO_2. Peatlands covered by a reed-dominated vegetation have been shown to be hot spots for CH_4 emissions, particularly after rewetting. To verify whether these findings hold true also with long-established reed areas we measure CH_4 and CO_2 fluxes of a reed (Phragmites australis) covered fen located in the shore area of a glacial lake in Southwest Germany. In the end of 2012, we installed an eddy covariance tower in the center of the reed area equipped with an open-path CH_4 analyzer and an enclosed-path CO_2/H_2O analyzer. In addition, soil temperature and moisture, net radiation, and water table depth are measured in high temporal resolution. Below- and aboveground biomass as well as the leaf area index of the reed are measured every four to six weeks

Our measurements have shown that both CH4 and CO_2 fluxes exhibit a distinct seasonal and diurnal pattern being low during winter and spring while increasing during summer. From May and June on, CH_4 emission and CO_2 net uptake were highest around noon reaching rates of up to 0.35 and 15 μmol s-1 m-2, respectively. The spectral characteristics of ecosystem CH_4 and CO_2 exchange and measured environmental variables will be investigated in more detail by time-series analysis. Overall, the reed area is a source for CH_4, but a sink for CO_2. Based on the IPCC factor of 25, the sink effect overcompensates the source effect. Hence, under the current climatic and environmental conditions, the studied fen has a positive effect on the climate by acting as a net carbon sink. We will continue our measurements for at least 2 more years.

Keywords：*methane, carbondioxide, eddy covariance, fen, reed, GHG*

O25-5

[C2.5-3] A: Mechanism Controlling Greenhouse Gas Emissions from Soils

Carbon Dioxide Emissions and Soil Properties in Intact and Disturbed Tropical Peatlands of Indonesia

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Tropical peatlands store about 50 Gt carbon (C) and are being increasingly degraded and deforested. If land use (LU) change on intact peatlands continues at the current rate, all the undisturbed peat swamp forests will have vanished by 2030. Disturbances such as deforestation and drainage can reverse the process of peat accumulation and release a substantial amount of carbon dioxide (CO_2) into the atmosphere. The aims of this study were to 1) compare soil CO_2 fluxes on an intact peat swamp forest (PF), a transitional logged drained forest (DF) and an oil palm plantation (OP) located on the same alluvial peat plain, and 2) evaluate the characteristics of the peat under the same three LU. Field infrared gas analysers (EGM-4 IRGA, PP Systems) were used to measure soil CO_2 efflux from May 2012 to October 2013. In each LU, trenches were made to estimate heterotrophic soil respiration. Spatial variation of CO_2 fluxes was taken into account by placing the EGM collars as pairs with one close to a tree/palm and another one at mid-distance to the next tree/palm. At the same time as CO_2 flux measurements were taken, environmental variables were measured. Soil profiles were sampled for the determination of fine roots, and logs. Subsequently the fine soil was physically fractionated. In the trenched plots, the average flux close to tree/palm was higher in the OP (78 ± 15 kg C-CO_2 ha-1 d-1) than in the DF (45 ± 10 kg C-CO_2 ha-1 d-1) and in the PF (34 ± 9 kg C-CO_2 ha-1 d-1) (results from May 2012 to May 2013). On the three LU, there was a significant difference between the CO_2 fluxes at the different distances from the tree/ palm. A significant relationship was found between CO_2 fluxes and water table level in the peat swamp forest. The amount of logs in the soil (top 1 m) were 4.9 ± 0.4, 2.7 ± 0.5, and 3.1 ± 0.5 kg m-2 for PF, DF and OP respectively. For the same LU, the percentages of soil heavy fraction were 14 ± 10, 55 ± 46, and 66 ± 18 respectively. Our preliminaries results suggest that the conversion of intact peat swamp forests into oil palm plantations accelerates soil organic matter mineralization in the peatland plains of the province of Jambi Indonesia.

Keywords：*CO_2 fluxes, land use change, soil characteristics, heterotrophic respiration, Jambi Indonesia*

O26-1

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

Understanding Emergent Responses of Soils to Environmental Change: What Do We Know about Upscaling?

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Fifty years ago, soil microbiologists argued that to really understand the role of microorganisms in the myriad of processes occurring in soils, it was essential to be able to perform measurements at their spatial scale, i.e., at micron resolution or better. For many decades, this was more a dream than a reality. However, in the last few years, tremendous technological advances have been achieved in the technologies available to observe the physical, chemical, and microbiological characteristics of soils at the microscopic scale. The old dream is now within grasp. At the same time, modelling techniques have also made tremendous progress, and allow us to finally simulate how the spatial microheterogeneity of soils makes sometimes unexpected properties emerge at the macroscopic scale. This research raises a number of difficult questions in terms of how to describe these emergent macroscopic properties, and especially of what parameters to use to characterize them as simply as possible. It is clear that simple bulk measurements (volume or mass averages) over macroscopic volumes are entirely inadequate. Unfortunately, we do not have any straightforward alternative at this point. In this context, the purpose of the present talk is to review in detail what we know about the upscaling of emergent processes in microheterogeneous soils. The focus will be on the influence of the physical microheterogeneity of soils on the emergent behavior of the bacterial metabolism of organic carbon. We shall demonstrate first in what ways traditional volume averaging frameworks are inappropriate to upscale this type of process, then we shall analyze in detail a number of ingredients of suitable upscaling approaches. Different avenues for the quantification of emergent properties will be discusses in detail, as well as prospects for future research.

Keywords：*bacteria, soil organic carbon, emergence, macroscopic theory, micro heterogeneity*

O26-2

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

Mechanism of Increase in Hydrophobicity of a Forest Andisol by Thermal Impact

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Introduction

Soils often exhibit hydrophobic properties after forest fire. DeBano et al. (1976) reported organic compounds in the soil got volatized under high-temperature, and moved downward along the soil temperature gradient to form a hydrophobic soil layer at deeper and cooler in the soil profile. However, less study considered the effects of oxygen atmosphere on chemical changes of soil organic matter. In this study, we sought to clarify the increase in soil hydrophobicity as well as the changes in organic matter content in response to heating soil surface of field and laboratory experiments.

Material and Methods

Field experiment

A designated burning area (0.5×0.5 m) was prepared in the forest research station of the University of Tokyo at Chichibu, Saitama, Japan. Dry bulk density and total carbon content of the field soil ranged 0.3-0.6 Mg/m3 and 150-270 g-C/kg, respectively. For surface heating experiment charcoal was burned for 5.5 hours. During the heating, soil temperature at shallow depths and the oxygen concentration were monitored. Degrees of hydrophobicity as water drop penetration time, carbon and nitrogen contents of the soil were measured after the halt of burning.

Laboratory experiments

Muffle furnace heating was conducted to discuss hydrophobic layer formation in the field experiment. Soil sample was taken at the field experiment site. Heating temperature of the muffle furnace was 200 to 700°C. Soil sample was placed into a crucible and heated for 2 hours, either with a lid of the crucible on (aerobic condition) or off (oxygen-deprived condition). After heating, some of the soil was treated with either isopropanol-NH3 or dichloromethane to extract polar or non-polar compounds in the soil (Atanassova and Doer (2011)). After the extraction, degree of hydrophobicity and carbon and nitrogen contents were measured. Extracted compounds were analyzed by using gas chromatograph mass-spectroscopy (GCMS) (GC2010, Shimadzu Inc.)

Results and Discussion

Production of hydrophobicity by heating

During the field experiment, surface temperature increased to 600 to 700°C however, 5.5 hours of surface heating could not make temperature of the soil deeper than 4 cm to be higher than 100°C. Field experiment caused distinct soil hydrophobicity at layers that reached 200 to 400°C. Under oxygen-deprived muffle furnace heating, soil samples heated with 300 to 400°C were highly hydrophobic, and hydrophobicity depressed at temperature higher than 400°C. Aerobic muffle heating, heated without a lid, did not produce soil hydrophobicity when soil temperature exceeded 300°C.

Production of Hydrophobic materials in soil

Under oxygen-deprived condition, soil organic carbon could remain after heating with high temperature, 400 to 600°C. Field

experiment showed soil carbon remained with the similar temperature while soil induced aerobic muffle heating lost most of the soil carbon when soil temperature exceeded 400°C.

Hydrophobicity followed by muffle furnace heating under oxygen-deprived condition was depressed by extraction using isopropanol-NH3 solution. Dichloromethane could not remove hydrophobicity of the hydrophobic soil samples. Polar compounds removed by isopropanol-NH3 solution are expected to have roles in soil hydrophobicity. Analysis by GCMS suggested the extracted isopropanol-NH3 solution from the hydrophobic soil contained dominantly monosaccharaides and the saccharides were not detected in the extracts from hydrophilic soil samples.

During oxygen-deprived muffle furnace heating, soil organic carbon did not wholly combusted under temperature of 400°C and higher. Soil under this condition showed both hydrophobicity and monosaccharaides in the isopropanol-NH3 extract. This suggested soil organic carbon transformed to be hydrophobic organic compounds such as monosaccharaides during heating. This could be a reason that soil carbon could remain in the soil heated with 300°C and higher under oxygen-deprived condition.

From these results we can expect, in the field, without migration of soil hydrophobic compounds along the thermal gradient, production of hydrophobic compounds at the depth in the soil where proper conditions, temperature and deficit of oxygen, for the chemical reactions were satisfied may cause soil hydrophobicity.

Conclusion

Comparisons between field and laboratory soil heating experiments suggested limited supply of oxygen to soil under properly high temperature may be a reason to exhibit soil hydrophobicity after a forest fire.

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Keywords：*hydrophobicity, oxygendeficit, Andisol*

O26-3

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

Effect of Soil Type and Bulk Density on the Stem and Root Lodging Resistance of Wheat

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Many of the world's small grain crops are susceptible to falling over - known as lodging - during grain-filling when their ears or panicles are at their most heavy, and can cause economic loss by reducing harvestable yield, increasing harvest time and the drying time of the crop. Consequently preventing or reducing the incidence of lodging is essential to improving profits and crop yields. In wheat grown in the United Kingdom root lodging (whereby the anchorage fails, allowing the stems to topple over and lie flat) is more likely than stem lodging (whereby the stems buckle and fail towards their base, causing the stem to fall over) as the stems are usually strong enough to resist damage. Furthermore, lodging is more likely to occur when with high yielding crops because they are more top-heavy and therefore more prone to failure. Reducing the incidence of root lodging is therefore a goal of growers, whilst maintaining high yields. One means of achieving this aim is to increase the anchorage strength of the plants - which depends upon both properties of the basal anchorage coronal roots and also the physical properties of the soil. To investigate the effects of soil strength of anchorage, therefore, a 'pot' experiment was conducted to investigated the influence of two soil textures (sandy loam and clay loam) at three wet soil bulk densities (low bulk density (1.07 g cm-3 for sandy loam and 1.13 g cm-3 for clay loam soil), moderate 1.3 and high bulk density 1.5 g cm-3) on soil shear strength, penetration resistance, plant anchorage strength and the above ground properties (stem height, plant fresh weight, ear weight, number of tillers, self-weight moment, centre of gravity and stem strength) of winter wheat. Ear weight (hence grain yield) was lowest in the loosest soils, and encouragingly ear weight of plant in both moderate and high compacted soils was similar highlighting that soil compaction (bulk density) with certain limit can be increased without necessarily reducing yield. Anchorage strength was lower in the loosest soil with lowest bulk density compared with the moderate and compacted soils - which had similar values. This was because root development was poorest in the loose soils and best in the moderate bulk density soils. Anchorage strength was similar in the soils with the highest bulk density because any impairment in coronal root development was compensated by the concomitant increase in shear strength. Unsurprisingly soil shear strength and penetration resistance increased with soil bulk density, whilst soil type and its bulk density had a significant effect on the above ground development of the plants, although to a far lesser extent than it had on root development. The "safety-factor" against anchorage failure was only around a third that of the safety factor against stem failure, highlighting that root lodging was more likely. Plant anchorage strength (resistance to overturning) is soil shear strength dependant (which in turn depends upon soil bilk density) and is also related to the development of the anchorage root system (the basal coronal roots). Therefore, taking root development into account, this experiment highlights that manipulating soil bulk density in the field could improve anchorage strength and thereby reduce the likelihood of root lodging by optimising the shear strength of the soil with root growth. Care is needed, not to increase the bulk density too much, as this would impair root development, and could reduce anchorage strength and reduce yield.

Keywords：*Plant anchorage strength; stem lodging; Shear strength; Penetration resistance; Soil bulk density.*

O26-4

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

Spatial Variability of Crop Yield on an Eroded Silt Loam Soil with Varying Depth to Root Restrictive Layer

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Soil erosion has presented a challenge for agricultural management of our most precious resource since ancient times, with the major impact of erosion being the loss of soil productivity because of degradation of soil biological, chemical and physical properties. Soil erosion not only reduces crop production, but because of sediment deposition, it also negatively impacts the environment. A study was initiated in 1985 to investigate the effects of soil erosion on soil productivity and corn production in southwest Wisconsin, USA. Three levels of erosion (slight, moderate and severe) were identified based on the depth of topsoil above a red clay residuum (2Bt horizon) on a Dubuque silt loam soil loam (fine-silty, mixed, mesic, Typic Hapludalfs). A three-dimensional (3-D) map of this eroded landscape was developed with the aid of a profile cone penetrometer (PCP). Corn (Zea mays L.) grain yield data were collected with a grain combine equipped with a yield monitor and a global positioning system, which were then overlaid on PCP data that displayed soil depth. Yield was related to topsoil depth with a trend of decreasing yield with decreasing depth to the root restricting layer (i.e. increasing erosion level). Combination of modern technologies such as 3-D soil and yield maps can help landowners identify better management systems for their land than traditional methods of erosion impact assessment.

Keywords：*Cone penetrometer, soil erosion, root restricting layer, soil depth, soil map*

O26-5

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

Soil Structure and Its Functions in Ecosystems: Scale Matter & Phase Matter

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This lecture will emphasize soil structure is relevant t either with phase matter or with scale matter. On the fact of phase matter, transport and retention of water and gas may more link directly to pore phase, while the aggregation is talking more on solid phase. On the fact of scale matter, water flow is deducted from soil core scale (cm or bigger scale), but soil structure formation, stabilization, and degradation are generally based on researches on aggregate scale. The interaction between organic humic and clay surface may be less than several micrometers. Impaction of the phase and scale dependent soil structure on the driving force and methodology will be detailed in this lecture as well.

Keywords：*Soil structure, Scale matter, Phase matter, aggregate, organo-mineral complex*

O27-1

[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Quantification by Image Analysis on Soil Thin Sections of Lessivage and Bioturbation Rates in Soils in Response to Land Use Change and Recycling of Organic Residues

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Soils provide numerous ecosystem services like production of food, carbon storage and recycling of wastes. The intensity at which soils provide these services are function of soil properties that permanently evolved as a result of physical, chemical and biological soil processes (Targulian and Krasilnikov, 2007). To sustain and improve the benefits from soil ecosystem services, it is thus necessary to predict these evolutions.
Land agricultural management has strongly influenced soil evolution since the beginning of the Anthropocene Era and agricultural practices have to be now assessed according to their influence on soil processes (Lin, 2011). However there is a lack of quantitative data about agricultural effect on soil processes dynamics especially at generational time scale (Cornu et al., 2009).
Lessivage and bioturbation by burrowing animals are two major pedologic processes in temperate climate. They are of crucial importance as they imply the clay size fraction. These processes are still poorly understood although land-use change or agricultural practices induce changes in their intensity (Thompson et al., 1990).
This study aims at characterizing the dynamics of these processes and quantifying their intensity after (i) a change in land use and (ii) the introduction of a widespread agricultural practice i.e. organic amendments spreading.
In our investigation, we built an anthropo-chrono-sequence of three Luvisols located on a plateau in Feucherolles (Yvelines, France). The first one is under a deciduous forest and the second one is under conventional agricultural management both with no change in land-use for the past two centuries. The last one is a cultivated Luvisol with regular manure spreading since 1998. Undisturbed soil samples were collected in each horizon of the three Luvisols and large thin sections (57 cm2) prepared according to the method of Guilloré (1985). Clay illuviation features and macropores of biological origin (>100 μm) were quantified by image analysis on the thin sections to evaluate the intensity of lessivage and bioturbation respectively. Size and shape of the macroporosity were used to quantify the activity of mesofauna and of endogeic and anecic worms
In case of cultivation, we can note a global increase of macroporosity and clay coatings abundance. The global greater macroporosity observed on cultivated profiles was undoubtedly due to endogeic and anecic worm activities. Moreover, whereas macroporosity is preferentially located on soil surface under forest, it is better allocated all along the soil profile after cultivation. The greater abundance of clay coatings shows an increasing intensity of lessivage under cultivation. These facts clearly suggest that formation and maintenance of a biological large porosity promoted these preferential transfers of fine clay particles.
After 15 years of organic matter spreading the soil presents intermediate results of biological macropores and clay coatings abundances which would lead us to believe that this agricultural practice tended to lower the intensity of bioturbation and lessivage. Cultivation was found to induce an acceleration of bioturbation and lessivage on time scales as short as a few centuries. We support the conclusion that bioturbation favours lessivage by modifying soil poral network characteristics. It is our opinion that organic residues spreading would further reduce lessivage intensity if performed on longer time scales.
Finally, our study points out the fact that (i) lessivage is active in soils under present climatic conditions on shorter time scales than commonly thought (generational ones) and that (ii) land use change act notably on clay particles transport through complex interactions linking bioturbation and soil morphology.
Our method may be particularly helpful to better understand relationships between bioturbation and (i) abundance and diversity of soil fauna, (ii) soil functioning and finally (iii) soil evolution on longer time scales. Soil evolution after a change in land use and the associated changes in the intensity of soil ecosystem services may be predicted by this way

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Keywords：*lessivage, bioturbation, image analysis, land use management, micromorphology, organic matter spreading, pedologic process*

O27-2

[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Identification of Relict Carbonate Pedofeatures in Modern Chernozems

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Three soil profiles were investigated in the central-southern part of the European plain. Two soils – Voronic Chernozem Pachic Siltic (in forest) and Voronic Chernozem Pachic Siltic Anthric (under meadow vegetation) are located in forest-steppe zone (Lipetsk region) at the territory subjected to the glaciations in the past. The third soil – Voronic Chernozem Pachic Siltic under the steppe vegetation is located in the out of glacial region in Ukraine. The soils differ in parent material, modern climate and vegetation, and the history of pedogenesis. All of them contain pedogenic soft and hard carbonates of various morphologies. The aim of this research was to identify the relict features in these present-day soils on a base of their morphological and isotopic analyses.

Detailed morphological investigation in the field was followed by micromorphological and scanning electron microscopy (SEM) studies coupled with stable isotopic composition of carbon in soil organic matter, carbon and oxygen stable isotopic composition and radiocarbon dating of carbonate pedofeatures. Soils were classified according to WRB system.

Depth to carbonate decreased from 100-110 cm in meadow soil to 90-100 cm in the forest soil in forest-steppe zone, and up to 40 cm in the Chernozem under steppe vegetation. Fine veins and hard concretions appear at the same depth in meadow Chernozem but the concretions vary in size and internal morphology with depth from hollow and septaric to undifferentiated. In the forest Chernozem fine veins appear first while hard concretions occur below. The concretions there are less variable in size and internal morphology. Carbonate pedofeatures in the steppe Chernozem occur much deeper below the effervescence boundary, and are represented by fine veins, segregated soft masses and hard concretions with large impregnations at the very depth.

Variability of microfabrics was found in thin sections of hard concretions within the same soil profile, which expect their complicated genesis and re-crystallization of some concretions. This was especially typical for the hard concretions from Chernozems under meadow and steppe vegetation. SEM studies have also shown that hard concretions in meadow soil are on a way of dissolution and destruction. Both micromorphology and SEM revealed concretions at different stages of formation/degradation, which expects that some of the concretions are relict and polygenetic.

Radiocarbon age determined in the selected concretions have shown a wide range from about 3100-3600 yrs. BP in forest-steppe zone of glacial region up to 22000 yrs. BP in soil of the out of glacial steppe area.

Stable isotopic compositions of carbon in soil organic matter is in the limit of -26.15 to -24.48 o/oo in meadow soil, -25.86 to -25.18 o/oo in forest soil, and -26.5 to -25.1 o/oo in steppe soil. Carbon and oxygen isotopic compositions of carbonate concretions show the shift from lighter values in meadow soil (δ13C -10.1 to -9.4 o/oo and δ18O -9,37 to -8,9 o/oo) to the heaviest values in steppe soil (δ13C -9.5 to -7.9 o/oo, and δ18O -9,37…-6,7). At the same time most of δ13C values of the concretions are not in equilibrium with the δ13C of soil organic matter. This may indicate that most of them were formed under drier and warmer environment. The discrepancy is maximal in the steppe soil, where the concretions have the oldest radiocarbon age, and most likely are associated with the close position of an underlying paleosol. At the same time the microfabric and isotopic composition of some small concretions expect their formation under modern environment, and current growth.

Microscopic and isotopic investigations suggest that soils comprise the carbonate pedofeatures of different genesis and age, and have recorded the stages of various pedoenvironment.

Keywords：*Chernozem, carbonate concretions, stable isotopic composition, SEM, microfabric*

O27-3

[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Isotopic Techniques applied to Environmental Changes in Histosols in Itatiaia National Park, Brazil

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Based on the use of carbon isotopes (12C 13C) of Histosols organic matter (OM), previous environmental changes can be recorded and associated to vegetation and soil organic matter dynamics and climate inferences. This study was set in the Itatiaia National Park, located on the border of Rio de Janeiro and Minas Gerais states, between 22°16' - 22°28' S and 44°34' - 44°42' W, with altitude varying from 540 m up to 2,791 m. The flora on the Itatiaia Plateau has several endemic species, and the dominant families of vascular plants in the high altitudinal grasslands or "campos de altitude" are Poaceae and Asteraceae. The climate is mesothermic, markedly seasonal, with cold and dry winters and wet summers. Mean annual temperature is about 14 °C and lower temperatures may fall below -10 °C, freezing in the winter. Annual rainfall is about 2,400 mm, concentrated in the summer season. The dominant rock is nepheline-syenite, and some characteristics of this rock may have promoted plant diversity.
The main objective of this study was to characterize C and N isotopic composition of organic matter of Histosols in the Itatiaia Plateau, in order to study the succession of vegetation during the soils formation. Two profiles were sampled, one (RJ-01 - 23K 0533769 7524084) very poorly drained and located at the bottom of a narrow valley, at 2100 m of elevation; the other (RJ-02 - 23K 0530905 7525596) at the lower part of a talus, somewhat poorly drained and at 2400 m. Total organic C (%), total N (%), δ13C (‰) and δ15N (‰), were analyzed in the Stable Isotopes Laboratory of CENA, University of Sao Paulo (USP).
The values of C and N decreased with soil depth, from 0-10 cm, 20%C, 1.2%N, to 40-50 cm, 10%C, 0.6%N, between 60-170 cm, at RJ-01, 10%C, 0.7%N and RJ-02, 5%C, 0.7%N, after 170 cm the values were the same, 5%C and 0.3%N in both profiles. The lower elevation and poor drainage conditions at RJ-01 in relation to RJ-02 probably permitted the higher influence of humidity, reducing conditions and organic matter preservation, reflected mainly in the 0.5-1.6 m soil depth interval. The lower C:N values varied from ~13 to 17 in the soil profile at RJ-01 and reinforce the higher influence of algae in the SOM composition, when compared with the higher values (~17 to 25) obtained at RJ-02, which suggest the dominance of terrestrial OM.
The δ13C showed depleted values (~-28 ‰) in the shallow layers of both locations, characterizing the vegetation cover composed of C3 plants (herbs). With the increase of soil depth it is observed 13C enrichment up to -22 ‰ in the RJ 02 profile, probably associated to the higher influence of C4 plants from ~1.80 m to 1.40 cm soil depth. The δ15N values varied from 3 to 10 at RJ-01, suggesting higher influence of algae in the SOM, mainly in the 0.3-0.5 interval The δ15N values of 8 to 10 in the interval 0.3 to 1.0 m for δ15N and -20 to -25 for δ13C correspond to OM mainly from algae, and are related to environments with water saturation for a continuous period of time. In the RJ-01 profile suggested higher influence of algae in the OM than in RJ-02, and it was in agreement with the lower values of C:N described earlier for the same soil depth interval and location. Therefore, the C:N and δ15N values suggested higher influence of algae in the OM composition of RJ-01, in the depth interval of 0.3 m to 1.0 m. According to δ13C and C:N ratio, two environments were observed, RJ-01 with indication of OM from algae, and RJ-02 where the δ13C shows dominance of C3 plants. In addition, a mixture of C3 and C4 plants was observed in the interval from 1.80 to 1.40 m at the RJ-02.

Keywords：*Environmental changes, Soils from high altitudes, Organic soils, Plant sucession*

O27-4

[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Effects of Anthropogenic Interventions on the Entisols of Al-Khoud Dam Area in a Dry Region of Oman

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A pedological study was conducted to investigate the impacts of anthropogenic activities on the pedogenesis and morphology of Entisols induced by the construction of Al-Khoud recharge dam in a dry region of Oman. The study involved a detailed soil survey, pedons descriptions, investigation of landscape geomorphology, mechanical analyses, and examination of the mineralogy and micromorphology of the soil fabric using petrographic techniques, viz. SEM and XRD. Dam construction and ensued engineering interventions has resulted in distinct spatial differences in the topography of the soil landscape, topology of wadi surface flow, and the pattern and nature of sedimentations of the Entisols of the area. As a consequence, there was an alteration in dynamics of water movement (runoff-infiltration-evaporation) dictating the nature and type of the physico-chemical and pedogeneic processes, which ultimately influenced the evolution of these soils. The micromorphological and mineralogical data depict formation of a web-like network with narrow bridges of calcic materials between the soil grains. The calcic bridges observed in the Entisols of the Al-Khoud dam area were characterized as weakly developed or incipient cements and their pedogenesis is linked to alteration in the hydropedology of the area. In addition, the petrographic techniques added with the mechanical particle-analyses data showed variability with depth in soil fabric among the Entisols in terms of density and extent of packing of the soil grains. Vertical translocation of fine particles driven by infiltration pulses through a coarse alluvial skeleton was also detected. The entrained fine particulates were composed primarily of a very fine sand and silt with some clay.

The regularly monitored, 25 years long geotechnical intervention has induced remarkable and non-trivial soil evolution, geomorphology, and hydropedological properties of the examined Entisols. The results proof that soil changes caused by human engineering activities are often more rapid and far reaching than a standard centuries/millennia-long time scale predicts. This appears to be grossly overlooked in the analyses of soil forming mechanisms. Hence, human should be recognized as the sixth "fully fledged" soil forming factor separate from other organisms, in congruity with the recent calls by many soil scholars.

Keywords：*Human factor, soil genesis, soil development, morphology, incipient cementation*

O27-5

[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Digital Soil Mapping and Classification for Sustainable Crop Cultivation in Northeast, Akwa Ibom State, Nigeria Using Digital Elevation Model and Geographic Information System

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For farmers and other land users to have better understanding of the kind of soils found in the landscape where they operate, there is need for proper soil mapping and classification. This will facilitates the judicious allocation of land to best uses. Hence, digital soil mapping and classification in northeast Akwa Ibom State, Nigeria using digital elevation model and geographic information system, was carried out. The aim was to assess the effectiveness and reliability of the tools in digital soil mapping and classification. Contour map of the study area was generated from digital elevation model (DEM) and superimposed on the topographic map at scale of 1: 50,000 to produce the base map. The base map was classified, which resulted into predicted soil classes. With the help of hand held Global Positioning System (GPS) and random soil augering at representative locations, the predicted soil classes and soil boundaries were established in the field. Three soil mapping units were delineated. Profile pits were sunk at various representative locations within the three mapping units. A total of 16 profile pits were dug in the study area and 70 soil samples were generated for laboratory analysis. The results of soil characterization of the soil units showed that soil unit 1 was characterized with mottles in the A-horizon. Soil unit 2 was characterized with mottles in the B-horizon, while soil unit 3 was characterized with no mottles within 200 cm of soil depth. Mean soil reaction measured in KCl was strongly acidic (pH 5.1) in the topsoil and very strongly acidic (pH 4.7) in the subsoil of soil unit 1. In soil unit 2, mean soil reaction was very strongly acidic (pH 4.5-4.9) in both top and subsoil. In soil unit 3, mean soil reaction was very strongly acidic (pH 5.0) in the topsoil and extremely acidic (pH 4.3) in the subsoil. Organic carbon was high (1.6-1.9 %) in topsoil of soil units 1 and 2, and moderate (1.4 %) in soil unit 3. Mean available P was moderate (8.17-19.50 mg/kg) in both top and subsoil of all the three soil units. Exchangeable K (0.05-0.12 cmolkg) and total N (0.04-0.13 %) were low in all the three soil units. CEC was moderate (12.53-14.39 cmol/kg) in the topsoil and low (11.14-11.75 cmol/kg) in the subsoil in all the three soil units. Available Fe was excessive (280.0-344.4 mg/kg) in all the three soil units. According to USDA Soil Taxonomy, soil unit 1 was classified as Typic Epiaquept, which approximately correlated to Gleyic Cambisol (FAO / UNESCO Soil Map of the World Legend). Soil unit 2 was classified as Aeric Epiaquept (USDA Soil Taxonomy), which correlated to Gleyic Cambisol (FAO /UNESCO). Soil unit 3 was classified as Typic Hapludult (USDA Soil Taxonomy), which correlated to Haplic Acrisol (FAO / UNESCO).

Keywords：*Digital Soil mapping, GIS, Akwa Ibom State soils, classification*

O28-1

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Droughts and Climate Change in Bulgaria: Assessing Maize Crop Risk and Irrigation Requirements in Relation to Soil and Climate Region

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This study aims at assessing maize cropping risk due to observed trends for drought aggravation for the maize crop season which is associated with possible climate change trends relative to precipitation, temperature and reference evapotranspiration (ETo) relative to selected weather stations of Bulgaria. Consequent trends were also observed for the standard precipitation indices for 3 and 12 months time steps, SPI-3 and SPI-12

Rainfed maize is associated with a great yield variability (29<Cv<72%) due to interannual climatic variability during the maize season. Water balance and relative yield computations were performed with the model WinISAREG after its calibration and validation for maize at various locations of Bulgaria and using long-term experimental data (e.g., Popova et al., 2006: 2012). The largest yields variability were found for Sandanski and Plovdiv when a soil with low total available water (TAW=116 mm m^{-1}) is considered. The least variable yields are those for Sofia when TAW=180 mm m^{-1}. Basing upon economic considerations, relative yield decreases (RYD) were computed with the threshold of 60 and 48% of the potential maize productivity in Plovdiv and Sofia. Maize production is risky in 32 % of years in Plovdiv when TAW is large, which is the double of risk in Sofia. If TAW is medium the risky years double and reach 50% of years in Varna.

A relationship between the SPI-2 index computed for "July-Aug" with the simulated RYD of rainfed maize was found. It is quite significant in Plovdiv where R^2>91% was found. Results are less good for Sandanski and Sofia (73<R^2<83%). Results indicate that when rainfed maize is grown on soils of large TAW, maize development is less affected by the water stress. Economical losses are produced when high peak season (July-Aug) SPI-2 is less than +0.2 in Sandanski, -0.50 in Plovdiv and -0.90 in Sofia. In North Bulgaria the respective SPI threshold ranges between -0.75 at Lom and -1.5 at Pleven. When irrigation is considered, a relationship was also found relating the net irrigation requirements (NIRs) with SPI-2"July-Aug". Consequently, the corresponding economic thresholds relative to the yield losses were computed for all locations this allowed to estimate the NIR thresholds that may lead to favourable cropping returns.

The derived reliable relationships and related SPI-2 thresholds relative to "July-Aug", under which soil moisture deficits lead to severe impact of drought on rainfed maize yield for the studied climate regions and soil groups were used for mapping the risk of rainfed maize yield decreases as a function of drought intensity, which combined with maps relative to NIR to overcome drought effects on maize production.

Keywords：*Drought Intensity-Yield Relationships, Isareg Model, Irrigation Requirements,Rainfed Maize,SPI-index*

O28-2

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Effect of Mulching on Dryland Soil Water, Winter Wheat Yield, and Water Use Efficiency

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Mulching can affect dryland winter wheat yield and water use by conserving soil water. A study was conducted to examine the effect of surface mulching on dryland soil water content, winter wheat yield, and water use efficiency (WUE) from 2008 to 2012 in the Loess Plateau of China. Treatments included whole-year wheat straw mulching at 9000 kg ha-1 (HSM) and 4500 kg ha-1 (LSM), summer wheat straw mulching at 9000 kg ha-1 (SSM), whole-year plastic film mulching (PFM), and no mulching (CK). In the years with below-average precipitation (2008-2010), mulching increased soil water storage, winter wheat yield, and WUE by 0.2-7.3%, 1.4-8.1%, and 2.0-7.3%, respectively, compared to the no mulching treatment. There was no significant difference between HSM and LSM on winter wheat yield and WUE. In the years with above-average precipitation (2011-2012), mulching had no significant effect on soil water content, but winter wheat yield reduced from 7.1 to 13.8% and WUE from 9.8 to 14.01% in the mulched- than the no-mulched treatment. The harvest index decreased with mulching, especially with HSM. Wheat straw mulching at 4500 kg ha-1 can be used to conserve soil water and increase winter wheat yield and water-use efficiency, especially during the drought, in the Loess Plateau of China. Plastic mulching was no more effective than wheat straw mulching in soil water conservation and winter wheat yield and water-use efficiency.

Keywords：*Dryland farming, Surface mulching, Soil water, Water use efficiency, Winter wheat*

O28-3

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

"Fallow Band System", a Do-nothing Practice for Controlling Desertification and Improving Crop Production in the Sahel, West Africa

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Desertification in the Sahel, located at the south fringe of the Sahara Desert, is mainly caused by wind erosion. So far, three effective countermeasures against wind erosion (i.e. ridging, mulching with post-harvest crop residue, and windbreaks) have been proposed, but they were not practical for the Sahelian farmers who are economically challenged and have limited manpower and thus, not adopted by them. Since wind erosion in the Sahel was not fully understood, we first designed a new sediment catcher, named "Aeolian Materials Sampler (AMS)," to compensate for the disadvantages of the conventional ones, and verified its effectiveness by the wind tunnel experiments. Then, we conducted three-year field experiments using the AMS and revealed that the annual soil loss in the cultivated field was 60−80 Mg ha^{-1} yr^{-1} (corresponding to 4−5 mm of topsoil) and the nitrogen loss was 40−50 kg ha^{-1} yr^{-1} that is 2−3 times as much as the annual crop uptake. However, most of the eroded soil and nutrients were trapped by the fallow land located at the leeward side of the cultivated field within the first 5 m. On the basis of these results, we designed a new countermeasure against desertification in the Sahel, termed the ''Fallow Band System,'' which can be used both for controlling wind erosion and improving soil fertility and crop production. In this system, (A) 5-m-wide herbaceous fallow bands are arranged at a right angle to the erosive wind direction (east) in a cultivated field during the rainy season. Because the fallow bands can be easily created by skipping the usual seeding and weeding (by doing nothing), this system does not impose any additional expenses and labor requirements on the Sahelian farmers, which is crucial for the feasibility for them. Crops are cultivated in the remainder of the field with a conventional method (called "cultivated band"). The fallow bands are maintained during the subsequent dry season and early rainy season so that they will trap wind-blown soil materials and control wind erosion in the field. (B) During the next rainy season, new fallow bands are established windward of the former fallow bands, where in turn crops are cultivated as well as in the cultivated bands. (C) Step (B) is repeated each year. The objective of this study was to evaluate the effects of this system on wind-erosion control, soil fertility, and crop production. We conducted field experiments at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) West and Central Africa and the farmers' fields in Niger and found that (i) a single fallow band can capture 74% of wind-blown soil materials, suggesting that it can effectively control wind erosion, (ii) the amount of soil nutrients available for crops in a former fallow band was increased by the decomposition of the trapped soil materials containing considerable amounts of nutrients (e.g. available N was increased by 60 kg ha^{-1}), and (iii) the amount of soil water available for crops in a former fallow band was increased by the trapped wind-blown soil materials through the improvement of rainwater infiltration into surface soil (e.g. field hydraulic conductivity was increased by 600%), iv) pearl millet yield on the former fallow bands was higher than the cultivated bands when the spacing between the bands was larger than 29 m, v) this positive effect of fallow bands on the crop yield continued at least two years, vi) simulation results based on the results of i), iv) and v) showed that the crop yield was increased by 30% to 80% compared with the field not applied with the "Fallow Band System". On the basis of above-mentioned results, we concluded that the ''Fallow Band System,'' the do-nothing practice, can be useful for preventing desertification and improving soil fertility and crop production in the Sahel, West Africa. Until the end of March 2013, this system was adopted in 5 regions, 23 districts, and 89 villages of Niger.

Keywords: *Soil and water conservation practice, Wind erosion, Soil crust, loose layer, feasibility for farmers*

O28-4

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Soil Infrastructure Evolution and Its Effect on Water Transfer Processes under Contrasted Tillage Systems

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The heterogeneity of soil structure and porosity are highly influenced by external factors like tillage systems and other land management approaches. The aim of this project is to investigate the effect of soil tillage along with residue management on the changing pattern of soil structure. This investigation will help to emphasize the different water flow dynamics especially the preferential flow processes through the soil that are influenced by the changes in structural distribution in the soil profile. Mostly the preferential flow of water is addressed by the apparent velocity through the soil but this study will focus on soil structure along with soil moisture dynamics at aggregate scale or more specifically at pedon scale. The experimentation has been started from June 2013 in the research field known as Solcouvert (objects: strip-till versus winter ploughing) and Solresidus (objects: no-till with organic matter restitution versus no-till without organic matter restitution). Soil profile description has been carried out in the four objects of land management. Soil sampling has been done in different depths of soil according to the soil profile description. Soil samples will be used for the measurement of water retention capacity (pressure plate and evaporation technique), hydraulic conductivity and x-ray microtomography. In addition there will be soil moisture sensors (Decagon 10HS, 5TM and ML3 Thetaprobe) in the field under four different trials. The soils from the different trials and also from different depths (0-15, 25-30 and 50-60 cm) were calibrated with the sensors. The calibration results were significantly ($p<0.05$) different between Solcouvert and Solresidus and there was also significant ($p<0.05$) difference among depths of same field especially between 0-15 and 50-60 cm. Soil bulk density and textural differences are the main reason for the differences of moisture content of different sites and depths measured by the moisture probes. In addition, the results were inconsistent along with overestimation of moisture content if the manufacturer based equation is used for the calibration. We conclude that, site and depth wise calibration of low cost sensors is very essential for the interpretation of results. In our study, to capture the total soil moisture networks, the moisture sensors will be in the field in winter to spring and summer to autumn. All the experiments will be repeated twice a year. For the specific spatio-temporal comparison, the monitoring results from electrical resistance tomography will be available from the collaborated project of the same faculty.

Keywords：*Soil structure, Tillage systems, Soil moisture dynamics*

O28-5

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Soil Hydraulic Properties and Moisture Regime as Affected by Agronomic Management Practices in a Clayey Ultisol

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Soil erosion and seasonal drought are the constraints limiting yield in sloping farmland in southern China. The poor hydraulic properties of the red soil (Ultisol) are usually worsened with the soil structure degradation by rain-induced soil erosion in wet season. Subsequently, crops often undergo water stress even in a short dry spell in summer, due to the increased evaporation rate at high level. Many studies focus on water erosion in red soil, but few attention has been paid to the soil water management in dry season. Despite many well-recognized practices in arid land farming, neither the practice could be implemented in the humid area, nor the benefit could be remained in clayey red soil. Therefore, for the viable water management strategy in red soil, it is important to estimate the effects of agronomic conservational practices on temporal variability in soil hydraulic properties and root-zone water dynamics.

A four-year experiment was performed at a 8° field growing maize from June to September in 2008-2011. The field is located in Xianning, China (114°21′E and 30°01′N). The soil is characterized by poor properties, with 55.7% of <0.002 mm clay and 0.61% of organic matter. Agronomic conservational practices were employed to reduce soil erosion and to improve soil water conditions in the field. There were four treatments including (1) no conservational practices (CK), (2) application of polyacrylamide mixed with surface soil at the rate of 2.0 g per square meter (PAM), (3) straw mulching in soil surface with 10 cm long rice straw at the rate of 1.0 kg per square meter (SM), and (4) growing bahiagrass as contour strips at 0.5 m wide and 5.0 m interval (GS). In the maize growth period which is the transition between humid and dry seasons, the temporal variability of soil hydraulic properties and soil water storage in the root-zone of 0-40 cm were simultaneously investigated.

After each intense rainfall in wet season, soil crust were formed with more than 70% coverage in PAM, GS and CK treatment. The application of PAM significantly decreased the crust size distribution, hardness and coverage, but SM treatment completely avoided crust. Compared with CK, the treatment of SM and PAM improved water-stable soil aggregation with a redistribution of micro-aggregates (<0.25 mm) into macro-aggregates to resist the tendency to form surface crust. The most notable change in soil hydraulic properties is that soil saturated hydraulic conductivity, Ks, significantly declined due to intense rainfalls. As expected, the conservational practices mitigated the degradation of soil Ks. However, the temporal decrement of soil Ks was much greater than the effects of the conservational practices. Despite the benefits on soil hydraulic properties, the practices slightly increased soil water storage as demonstrated by the root-zone water weekly dynamics in wet season, suggesting the soil's pore spaces were already filled with rainwater because the soil water holding capacity was low. In dry season, on the other hand, the soil water storage were significantly different between the treatments. Soil water storage in 0-40 cm in SM was the highest, followed by PAM and CK, and GS was the least because of the vigorous grass growth for water uptake. The noteworthy is that the soil moisture difference between the treatments became larger and larger over the period of soil drying. The soil unsaturated hydraulic conductivity, Ku, measured in situ by a tension infiltrometer showed that a slightly decline in soil moisture (tension from 0.3 to 0.9 KPa) resulted in a dramatically decrease in Ku (from 3.2 to 0.04 mm/h). Hence, the Ku of the red soil is basically governed by water moisture in dry season. This kind of relationship between Ku and soil water content is the reason why crop water stress occurs easily even in short dry period. From this perspective, remaining soil moisture is more urgent than improving soil properties to resist seasonal drought. As a result, the treatment of SM is the most effective soil water management practice compared with PAM and GS in dry season, although they all had benefits on protecting soil hydraulic properties in wet season. The result suggests the best strategy on water management in erosion- and drought-threatened red soil is residue cover.

Keywords：*Hydraulic properties, Soil crust, Soil moisture profile, Temporal variability*

O29-1

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Synchrotron-based µ-Xafs, Nanosims, and Afm Microscopy as Novel Tools to Assess Micro- and Nanosite Mineralogy and Reactivity of Soils and Soil Particles

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In recent years, the great relevance of soil micro- and nanostructure for soil ecological processes has become increasingly evident, and novel methods have become available to investigate the micro- and nano-site mineralogy and reactivity of soils and soil particles as crucial biogeochemical interfaces which control these processes. Among the most promising methods are (i) synchrotron-based micro-X-Ray Absorption Fluorescence Spectroscopy (µ-XAFS), (ii) Secondary Ion Mass Spectroscopy at the nano-scale (NanoSIMS), and (iii) Atomic Force Microscopy (AFM).Each of these methods for itself is able to substantially increase our knowledge about specific physiochemical and mineralogical properties of soil and soil particle micro and nano-sites; however, combination of these methods can yield significant additional benefit.

We shortly present these methods with their specific potentials and limitations. Moreover, we present examples about new insights on soil mineralogy and reactivity patterns of micro- and nano-sites from different soils and soil particles as obtained by applying these methods, either as stand-alone methods or in combined approaches.

Keywords：*soil particles colloids micro-scale nano-scale enrichment zones speciation XANES STXM*

O29-2

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Characterisation of Carnotite Grain and Cement Boundaries using Micro Xrd and Xanes Analyses

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Carnotite (K2(UO2)2(V2O8)2·0-3H2O) is an important global source of uranium (U) and vanadium (V). In Western Australia, it occurs in surficial, calcrete-hosted deposits with average grades ranging between 500 and 1000 ppm U - akin to U 'contaminated' soil. The mineralogy is dominated by dolomite/ calcite minerals, along with a range of phyllosilicates (micas, talc, smectite, kaolinite, palygorskite), feldspars, and a minor iron oxide content (dominantly as goethite). Carnotite formed here as discrete grains as well as cementing phases. Whether the aim is to process the deposit or to determine potential environmental risks associated with the U mineralogy, studies focusing on the boundaries of the cements/ grains reveal which mineral phases coat the peripheries and provide it with naturally occurring passivation layers.

We employed a combination of electron probe micro analysis (EPMA) and synchrotron-based (beamline X27A, NSLS - Brookhaven National Laboratory) micro (μ) XRD (17,479 eV, λ = 0.7093 A) and μXANES (U L-III edge, 17,167 eV) analyses to determine mineral phases coating carnotite grains/ cements and changes in U speciation (oxidation state as well as mineralogical) as function of transitioning onto the grain/ cement. The ability to combine of μXRD and μXANES at X27 is very fortuitous as we can ascertain compositional, crystallographic and chemical state changes at the micron scale (spot size ~ 5*10 μm) while assuring that physical limitations of each technique (e.g., self-absorption effects in μXANES spectra) are limited with minimal loss of information. Hereby, μXRD analysis proves especially useful as the acquisition time for data is 60 seconds (as opposed to ~ 30-40 minutes for μXANES data) and μXRF spectra per spot of investigation can be collected at the same time to aid in the interpretation of μXRD and μXANES data. Short acquisition times lead to high data volume, which can be used to assess several tens of patterns using statistical methods such as factor analyses (e.g., principal component analysis). Last but not least, EPMA analysis at sub-micron spot size analyses, can identify additional compositional and morphological characteristics that are 'invisible' at the beamline due to spot size and probing depth.

Our results (EPMA and μXRD) show that the main mineralisation is meta-carnotite (0 H2O of hydration) with variable (Ca, Sr) but dominantly potassium (K) interlayer composition. The characteristic (100) plane shows small expansions relating to this variance, while the (200) plane is shifted to higher degrees of 2 theta. At the boundaries, we have observed goethite (α-FeOOH, P nma) and alternate U mineral phases, specifically uraninite (UO2, F m3m) and vorlanite ([Ca,U]O4, F m3m). Small amounts of chromium and manganese Ka fluorescence energy emitted in goethite locations are possibly associated with Cr/Mn lattice substitution for Fe, although Cr (as chromate) is known to replace V (two inverted square pyramids: V2O8^6-) in the carnotite lattice as well. The occurrence of UO2 (U-IV) and vorlanite (U-VI) are of great interest: 1) the minerals share the same symmetry (cubic, t-halite structure) with on crsystallographic metal site that is occupied in approximately equal amounts by U(VI) and Ca(II) in vorlanite, thus preserving the sites formal charge. 2) At least UO2 is quite insoluble in carbonate/ bicarbonate media, which poses challenges for industrial extraction, but presents interesting prospects for stabilising U in the soil in general. 3) The presence of vorlanite as a possible weathering product of UO2 (oxidation/ re-precipitation) in calcrete environments adds new insights into the formation of this rather rarely observed U mineral. μXANES analysis is less informative than concomitant μXRD data. This is owed in part to the low signal-to-noise ratio of XANES data collected with a Si(311) monochromator at the edge of grains where U is scarce. Shifts of the binding energy can be identified in UO2 regions, but the co-presence of vorlanite and the short core-hole lifetime (broadening of edge features) at the U L-III edge make distinction between oxidation states challenging. Principal component analysis has proven to be very promising to assess many tens of μXRD patterns. Employing a Varimax rotation to the reproduced data matrix, we can visualise the primary principal components as pattern-like abstract factors. Different mineral phases co-present with carnotite (e.g., quartz, goethite, UO2, vorlanite) can be identified, as well as single crystal and orientation effects on carnotite.

Keywords：*μXRD, uraninite, vorlanite, goethite, carnotite*

O29-3

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Phosphate Effects on Cadmium(ii) Sorption to Ferrihydrite

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Elevated cadmium(II) concentrations in soil is a problem both in soils contaminated by industrial activities and in agricultural soils. Cadmium(II) adsorbs to iron oxides in soil and if phosphorus affects this process it should to be taken into account in geochemical models. To elucidate the effects of phosphate on cadmium(II) sorption to iron oxides (here ferrihydrite) a combination of batch experiments, extended X-ray absorption fine structure (EXAFS) measurements and surface complexation modeling with the CD-MUSIC model was performed. The more specific aims were to identify the surface complexes formed and generate surface complexation constants for the reactions involved. Sorption experiments with cadmium(II) and ferrihydrite, with and without addition of phosphate, covered a pH range of about 4 to 7. To extend the possibilities for EXAFS analysis arsenate was used in some experiments as a phosphate analogue. Sorption of cadmium(II) to ferrihydrite was enhanced by phosphate at about pH<7. The sorption of cadmium(II) in single sorbate systems was, based on interpretation of EXAFS measurements, attributed primarily to inner sphere edge-sharing complexes (Cd-Fe distance about 3.3 Å) but with a possible contribution from corner-sharing complexes (Cd-Fe distance about 3.8 Å). A surface complexation model with a bidentate cadmium(II)-ferrihydrite complex provided a good model fit for the single sorbate systems. However, the EXAFS results showed a change in cadmium(II) coordination when phosphate was present. This could be explained by the introduction of a ternary surface complex in the surface complexation model in addition to the complexes of the single sorbate systems. In conclusion, geochemical models used for simulating trace element behavior in acidic environments need to account for ternary metal-phosphate surface complexes to properly describe partitioning of metals between solution and the solid phase.

Keywords：*Cadmium, iron oxide, ferrihydrite, exafs, surface complexation model, CD-MUSIC*

O29-4

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Dissolution of Phosphate-adsorbed Goethite by Desferrioxamine B

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Desferrioxamine B (DFOB) is one of microbial trihydroxamate siderophores, which is exceted by soil microbes and plant root under Fe-deficient conditions. It is a Fe-specific chelator and increases the availability of iron through dissolution of Fe oxide minerals. Phosphorus is well known to be easily fixed by Fe minerals in soil. Because phosphate and DFOB may compete the same surface binding sites, it is unclear whether P availability is increased when Fe oxide minerals are dissolved by DFOB. The aim of this research is to investigate the effects of DFOB on the releasing rates of P and Fe from P-adsorbed goethite. DFOB-promoted dissolution experiments were conducted for goethite with different P loading amounts at different temperatures and pH values. The corresponding dissolution rate constants were obtained and subsequently used to calculate the pre-exponential factor (collision frequency) and activation energy for the dissolution reaction of goethite with different P-loading amounts. The DFOB accessibility to the surface binding sites, which is dependent on the amount of phosphate adsorbed on goethite, was proposed to be one of the key factors in determining the Fe and P releasing rates of goethite in the presence of DFOB.

Keywords：*Siderophore, Desferrioxamine B, phosphate, goethite , adsorption, dissolution , rate constant, activation energy*

O29-5

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Arsenic Accumulation in Soil Matrices in Relation to Microsite Composition

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Arsenic mobility in the environment is regulated in part by the stability of solid-phase chemical species of arsenic in different oxidation states. Oxidation and reduction of arsenic are known to couple with specific minerals such as manganese oxides, and with organic matter. Iron and aluminum oxides are considered to be dominant sorbents of arsenic in soils. However, it is not known how the co-localization of multiple soil components within soil microsites affects arsenic redox transformations and retention. Our objective is to determine how multicomponent complexity affects arsenic reactivity within soil matrices.

We characterized the spatial distribution of arsenic accumulation in mineral-organic coatings on individual quartz sand grains following multiple treatments with As(III). The sand grains were isolated from a loamy-sand soil that typically occurs in the Atlantic Coastal Plain region of the southeastern United States. Arsenic and selected soil matrix elements were mapped across grain coatings using synchrotron micro X-ray fluorescence (XRF) before and after treatments with 0.001, 0.01, 0.1, and 1 mM Na-arsenite solutions. XRF maps were collected at multiple energies near the arsenic K-edge to assess arsenic oxidation states. Following all treatments, grains were analyzed using time-of-flight secondary ion mass spectrometry (TOF-SIMS) to map spatial distributions of iron along with aluminum and carbon. The spot size of micro XRF and TOF-SIMS analyses was approximately 10 microns. Synchrotron x-ray computed microtomography indicated that grain-coating thicknesses were variable, but were in the range of 15 – 20 microns. Multivariate spatial statistical techniques were used to determine how multiple elements co-localized within soil microsites potentially affected arsenic oxidation and accumulation.

Arsenic accumulation in sand-grain coatings was spatially heterogeneous and showed a trend of increasing accumulation with increasing iron in microsites. Considerable scatter in the As-Fe trend data and statistical analysis of pairwise relationships suggested that elements other than Fe affected arsenic accumulation. For example, TOF-SIMS showed a trend of aluminum associated with iron in soil microsites. A significant proportion of the reacted As(III) was oxidized to As(V); however, the particular redox couple(s) involved could not be ascertained from our data. Nevertheless, direct analyses of arsenic reactivity at a microscale in soil materials along with spatial statistical analyses of matrix elements within soil microsites can potentially infer reaction mechanisms that control arsenic oxidation and retention in the environment.

Keywords：*trace elements, arsenic, microreactivity, X-ray absorption spectroscopy*

O29-6

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Interspecies Transfer and Cycling of Phosphorus in Agricultural Soils

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The anthropogenic eutrophication of aquatic systems primarily due to diffuse nutrient sources such as agricultural phosphorus (P) is a growing worldwide water quality problem. Managing the loss of agricultural P to curb eutrophication is an inherently complex problem which requires thorough understanding of soil reactions and processes including surplus P beyond plant uptake. We apply phosphate oxygen stable isotope ratios and Nuclear Magnetic Resonance (NMR) techniques to elucidate P cycling and interspecies transfer reactions among soil P pools with an aim to identify ultimate fate of surplus P and identify whether legacy P is more recalcitrant to leaching compared to freshly applied P fertilizers. Our results show that the fertilizer P applied in the agricultural soils undergoes rapid interspecies transfer and tend to become gradually unavailable to plants and ultimately precipitates as calcium phosphate minerals. The kinetics of this reaction is controlled primarily by the timing of fertilizer application and plant uptake, while soil mineralogy and microbial P cycling play subordinate roles. This reaction influences the leachable P in the soils with continued high and long-term applications of fertilizers and animal wastes. Interspecies transfer pathway in agricultural soils is opposite to that in non-agricultural soils where weathering and dissolution of minerals supply P to plants and microorganisms. It is, however, yet unclear the long-term impact of reversed P cycling in agricultural soils. In overall, these unconventional findings are expected to provide insight into soil P reactions and processes that can be exploited for realistic and beneficial nutrient management practices and to minimize P transfer from agricultural soils to surface waters.

Keywords：*Phosphorus, Eutrophication, Stable isotopes, NMR, Interspecies Transfer*

O30-1

[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

How much Soil Spatial Information do We Need to Address Critical Uncertainties in Development Decisions?

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Digital technology has vastly increased our ability to generate data on soils at a variety of scales. Pedometric advances include georeferenced ground survey, analysis of soils using spectroscopic techniques, increased availability of remote sensing data, and advances in spatial statistics and digital mapping, which can now be combined to directly map soil functional properties at different scales. Examples of this are given from the Africa Soil Information Service and the Ethiopian Soil Information System. However there is now a danger that much effort will be spent on generating large amounts of data with little regard to its actual use in improving development decisions. There is opportunity to couple pedometrics with the field of decision analysis to optimize the utility of soil data.

The author conducted a global review of monitoring systems in agriculture, environment and livelihoods and found little evidence for impact of monitoring systems on management or policy decisions. A follow-up review of data requirements for stakeholders in African agriculture revealed a lack of alignment between perceived data needs, uncertainties, and data gathering efforts. These reviews recommended a decision analytic approach whereby researchers first model the uncertainty in key decisions they seek to improve before designing measurements.

The decision analysis process, using an applied information economics approach, has the following steps: (i) define the decision and identify relevant variables, (ii) model the current state of uncertainty for all variables, (ii) compute the value of additional information, (iv) measure where the information value is high, and (v) optimize the decision. This Bayesian approach makes efficient use of existing information, pinpoints where further uncertainty reduction is required, and tells you the maximum amount you should spend on new measurements. Examples are given at national scale for planning fertilizer programmes, and at farm scale for decisions on fertilizer application.

Keywords：*soil spatial data, uncertainty reduction, decision analysis*

O30-2

[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

A Non-probabilistic Approach to Estimate Prediction Uncertainty with Sparse Ad Hoc Samples

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The importance of estimating uncertainty associated with the predicted value of soil properties at unsampled location has gained increasing awareness in the past decades. Prediction uncertainty will not only be useful for indicating the quality of soil information predicted at each location but also valuable for optimizing the allocation of additional sampling resources. Probabilistic approaches have been widely adopted to estimate uncertainty in pedometrics applications. The applicability of probabilistic approaches is often limited by the large amount of soil samples and the specific spatial distribution required. This paper developed a non-probabilistic approach for estimating uncertainty using sparse ad hoc samples. Based on case-based reasoning theory (CBR), this approach adopts a similarity-based reasoning procedure to predict the values of targeted soil property at unvisited locations and estimate prediction uncertainty. Each individual soil sample can be treated as a case representing the soil-environmental relationship at the sample location. By assuming that the more similar environmental conditions between two locations the more similar their soil properties, the value of targeted soil property at unvisited locations can be predicted by referring to environmentally similar samples. Prediction uncertainty then comes from using similar soil sample cases to predict the value of targeted soil property at unvisited location according to the environmental similarity between the two locations. The confidence of making a prediction at unvisited location is inversely related to the degree of environmental similarity. Such prediction uncertainty is estimated at every location by analyzing its environmental similarities to all existing soil sample cases. This method has been applied in a case study located in Ily valley, Xinjiang Autonomous Region, northwestern China for predicting the content of soil organic matter (SOM) in the top layer and quantifying prediction uncertainty at every location. For the total over 56,000km2 area, only 75 soil samples had been collected in 1980s with an ad hoc spatial distribution pattern. The validation result showed a positive relationship between the estimated uncertainties and the predicted residuals at 32 independent soil sample locations. This result supports the conclusion that the non-probabilistic approach developed in this paper can be an effective alternative for quantifying prediction uncertainty when available soil samples are sparse and ad hoc.

Keywords：*non-probabilistic, uncertainty estimation, sparse ad hoc samples, soil property mapping*

O30-3

[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

Changing Epistemic Uncertainties in Soil Classification and Digital Mapping

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Changing epistemic uncertainties are discussed in the context of soil classification leading to the production of a digital soil map. Uncertainties are associated with a diverse range of data inputs with each input subject to possible errors in data acquisition and transmission. Epistemic uncertainties relate primarily to the information content, or lack thereof, rather than to variability in covariates or inputs - which are referred to as aleatory uncertainties. The discussion covers topics related to changing uncertainties in data and its collection over time, and the possible effects on classification of soils and their representation at different scales and the surrogates used.

Keywords：*Epistemic, uncertainty, digital soil map, soil classification*

O30-4

[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

Uncertainty Directed Digital Soil Mapping

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Legacy samples are valuable sources for soil mapping. However, these samples are often small in size and ad hoc in spatial distribution. The overall accuracy of produced maps could be very low based on traditional interpolation methods using these samples. Liu et al (2012) developed an approach to map soils using sparse and ad hoc samples for locations well-represented by existing samples and to quantify the prediction uncertainty. Constrained by the limited representativeness of such sample set the obtained soil maps are often incomplete in spatial coverage with "gaps" at the locations which cannot be well represented by the samples. The maps may also contain areas of high prediction uncertainty. In order to extend the predicted area and reduce prediction uncertainty additional samples are needed. This paper presents a sampling design scheme based on prediction uncertainty to select samples which will complement the sparse and ad hoc sample and effectively maximize the spatial coverage of prediction and minimize prediction uncertainty. A case study in China shows that this sampling scheme was effective in reaching these goals. The finding of this study suggests that prediction uncertainty is a useful mean to aid field sample selection and that samples from different sources can be effectively integrated. Furthermore, using this approach the increase in mapping accuracy can be quantitatively related to the number of additional samples needed which opens a new horizon for mapping in this digital era.

Keywords：*Legacy samples; Individual representativeness; Prediction uncertainty; Sampling design, Uncertainty*

O30-5

[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

Bayesian Geostatistical Modeling of Soil Organic Carbon with Uncertainty Analysis across a highly Heterogeneous Landscape

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There has been a growing interest in quantifying soil organic carbon (SOC) with uncertainty assessment because the SOC reservoir plays an important role in global carbon cycling. To understand if soil carbon acts as a sink or source in the global carbon cycle it is not only important to make reliable estimates, but also determine upper and lower bounds through uncertainty analysis that represent "best and worse" case conditions. In this study, we applied the Bayesian geostatistics in a large region – Florida, USA. The specific objectives were to: 1) apply the Bayesian geostatistical approach to characterize the spatial variability of SOC in the topsoil (0-20 cm depth) and compare them to conventional geostatistics; 2) utilize the Bayesian geostatistical models for spatial predictions of SOC with uncertainty assessment; 3) validate the Bayesian derived predictions of SOC and credible interval using an independent validation dataset. Results showed that Bayesian geostatistics with Markov Chain Monte Carlo agreed with the conventional geostatistics with Restricted Maximal Likelihood in the estimates of spatial random effect parameters. The Bayesian geostatistical model, incorporating six covariates representing soil moisture, vegetation and topography, had better prediction accuracy than the Bayesian model with only spatial random effect. In addition, the former has a narrower prediction interval of 95% probability coverage indicating it has higher prediction precision. Generally, the width of Bayesian prediction intervals increased with the posterior mean SOC predictions. The standard deviation of the posterior parameter distribution reflected the attribution of the parameter uncertainty to the posterior SOC prediction uncertainty. The result showed that effects that explained more of the SOC variance contributed more uncertainty to the SOC prediction. The validation of prediction interval on the independent dataset also confirmed that the empirical coverage probabilities of the prediction interval are close to the corresponding nominal coverage probabilities (50 and 95%). Our findings are important to quantify SOC stocks in the southeastern USA where a heterogeneous mosaic of high and low carbon in soils occurs ranging from 0.45 to 34.15 kg m-2. The uncertainty of SOC predictions facilitates to identify not only "hot" and "cold" spots in a landscape to mitigate and adapt to global climate change, but also informs scenario assessment to imagine possible carbon-rich, -neutral, and -poor futures.

Keywords：*Model Parameter Uncertainty, Bayesian Hierarchical Model, Markov Chain Monte Carlo, Soil Organic Carbon, Digital Soil Mapping*

O31-1

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Bread and Soil in Ancient Rome: a Vision of Abundance and an Ideal of Order based on Wheat, Grapes, and Olives

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"If the theory of the insidious decline of the soil as the result of human cultivation is correct, would humanity not have met its demise a long time ago? Is humanity's survival for thousands of years and its enormous growth in numbers since the invention of agriculture not proof enough that there must be elements of sustainability not accounted for by this theory?" - Joachim Radkau

The words of the environmental historian Joachim Radkau speak cogently to the underlying, mysterious roles of soil in the sustainability, resilience, and continuity of human civilizations based on agriculture; in particular, that of ancient Rome. The soils of the Mediterranean Basin were a source of political power, economic wealth, and surplus food; all of which were essential for the growth and evolution of the Roman civilization over millennia.

A common refrain written by many over centuries since 500 CE is that the ancient Romans misused, exploited, or abused soils on erodible landscapes of fragile Mediterranean ecosystems. As a result, the Roman Empire as a "monster-state" and "vicious and ridiculous system" ultimately fell, and the civilization of the western Mediterranean region collapsed in the 5th century CE into a society controlled by barbarians. A "ruined landscape" remained with low soil fertility, eroded soils, and little native vegetation characteristic of the bio-region. Have we overlooked a narrative of sustainability in Roman times by focusing too much on the oft-told, historical drama of the 5th century CE? What can we learn from events in earlier centuries of Roman history that speak to the rise and resilience of their culture, and not just their presumed demise based on soil exploitation?

A close reading of the environmental and agricultural histories of ancient Rome, linked to modern soil science and interpreted with new theories of the dynamics of ecosystem disturbance and recovery, leads to a more heuristic narrative of cultural and ecological change in Roman history. This is particularly germane to our understanding of the dramatic transition period of approximately 240 years of Roman Antiquity starting with the onset of the Punic Wars in 264 BCE. This time of cataclysmic social change encompassed the years of the Crisis of the Republic (133 to 44 BCE), including civil wars and the assassination of Julius Caesar (44 BCE). It ultimately set the stage for the two centuries of Pax Romana (from ~27 BCE) that gave birth to the nascent Roman Empire under the first emperor, Caesar Augustus, who ruled from 27 BCE to 14 CE.

We explore this particular period of Roman history as a time of dynamic cultural evolution based on a mosaic of resilient ecosystems supported by soils that were used and managed for agriculture. We focus on the peninsula of Italy, the island of Sicily, and the Mediterranean coastal zones of North Africa where wheat for bread, grapes for wine, and olives for oil were produced. This unusual triad of foods that was and still is the core of the Mediterranean diet based on the seeds of a non-native, annual grass and the fruits of two native, woody perennials was produced on a challenging landscape that required considerable creativity to provide enough food to feed burgeoning metropolises, especially Rome, and a mighty military machine spread over a vast geographic region. Land stewardship practices varied regionally and changed temporally from small farms owned and worked by peasants to huge estate farms (latifundia) controlled by absentee owners and supported by an abusive, but profitable, system of slave labor.

Our transdisciplinary study leads to the conclusion that the Romans of this period did not create a degraded landscape and eroded soils. The climate, topography, and diversity of the biogeography of the region appear to have contributed a resilient resource and biophysical system that was supportive of the Romans, and that was resilient in the face of natural and cultural change over centuries.

Keywords: *civilization, soil resilience, environmental history, ecology, erosion*

O31-2

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Climate Change-an Underfoot Perspective

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Life on Earth has been sustained by soils since its emergence about 4.5 billion years ago. During this time climate has been a key soil-forming factor and, conversely, soil processes have been regulating the climate. As soils and climate are inextricably linked, our use of soils can be both a cause of climate change and an answer to meeting this great challenge of our age.
Natural climate changes have in the past been the cause of large-scale human crises, including famines. Now the excessive use of fossil fuels and the exploitation of land in order to feed an expanding population, projected to reach 9 billion within 30-40 years, are contributing to widespread increases in flooding, droughts, and heat waves, as well as the melting of glaciers and ice caps. Accordingly, there is an urgent need to replace fossil fuels with renewable forms of energy, halt deforestation, prevent the loss of productive soils, and improve the resilience of our land-management practices. The problem is compounded by our current economic systems, which rely heavily on massive subsidies from the environment, including our soils, and on the use of outmoded indices of progress like GDP.
The biological turnover of carbon and nitrogen in soils is central to our understanding of how soils act as a source or sink for atmospheric CO_2, CH_4, and N_2O, as well as support food production and regulate climate, water supplies, and biodiversity. Better understanding and management of these processes are essential if we are to reduce greenhouse gas emissions. While our knowledge of key soil processes is incomplete, some of these processes can already be applied to mitigate greenhouse gases, and to adapt to the future impacts of climate change. Examples include the use of clays and soil bacteria to mitigate CH_4 emissions, and the use of microorganisms for biofuel production. Although our soils can continue to provide many of the services we need, with careful management and innovation, we must make the appropriate changes to our underfoot perspective.

Keywords：*Soil underfoot,greenhouse gases, climate change*

O31-3

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Picturing the Soil: Artistic Approaches to Raising Soil Awareness

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Covered by layers of rotting leaves on the forest floor, the golden stubble of fields and meadows, or the weed-and-litter-fringed concrete slabs of city sidewalks, soil is hidden by default. The most common images we have of the soil come from two main sources- the scientific community, with its numeric graphs and analytical descriptions, and popular media. Both are powerful and informative, but insufficient in providing imagery to truly inspire stewardship or stop soil degradation.

In the practice of image-production, contemporary artists are expert craftspeople who use innovative techniques to make the invisible visible. For this reason, soil enjoys a special place in painting, printing, and photography and its representation throughout art history has been analyzed (Busch 2002, Feller et al 2010, Hartemink 2009, van Breemen 2010,) as well as taken on as an expressive medium within the soil science community (e.g. Gerd Wessolek, Jay Noller, Ken Van Rees). Bachmann (2001) emphasizes the ability of artists to bring to the surface more than mere facsimiles of the soil profile: "The aesthetic portrayal of soil is more than just representation of what is found in nature, rather it is an image charged with metaphors and meanings. …To bring the sound of the earth to vibration …to make the color of time visible, to learn to read the soil again - the arts could show us the way…"

This paper presents a range of contemporary artworks with the aim of expanding the scientific portrait of soil as a pedogenetic body. Together, the artworks deconstruct conventions of genetic classification by inventing new methodologies of understanding defined by sensory experience, cultural contextualization, and an intuitive collaboration with the soil itself as material guide. From the pioneering works of herman de vries and Walter de Maria to the experimental bioart of Daro Montag, the sediment paintings of Mario Reis and street art of Jesse Graves, these works restore "a sense of emotion and spirit to the understanding of the substance that underpins our existence," (Lines-Kelly 2004), introducing concepts of the soil beyond scientific and economic rationalism or popular imagery.

While the works presented here allude to issues of environmental and social justice, soil protection and diverse underlying cultural contexts, what they mainly have in common is an aesthetic entry to the hidden realms of the pedosphere. With aesthetic entry a formalist aesthetic reading is implied, i.e., the appreciation of that which may be physically referenced not only in the formal compositions of artworks, but also in soil environments: color, texture, form, contrast, rhythm, balance, topography, etc. (see Zangwill 2001 for discussions on aesthetic formalism and the environment). All of the works presented are produced in highly aesthetic styles to expose the beauty, diversity and uniqueness of the soil and the landscapes from which soils develop. The works are loosely organized by genre, including: painting, pigmenting, printing, and artists' archives. Beyond these categories, aesthetic awareness is also created with installation, performance, and different types of participatory engagement. By blending a range of

contemporary artistic positions with scientific concepts, an attempt is made to re-imagine and re-evaluate the soil.

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Keywords：*art, painting, archiving, visualizing, raising soil awareness*

O31-4

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

The Finite Soil Resource for Sustainable Development: the Case of Taiwan

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In order to anticipate the kinds of challenges and problems we will all face, it is pertinent to examine the case of Taiwan, which is a relatively small island nation in area, but with a high density of population and which is quite highly developed, both agriculturally and industrially. As a result, the soils and those who manage them have experienced many challenges and problems. This case study of the way that these are being met by soil scientists and society in Taiwan can provide lessons for us all for the future. Human-induced processes that markedly change soil properties and result in diagnostic horizons or properties are termed 'anthropogenic processes'. In the case of soils affected by human activity in large-scale farming, the anthropogenic processes have operated in Taiwan for approximate four hundred years. They have particularly involved the numerous agricultural activities in soils, such as puddling of surface soils (mechanically stirring and mixing surface soil with water and making it into a muddy paste) for paddy rice production by human beings. Paddy soils (rice-growing soils) are developed from various other soils. Land leveling and terracing produce changes in the soil moisture regime for paddy rice production. The recognition of paddy soils is mainly based on the obvious impacts of anthropogenic activities on the soils. Artificial and seasonal water saturation often lead to the formation of special layers characterized by Fe and Mn distribution. Puddling is often necessary practice for easy transplanting of seedlings, and it results in a poor soil structure in the plow layer and a compacted plow pan. This latter is good for saving irrigation water as long as it does not adversely affect the growth of roots. Therefore, a principal distinction of paddy soils from upland soils is the variation in their oxidation and reduction status. The agricultural soils have been intensively cultivated for crop production to fulfill the needs of the large population in Taiwan, especially in the last four decades. Soil degradation has occurred as a result of both natural hazards and human activities. The total area of cultivated soils in Taiwan is 0.85 million ha (24% of the total area in 2012), while over 30% of the cultivated soils are potentially degraded. The major types of degradation of soils in Taiwan are soil erosion, soil acidification, soil compaction, high salinity and heavy metal contamination, especially in last three decades. Rapid development makes soil contamination an inevitable problem and a big challenge for scientists and environmental policy makers. In order to sustain soil health for future generations around the whole globe, the soil resource worldwide should be protected against slow and insidious poisoning by contaminants released from industrial development and intensive agricultural activities. We are standing at the cross roads for the development of pedology in Taiwan. Basic pedology courses, including basic soil science, soil morphology, genesis and classification and soil survey techniques, are still offered by four national universities of Taiwan. However, in the last decade in Taiwan, most graduate students have shifted their interests to other fields in order to find jobs, especially on soil survey, and on the prevention and remediation of potentially highly contaminated sites for environmental consultant companies in Taiwan.

Keywords：*Anthropogenic process; soil degradation; heavy metal contamination; land use*

O31-5

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Seeing Soil

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Most people are soil-blind. They walk on soil, they see it in the distance, they appreciate its bounty, but they have no awareness of soil as a complex living organism. If we are to move towards a world in which we treat soil with respect, finding ways to bring soil alive to the general public is essential. And treating soil with respect is essential to our survival.

Several years ago I decided to make a film about soil and I soon found myself in a dilemma: how to create a film, a medium which is about light and movement, about soil, a medium which is dark and seemingly inert. So I began the process of figuring out how to see soil: as an organism, as an ecosystem, as a community, microscopically, from a satellite, as evolving in time and as developing in unique spaces. I came to see soil from the point of view of the farmer who works his land, the scientist who studies her samples and the philosopher whose work connects heaven and earth. Ultimately, I came to see soil as heroic, a protagonist of our planetary story.

As the film took shape, I had a revelation as to what the perfect title would be: Symphony of the Soil. A symphony is complex, with many cycles, rhythms and textures just as soil is complex. A symphony is made up of different parts which come together as a satisfying whole, as I hope my film does. And by choosing to call the film a Symphony, I could bring together the worlds of science and art. Making Symphony of the Soil, was a deeply rewarding experience. In order to appreciate soil, one has to understand it. Figuring out how to use highly technological means to help people connect with nature and with soil, which resonates deeply within our human nature, was not only a fascinating challenge, it was fun!

O31-6

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

The Soil Underfoot: the Concept of the Book and its Realization

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The book 'The Soil Underfoot: Infinite possibilities for a finite resource' (CRC Press, 2014) is an edited volume that originated in Commission 4.5, the History, Philosophy and Sociology of Soil Science. It therefore belongs to the tradition of producing books that has been maintained by this Commission. Previous books in this tradition were edited by Yaalon and Berkowicz (1997), Warkentin (2006), and Landa and Feller (2010). The two earlier books dealt with the history of soil studies, while Landa and Feller's volume was concerned with the cultural aspects of soils. In The Soil Underfoot, we have set out to search for and compile views of our greatest natural asset from far and wide, past and present for attitudes, ethics and evidence in order to help sustain humankind into an uncertain future

We saw the need for this book coming from the challenge we face to enable humankind to survive into a future when there are >9 billion of us, while many changes continue to occur in the global environment. There is a need for us humans to enable our survival while maintaining the best that the earth can offer in terms of biodiversity and a healthy environment. If this is to occur, we consider that it will be necessary to maintain, and if possible, improve the quantity, and productivity (and therefore, quality) of soils in order to be able to support more people in a changing environment. Other books have attempted a technical analysis of the means by which we can sustain soils for the future requirements of humankind; but this present book is not primarily technical in nature. Instead, it is a collection, from diverse cultural and geographical sources, of descriptions of attitudes to soils, including philosophical and ethical frameworks, which have either sustained them, or led to their degradation, in the past. These are combined with current analyses, and with examples of what may be required- some from different scientific viewpoints, and some from niche user viewpoints. It obtains its inspiration from Leonardo da Vinci's statement "We know more about the movement of celestial bodies than about the soil underfoot."

We were fortunate to be able to include 30 chapters in the book, with their authors coming from 13 different countries. The book comprises sections on Future Challenges (5 chapters), these also include threats; Valuing Soils (6 chapters), including some continuation of themes from Landa and Feller's 2010 volume; Cultures and History (11 chapters), which is the bulk of the volume; Technologies and Uses (5 chapters), these include non-agricultural uses of soils; and Future Strategies (3 chapters), including informed crystal-ball gazing.

This paper will outline the background and scope of the book. The aim of the paper is to introduce the main themes that have emerged from the collection of expert contributions to the book. These include the fragility, yet wonder, of soils and their requirement for our stewardship; their essential biological nature and the need to investigate and devise new and ingenious ways of the more efficient use of water in soil to grow plants and sustainably supply more food. In the book, these questions are approached by interrogating the 'wisdom of the elders', especially those from past civilizations, as well as their follies. In addition, they are pursued through new approaches, both technological and those borrowed from other land uses besides large-scale agriculture. The paper will summarize these various aspects of the major challenge that is posed for soil scientists to feed a burgeoning population while sustaining soils into the foreseeable future.

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Keywords：*Burgeoning population; sustaining; survival; future; civilizations; water; environment*

O32-1

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Pedogenic Processes in Anthropogenic Mine Soils

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The basic concepts of soil forming processes are based on the five classic soil forming factors, i.e. parent material, topography, climate, time and organisms (the latter includes the human impact), but the human factor should be highlighted based on the vast positive and negative influences.
In the case of mine tailings, which is not regarded as soil in its fresh and unaltered state, but as an anthropogenic soil, the human impact is huge considering the following:
- The material is mostly rock which is crushed to a fine, well-sorted medium by human activities;
- New, man-made landscapes and structures, e.g. tailings and rock dumps, are created;
- Different micro-climatic conditions dominate different aspects and elevations of the new, man-made landscapes;
- The time frame for nearly all pedogenic processes is reset to zero as soon as the material is deposited (which is very difficult to imagine for natural soils);
- Micro-organisms, and specifically soil microbes, dominate the upper part of natural soils, but hardly any traces have been found in fresh mine tailings;
- The human impact dominates the entire new anthropogenic landscape and material; to a great extent it determines the process of disturbance and pollution potential as well as the potential to become a respectful part of the holistic ecosystem with specific entities and characteristics. These new ecosystems are mainly the product of human influence, whether negative or positive.
Natural pedogenic processes can be enhanced by human activities to create new sustainable ecosystems as soon as possible. Therefore amelioration programs, e.g. lime neutralisation, compost, fertiliser, irrigation and soil microbial inoculation are common applications in tailings rehabilitation programs. These amelioration programs are focused on stabilisation of the surface of tailings dams as soon as possible. Natural pedogenic processes such as oxidation, illuviation, leaching, hydrolysis, etc. are the ultimate drivers behind the new pedogenic restoration.
This abstract and presentation involves different pedogenic processes grouped into the pedotransfer groups which dominate on mine tailings materials.
Gold mining has been a common activity in South Africa for the last 130 years. It is associated with quartzitic conglomerates from the Witwatersrand Supergroup and is mainly associated with pyrite in the conglomerates. The moment the pyrite is exposed to atmospheric conditions (as on the tailings dams), the oxidation process immediately starts with the following basic geochemical reaction:
$FeS2 + 3.5\ O2 + H2O = FeSO4 + H2SO4$
It is evident that both acidification and salination dominates and that it differs from most natural soils. Ongoing oxidation and acidification can remain for many decades in this material if conditions remain favourable. As soon as solution of any sort of substance occurs, transportation processes are initiated, e.g. leaching, illuviation, seepage. Each one of these pedotransfer processes have their own end results or trigger new activities. The geochemical transformation processes normally occur very soon after deposition, but it takes approximately ten years for an ameliorated and rehabilitated gold tailings dam to show real-time horizon differentiation and nutrient recycling.
The platinum mine tailings are dominated by pyroxene and anorthosite with very little pyrite. Both the pyroxene and anorthosite weather away much more quickly and the geochemical end results are much less aggressive than those of gold tailings. Good internal drainage as well as Illuviation dominates and therefore leaching of harmful salination products is much less. In the case of platinum tailings, horizon differentiation occurs much faster and is evident within three to five years.
Minerals such as pyroxenite, olivine and calcite are common in kimberlite tailings together with some minor sodium minerals. This combination of minerals together with the deep origin of the kimberlites and instability when exposed to atmospheric conditions makes kimberlites much more prone to disintegration, e.g. slaking and dispersion. These two together convert the kimberlite rock and tailings much faster into soil-like material. There are examples where slick and slides and large desiccation cracks can occur within 60 years. Horizon differentiation by means of illuviation and secondary mineralization is common within one to two years.
It can be concluded that different mine tailings have different geochemical reactions dominating each tailings environment, which influence the pedogenic processes turning these hostile materials into soil again.

Keywords：*Pedogenic processes, tailings materials, pedotransfer processes, anthropogenic soil formation*

O32-2

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Human-altered and Human-transported Soils: a Bottom-up Approach in us Soil Taxonomy

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US Soil Taxonomy is a six-level hierarchical system of classification that has been in use since 1975 but has had few taxa and little consistency for classifying soils that have profound alteration by humans (human-altered and human-transported or HAHT soils). Literature review shows us that HAHT soils logically occur in every soil order and have the same range of properties as existing taxa (except for those that have diagnostic horizons and characteristics that take an extremely long time to form). We know that HAHT soils have high variation properties than less modified soils because of human purpose and parent materials, and are thus less predictable. HAHT soils are found on or above anthopogenic landforms and microfeatures, and are only considered different than other soils if the degree of alteration is profound and appears to have a purpose.

After over 14 years of input and testing in multiple urban and agricultural landscapes, the 12th Edition of the Keys to (US) Soil Taxonomy will be amended to add taxa at the family and subgroup level. Also, taxa higher than subgroup level will be moved down to that level. The bottom-up approach was chosen because it facilitates establishment of new soil series, the sixth level of the system, and increases the efficiency and organization of higher taxa. The soil series are the functional grouping of soils that have similar classification, properties, and interpretations for management, and thus are the key level for making and interpreting soil surveys. Established soil series for HAHT soils will need little modification. However, soils formerly classified based on fragments of diagnostic horizons will be allocated based on what diagnostic horizons they contain now.

A set of seven new subgroups will identify HAHT soils. The seven subgroups are Anthraquic (flooded), Anthrodensic (compacted), Anthropic (artifacts), Plaggic (thick plaggen), Haploplaggic (thin thick plaggen), Anthroportic (HTM), and Anthraltic(HAM). There will be a new family classes with 17 descriptors that add specificity for unusual materials or activity. These will be especially useful to identify parent materials most often observed in urban and suburban areas. Examples include: methanogenic (produces methane), asphaltic (contains significant asphalt), concretic (contains significant concrete), dredgic (hydraulically dredged), spolic (transported), and araric (mixed in place). Mine soils will be classified based on presence of densic contacts, cambic horizons, and replaced epipedons. The anthropic epipedon has been rewritten, and P content removed as a differentiating criteria from epipedons. Misallocation of HTM soils with irregular distribution of carbon with depth into the same category as floodplain and footslope soils has been eliminated. Artifacts, manufactured liners, HAM and HTM are now clearly defined. Anthropogenic microfeatures (e.g. scrape marks in the soil, tile drains) and anthropogenic landforms (both raised and excavated features) are used in identifying HAHT soils. Occurrence on an anthropogenic landform or above a buried landform carries with it evidence of a soil forming process and soil properties that require careful interpretation for use and management.

Many systems decided to recognize “Anthrosols” or “Technosols” at the highest level. This is possible because their systems do not have six levels, or they may have a very large number of soil orders. The intent of the ICOMANTH proposals is to collect data and define soil series for mapping and research in the most efficient manner possible. Since there would conceivably be a doubling/duplication in the number of suborders in at least half of the soil orders based on presence of HAM and HTM, adding taxa from the top down would not be the most efficient approach. Instead, as soil series for HAHT soils are created, they will fall into one of seven subgroups, added as needed to any great group in the current system from the bottom up.

Keywords：*classification, anthropogenic, artifacts, densic contact, mined soils, urban soils*

O32-3

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Human Transported and Altered Material as a Diagnostics Key Feature for Technosol

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Following an internationally acceptable consensus in differentiation of terms: urban (general term for soils located in SUITMA areas) and anthropogenic soils (classification term) we have tried to focus on Technosols (WRB 2006, 2007) as anthropogenic soils. The diagnostic involved in the WRB system is perceived by soil scientists very variously, and diagnostic can be vague. According to the new version of the Slovak anthropogenic soils classification the key features recognizing Technosols is human-transported and altered material (HTAM), and artifact content (ICOMANTH, 2011). Technozem (in Slovak version) is characterized as ex-situ located material, largely affected by physical-mechanical excavation, transportation and spread, as well as mixing and containing artifacts. Field survey has to involve into description features of anthro-pedoturbation and pedovariability on which a "new" pedogenesis takes place. Slovak Soil Classification System distinguish Technozems like soils developed from HTAM and recognize two horizons – technogenic top horizon and technogenic subsoil horizon. Three varieties of HTAM layers are classified:

- ♣ HTAM of natural origin – with share of < 10 % artifacts
- ♣ HTAM of natural-technogenic origin with share of 10 – 50 % artifacts
- ♣ HTAM of technogenic origin with share > 50 % artifacts.

Top horizon can be developed as a result of initial pedogenetic processes or as a result of recultivation measures. Also gleyic or stagnogleyic processes are taken into consideration. The cumulative horizons of HTAM are in thickness > 50 cm. As sub-ordered classes are recognized: reductic (contains a significantly high amount of active reductive gas which result from the anaerobic decomposition of organic matter), ekranic (soil sealing covering more than 80 % area), spoil bank (landfill material containing industrial or mining waste), spolic (landfill material containing garbage with methagenesis), urbic (landfill material containing construction artifacts).

Keywords: *Technosol, diagnostics, human-transported and altered material*

O32-4

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Introduced Soils of Urban Areas and their Placement in the World Reference Base for Soil Resources

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Soil composition of any urban area is very diverse: from natural differences that are specific to the given geographic region to man-influenced soils, man-changed soils and man-made soils. The man, being one of the factors of soil formation in urban area, cannot independently create soil in the classical (scientific) sense. However, based on the objective function of provision of conditions for the growth and the development of plants, the man purposefully creates a physical model of the root layer. As a result, organic-inorganic or organic materials (products of a long natural soil formation that was created at a different proportion of the factors) are introduced into the urban environment. Typically, this material is taken from various soils in adjacent lands. Such purposeful introduction of material of the humus (peat, peat-mineral) horizon into a new and alien environment of formation is similar to an introduction that is in turn similar to introduction of species in biology. Despite the considerable variation of the composition and the properties of the introduced horizon in different metropolises of the world, such horizon possesses specific and individual characteristics that allow it to be allocated into a separate diagnostic horizon in the WRB.

Introduced horizone: humus or organic, consisting of an introduced material of surface horizons from natural or humic-changed soils (Anthric, Folic, Histic, Hortic, Mollic, Plaggic, Umbric, Voronic). The introduction of the material is evidenced by a sharp lower boundary of the horizon and a lack of contingency between such horizon and its underlying mineral substrate. Oftentimes, heterogeneity is seen with respect to contents, composition, and density. Inclusion of artifacts is commonplace.

Experience of research and mapping of the soils in the City of St. Petersburg has demonstrated that soils with introduced horizons dominate the historical part of the city and are widespread in the new districts. Given the specific structure of the soil with introduced horizon, it has been proposed that another section be entered, within the new Russian soil classification, into the order of sinlitogenic soils: Introduced soils. The section “Introduced Soil” provides for 6 types of soil on the basis of the nature of the surface horizon and of the characteristics of the mineral substrate.

Classification of soils in urban areas can also be integrated into the WRB on the basis of the following principles:

A unified approach to the classification of all surface-exposed solid bodies that form the topsoil of the metropolis;

In the course of determination of the classification of soils of the urban areas, signs that reflect the degree and the depth of anthropogenic transformation of the soil profile must be considered; The object of classification of urban areas is natural soils, man-influenced soils, man-changed soils and man-made soils – superficial formations that contain an introduced humus (or organogenic) horizon on the surface;

In the course of determination of the classification of soils of the metropolis, it is necessary to consider not only the sequence of horizons (layers) but also the presence or absence of a genetic relationship between them;

For the purposes of diagnostics of the horizons in man-made soils and determination of the qualifiers, the characteristics inherited from natural soils are of top priority.

All introdusols are in an unstable state. Absence of system properties demonstrates initial stages of the profile-generating process. Soil processes in the profile are uncoordinated. The system of mineral and energy exchange is not balanced. No matching exists for the natural factors of soil formation. When estimating the age of introdusols, the following contradiction must be taken into account: the age of the surface humus horizons can be significant whereas the profile can be recently formed.

It is suggested that a new reference soil group (Introdusols) be included in the WRB; this new group is characterized by the positioning of the horizon on the bedrock, with a genetic link in the profile either being absent or present in a very weak form.

The following introdusols have been identified in St. Petersburg in terms of the nature of organic horizons and those of the characteristics of mineral substrate: Umbric Introdusols, Histic Introdusols, Pachic Introdusols, Urbic Introdusols, Spolic Introdusols, Mollic Introdusols, Gleyic Introdusols, Arenic Introdusols.

Keywords：*Classification,urban soils,principal classification,*

O32-5

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Agro-management Practices on Tropical Peatland for Mitigation of Soil C Flux

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Agricultural management and its approach to the environment has undergone dramatic changes as relations between sustainable, multifunctional agriculture and the need for longer term provision of natural resources were realised. In Malaysia, agricultural development largely for oil palm also widely known as the "golden crop" is the key impetus for the conversion of tropical peatlands. Agro-management practices including drainage and compaction are a pre-requisite to overcome the peat's natural state, which is invariably waterlogged, has very low pH and low bulk density. Moreover, yields comparable to mineral soils are achievable with proper management (Singh, 2008). However, conversion of peatlands into oil palm plantations is claimed to modify soil C pools and fluxes by declining C stocks and increasing greenhouse gas (GHG) emissions (Pouyat et al., 2002 and Miettinen et al., 2011). Contrarily, previous studies reported that soil C fluxes were lower in oil palm plantations compared with forests (Melling et al., 2005).

In order to quantify the effect of agro-management practices on the soil C flux in tropical peatland, a two-year study from 2011 to 2012 was carried out at two different ecosystems located in Sarawak, Malaysia. The two ecosystems namely oil palm plantation and primary forest represented the managed and unmanaged peat conditions, respectively. Soil carbon dioxide (CO2) and methane (CH4) fluxes were measured at monthly intervals over two years via closed-chamber method. Peat soil samples in triplicates at two depths: 0-25 cm and 25-50 cm were collected from each ecosystem for both physical and chemical analyses.

The mean air temperatures in the oil palm and primary forest ecosystems were 31.4 ± 0.20 and 29.3 ± 0.25 ºC, respectively. Mean water table in the primary forest ecosystem was higher at 7.5 cm compared with 65.9 cm in the oil palm ecosystem. In contrast, bulk density and water-filled pore space (WFPS) was higher in the oil palm ecosystem with a mean of 0.23 and 76.6%, respectively compared with 0.11 and 72.5%, respectively in the primary forest ecosystem.

The soil CO2 flux ranged from -35 to 210 mg C m-2 h-1 for the oil palm ecosystem and 47 to 322 mg C m-2 h-1 for the primary forest ecosystem. A regression tree approach demonstrated that the dominant factor influencing soil CO2 flux differed between the ecosystems. They were WFPS for oil palm ecosystem and water table for primary forest ecosystem. On an annual basis, the soil CO2 flux was higher in the primary forest ecosystem than the oil palm ecosystem in 2011, with an estimated production of 1.09 kg C m-2 yr-1 and 1.00 kg C m-2 yr-1, respectively. In 2012, the CO2 production rate was also higher in the primary forest ecosystem with an emission of 1.24 kg C m-2 yr-1 whereas at 0.76 kg C m-2 yr-1 in the oil palm ecosystem.

The soil CH4 fluxes in the oil palm ecosystem ranged from -0.10 to -0.36 mg C m-2 and -0.08 to 3.55 mg C m-2 h-1 for primary forest ecosystem. A regression tree approach showed that the dominant factor controlling CH4 flux was WFPS for oil palm ecosystem and soil temperature at 5 cm for primary forest ecosystem. In 2011, the soil CH4 flux for oil palm was 0.22 g C m-2 yr-1 and 9.55 g C m-2 yr-1 for primary forest ecosystem. Similarly, the CH4 production rate in 2012 was lower in oil palm ecosystem with an emission of 0.78 g C m-2 yr-1 whereas primary forest ecosystem at 8.38 g C m-2 yr-1. These results indicated that agro-management actually reduced soil C fluxes and could become an exemplary model for future sustainable agriculture development.

Keywords：*Tropical peatland, agro-management, carbon dioxide (CO2), methane (CH4)*

O33-1

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Linking Soil Health to Human Health

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Soil is often associated with food production and ecosystem services however soils have direct and indirect impacts on human health. Humans are directly exposed to soils, which can adversely impact public health in terms of what we eat, drink, and breathe. Soils contain pathogens and contain bacteria with antibiotic resistance genes and are a major source of endotoxin. Soiborne antibiotics are used to treat human infections, but can also result in antibiotic-resistant bacteria. Natural products isolated from soil resulted in 60% of new cancer drugs between the period 1983-1994. Soils are also crucial to human health through their impact on human nutrition. Micro nutrient deficiencies in human health need to be directly tied to soil as a source for infant development. Soils also indirectly impact human health via anthropogenic activities associated with soil.

Keywords：*Soil health, Human Health, nutrition*

O33-2

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Linking Soils to Global Food Security

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Estimates indicate the need to increase food production by 70 to 100% by 2050 to feed a growing world population. The magnitude of the necessary increase is affected not only by the number of people requiring sustenance, but also by the nutritional components in diets. In particular, increased plant and animal protein consumption will require additional resources beyond meeting basic caloric needs. Considerable acute and chronic hunger already exists globally. The prevalence of stunting and low birth weights are directly related to caloric needs as well as intake of critical nutritional components such as minerals, vitamins, protein, amino acids, anti-oxidants, and many other constituents. Thirty six countries are considered high-burden countries for stunting, with many of those having a prevalence of stunting >40%. Poverty and hunger coincide and 77% of the global extreme poor live in 10 countries. An estimated 700 million people have risen above extreme poverty in the past 15 years but 1.2 billion people remain. Addressing current hunger needs plus that of an increasing population will be challenging. Sustainable intensification is one approach that is being promoted globally. Such efforts will increase farm productivity from existing croplands, improve nutrition, and raise net income while reducing reliance on pesticides and fertilizers, reducing emissions of greenhouse gases, and leading to efficient and resilient farming systems that protect or enhance natural resources, and is generally aimed at small holder farmers. Note that increasing farm productivity can also come from animal agriculture as well as aquaculture. Sustainable intensification encompasses a farming systems approach, efficient resource management, climate resilient/smart technologies, and social and economic issues that influence adoption of improved practices. A critical component in efficient resource management will involve soil and plant nutrient management. Approximately 12% of the globe's land surface is used for crop production. Arable land per capita has decreased from 0.44 ha to 0.2 ha in the past 50 years reflecting a significant intensification of food production. However, little additional land is available for expansion of crop production without significant environmental and ecological impacts. Arable land is under pressure from soil degradation defined as a change in soil health that results in a reduced capacity of the soil to provide provisioning ecosystem services, i.e., less food, feed, fiber, and fuel. Soil erosion, salinization, desertification, plant nutrient deficiencies, and loss of soil organic matter are the primary issues. Climate variability exasperates these problems. Crop residue management practices play a key role in maintaining soil health. Farming systems in many parts of the world involve complete or nearly complete removal of crop residues for use as animal feed or fuel. These practices deny the soil the beneficial impacts of returning carbon to the soil and result in plant nutrient depletion unless such nutrients are returned to the soil in other ways, which is often not the case. Inorganic fertilizers can be in limited supply in developing countries, or prohibitively expensive, and animal manures are often used for fuel or other purposes and are not returned to the soil. These interactions illustrate the economic, social, and ecological complexities when attempting to improve soil quality through proven practices. In contrast, in other developing areas of the world inorganic fertilizers are heavily subsidized which promotes over application and subsequent degradation of water resources. Soil management practices and principles will be key components in the successful application of the sustainable intensification concept.

O33-3

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Land Take and Food Security: What We are Loosing?

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In 2008 more than 50% of the Earth's population were living cities, towns and urban settlements and this percentage is projected to reach 70% by 2050. This process will have an impact on soil resource and on their capability to deliver ecosystem services. Despite, in absolute terms, the percentage of land converted into urban land use will be relatively small, the quality of the soil affected by this process would be of possible concern. Soil is a limited, non-renewable natural resource, on which is based more than 95% of global food production. Furthermore the naturally fertile soils, suitable for a sustainable agriculture production, represent only a limited portion (13-18%) of the total land area of the Earth. On these areas are concentrated the majority of human presence and activities, leading to increasing pressures and degradation processes on soil. Land take and soil sealing, associated to urban expansion, is one of the most detrimental and irreversible degradation process, heavily affecting the food security at regional, national and global level.

In order to understand the impact of land take on soil resources, and in particular with the capability to support food production, high quality data on land use/land cover dynamics and soil properties are essential. The aim of this research is to estimate the intensity of land take at global scale and to evaluate its impact on soil resources and on their productivity.

Keywords：*Land take, soil sealing, soil quality, food security*

O33-4

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Sustainable Soil Fertility Improvement for Healthy Crop Production; a Panacea for Food Security

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It is a well-known fact that the world population is growing at an astronomical rate. Indeed, it was estimated that the world population hit 7billion in November, 2011 and will rise to 8.01billion in 2025 as predicted by United Nations (2008). Feeding has therefore become an increasingly great challenge for agriculturists and policy-makers especially in developing countries. One of the ways of meeting this challenge is to boost agricultural productivity through improved soil fertility. This must however be carried out in an environmentally sustainable manner to ensure that meeting the needs of the present does not jeopardize the needs of the future generations. Similarly, the issue of food security which is a function of improved soil fertility and good agricultural practices is not just about the quantity but also the quality of food. Consumer health and safety must therefore be taken into consideration while developing strategies for sustainable agricultural practice. Conventional method of farming, apart from not being sustainable due to its health and environmental implications, also promotes 'hidden hunger' arising from imbalance in essential micronutrients. In this wise, organic agriculture is currently being promoted. It involves the optimum and sustainable utilization of natural resources through the use of organic manures such as compost and biochar for soil amendment. This results in improved agricultural productivity which ultimately enhances food security. It is said to remove hidden hunger as well as, health and environmental hazards associated with the conventional farming system. It has also proved effective in remediation of heavy metal contaminated soil and crop yield improvement. However, the acceptability is still very low due to bulkiness and slow release of mineral nutrients from organic materials which are commonly used in organic farming system.

The research work being reported here compared the effectiveness of compost, compost tea and inorganic fertilizer (NPK) on the growth, yield, nutrient uptake, chlorophyll and carotenoid contents and biochemical compositions of two varieties of maize (Zea mays L.) (SWAN Y-X2 and DTMRY) in both pot and field experiments. In the screen house, dry compost at different levels (0, 5, 10 and 15 ton/ha), compost tea at (200m3/ha, 400m3/ha and 600m3/ha) and N.P.K (15:15: 15) fertilizer at 0, 100 and 150 kgN/ha were compared. Effective application rate for dry compost (10 and 15t/ha), compost tea (400m3/ha and 600m3/ha) and inorganic fertilizer (100 and 150kgN/ha) selected in the pot experiment were tested on the field. The pots were laid out in a Complete Randomized Design (CRD) while RCBD was used on the field with four replications. The experiments were also repeated for residual trials. Data were collected on growth and yield parameters of maize as well as nutrient uptake, chlorophyll and carotenoid contents and biochemical compositions. Pre and post planting soil nutrient analyses were also carried out. Compost application generally increased the concentrations of the essential nutrients in the soil compared to inorganic fertilizer and control treatments. In terms of nutrient uptake by the maize crop, soil amendment with compost also enhanced nutrients accumulation most especially, essential micronutrients unlike the maize crops treated with inorganic fertilizer. Although, mineral fertilizer performed better in all the growth parameters measured with the highest mean values compared with other treatments in the first pot experiment, these values were not significantly different ($P \leq 0.05$) from compost treatments at 10 and 15t/ha. On the field, 15t/ha of compost increased the dry matter yield, leaf chlorophyll and carotenoid contents compared to control and inorganic fertilizer treatments. For residual effect, earlier application of compost at 15t/ha performed better than all other treatments including inorganic fertilizer treatments. Higher compost tea treatment (600m3/ha) also had a significant influence on growth and yield parameters compared to other compost tea treatments but these were not as effective as dry compost. Compost compared favourably with inorganic fertilizer but outperformed it in the residual experiment. Soil amendment with 15t/ha compost could be recommended for improved soil fertility, maize yield and nutrient uptake. It also has greater residual effects on all the parameters considered which confirmed the carry-over benefits of compost on succeeding crops.

Keywords：*Compost, Chlorophyll, Maize, Yield, Inorganic fertilizer, Nutrient uptake, Soil improvement*

O34-1

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Arsenic Accumulation and Speciation in Rice Grains of Various Genotypes Grown in As-contaminated Paddy Soils

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Inorganic arsenic (As) is identified as a non-threshold, class 1 human carcinogen, and the intake of As through consuming rice grains may lead to the serious health effects. In order to selecting genotypes with low As contents in rice grains, this study investigates the effect of genotypes on the accumulation and speciation of As in rice grains grown in different level of As-contaminated paddy soils from Guandu Plain of northern Taiwan

Three levels of As-contaminated Guandu Plain soils (16.3 (L), 343.3 (M) and 512.3 (H) mg As kg^{-1}) and six rice genotypes commonly planted in Taiwan, including three japonica and three indica genotypes, were used in this study. Rice seedlings were pre-cultivated in nutrient solutions for 2 weeks and then transplanted to As-contaminated soils for nearly 130 days until the grain mature. The biomass, root length, shoot height, and rice yields were measured. The concentrations of As (As species) in pore water and plant tissues were analyzed by high pressure liquid chromatography-inductively coupled plasma-mass spectrometry (HPLC-ICP-MS). Iron and dissolved organic carbon (DOC) in pore water were determined by inductively coupled plasma-optical emission spectrometry (ICP-OES) and total organic carbon analyzer, respectively.

The concentrations of As in pore water of M and H soils was higher than 3000 μg L^{-1}, and the L soil below 200 μg L^{-1}. The grain As concentrations significantly decreased with As concentrations in pore water, due to the As phytotoxicity to rice in M and H soils, as also indicating by the decrease of root length, shoot height and grain yields. The grain As concentrations in rice grains of indica genotypes was higher than japonica genotypes, due to the higher As translocation capability from flag leaf to grains. The predominant As species were dimethylarsinic acid (DMA) and arsenite, and the concentrations and percentage of DMA increased with total As concentrations in rice grains, whereas the arsenite remained at small contents ranging from 0.1 to 0.3 mg kg^{-1}.

The results of this study indicate that As phytotoxicity can lead to the decrease of grain As concentrations and grain yields. The japonica genotypes are recommended for planting in As-contaminated soils due to their lower As translocation capability than indica genotypes.

Keywords：*Arsenic, Arsenic species, Rice, Rice genotype, Phytotoxicity*

O34-2

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Facilitating Remediation of E-waste Contaminated Soil by Mixed Chelants and Different Washing Schemes

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Ex-situ soil washing could be a promising way to remove heavy metals from arable soils contaminated by electronic waste recycling activities in China. The most widely investigated enhancing agents are aminopolycarboxylate chelants that contain multiple secondary/tertiary amines and carboxylic acid groups. This study aimed to: (i) explore the potential use of mixed chelants of EDTA (ethylene-diamine-tetraacetic acid, which is persistent in the environment but permits recovery and reuse) and EDDS ([S,S]-ethylene-diamine-disuccinic acid, which is a biodegradable substitute of EDTA causing less environmental impact); and (ii) improve the remediation effectiveness by adopting various washing schemes (multi-pulse, step-gradient, and continuous) of different chelant dosages. The results of chelant-enhanced soil washing showed that, regardless of the washing schemes, EDDS alone enabled a relatively low extraction efficiency of Cu, Zn and Pb from the e-waste soil. Although the extraction efficiency of 24-h continuous washing with EDTA alone was the highest, 3-h step-gradient washing with mixed chelants of EDDS and EDTA at a 1:1 molar ratio could achieve 72-89% of the best performance. The use of step-gradient scheme with mixed chelants could significantly reduce the operation time and EDTA dosage. Moreover, sequential rinsing with water could further enhance the washing effectiveness. Afterwards, the leachability and bioavailability of the treated soil were assessed by using TCLP (Toxicity Characteristic Leaching Procedure) and SBET (Simplified Bioaccessibility Extraction Test). The results corroborated that EDDS alone was less efficient in minimizing the leachability and bioavailability of residual metals, especially for multi-pulse and step-gradient washing schemes. Therefore, combined application of the two chelants can reduce the associated environmental risks and enhance the extraction performance of step-gradient washing scheme.

Keywords：*Contaminated soil; EDDS; EDTA; Ex-situ remediation; Soil Washing schemes.*

O34-3

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Relevance of Soil Bioindicators for Risk Assessment, Monitoring and Soil Characterization in Contaminated Soils. Results from the French National "Bioindicators Programme."

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Considering the few numbers of bioindicators available for soil risk assessment and soil characterization, a national research programme has been set up in France to develop indicators able to judge about soil degradation and/or remediation of its properties and functions. The main objectives of this "BioIndicator programme" were to (i) develop methods for measuring soil biodiversity and soil functions, (ii) use soil bioindicators to monitor soil quality and (iii) identify relevant bioindicators or endpoints for ecological risk assessment of soil contamination. In this programme involving 70 partners, 47 biological parameters have been tested i.e. microorganisms (e.g. biomass, genetical structure, enzymatic activities), fauna (nematodes, collembola, mites, earthworms, total macrofauna, metal accumulation in snails and in small mammals) and flora (e.g. lipid biomarkers in the leaves, free amino acid content, metal accumulation). These parameters were assessed on 13 sites leading in 47 plots which differ in terms of land use and agricultural practices (e.g. pasture rotation, tillage impact, management), soil type and contamination levels and origins (PAH or metal). The strengths of Bioindicator programme, which is unique at European Union scale, are (i) to test a large number of bioindicators, in a large panel of situations, (ii) to apply standardised sampling protocols managed by only one sampling team, iii) to manage high number of data (200.000) by using a common database thus facilitates the data analysis, iv) to collaborate with stakeholders (Ministry, environmental agency, Regional Board for Industry, Research and Environment,...). After 4 years of study, this communication will present i) baseline values obtained for different biological groups (microorganisms, fauna, flora), which will permit to facilitate the analysis of further results, ii) selected bioindicators for soil monitoring and soil characterization, iii) battery of bioindicators or biological index, ending in the evaluation of bioavailability of contaminant in soils, iv) relevant biological tools, in terms of sensibility but also transferability to end users, allowing the ecological risk assessment of contaminated soil (heavy metals, organic contamination).

Keywords: *soil bioindicator, risk assessment, characterization, monitoring, bioavailability*

O34-4

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Sequestering a Persistent Organochlorine with Organic Fertilizer and Organic Amendment to Increase Food Safety in Martinique

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Chlordecone is an environmentally persistent insecticide that was intensively used in banana cropping systems. Although its use was restricted 20 years ago, chlordecone permanently pollutes soils and consequently continues to contaminate crops, water resources, and food chains. This pesticide was recently suspected of being implicated in the increasing incidence of prostate cancer and in the impaired development of young children. Given the proven risks to human health, the release of chlordecone from polluted soil needs to be controlled to reduce contamination of the different food chains.

Natural decontamination of the soil through lixiviation will take decades to centuries. The persistence of chlordecone in soils is explained by i) its physicochemical properties: low solubility in water, hydrophobicity, which gives it a high affinity for organic matter and ii) its poor biodegradability related to its peculiar chemical structure with high steric hindrance. Chlordecone pollution concerns a large area, meaning chlordecone-polluted sites require efficient cost-effective in situ treatments. To date, phytoextraction and microbial degradation have not really been efficient in the case of diffuse pollution of chlordecone in the soil. Thus, sequestering chlordecone in the soil could be an alternative way to reduce its availability for crops and water resources. We then chose to study the ability of two different organic matters to sequestrate this molecule in the two main contaminated soil types presenting different characteristics: andosols, with amorphous clays (allophane), and nitisols, with crystalline 1/1 clays. We tested two types of organic matter: an organic fertilizer and an organic amendment. For each experiment (in microcosm, in pots and at field scale), the same quantities (5% w/w) of organic fertilizer or organic amendment were incorporated into both contaminated soils. During these experiments, we measured during three months the effects of organic fertilizer and organic amendment incorporation into soil on (i) chlordecone leaching by water, (ii) chlordecone bioavailability for susceptible crops (radish, cucumber, lettuce) and contamination of their different organs (roots, tuber, fruits, leaves) (iii) chlordecone distribution in different soil fractions (0-50µm, 50-200µm, 200-2000µm), (iv) soil microstructure (pore size distribution, specific surface area, mesopore volume and nanoscale structure).

A quick decrease in water extractable chlordecone was observed in amended soils and then its transfer from soils to plants. Depending on the soil and the crop, the soil-plant transfer was also reduced by a factor of 1.9 to 15 when organic matter was incorporated. Chlordecone distribution was modified by the incorporation of both organic materials leading to a transfer of the molecule from the finest to the coarser fractions according to the organic matter size distribution, thus raising a “sponge” effect, mainly observed on the nitisol, of the added organic matter on the chlordecone probably due to the high affinity to organic matter and hydrophobicity of this molecule. For the andosol, the results showed that the changes in chlordecone distribution in the different soil fractions were not as dramatic as those in the nitisol. This raises the question of the specific physical and structural properties of the allophanic clays. Considering the impact of organic matter on soil microstructure seen though the pore size distribution, after the addition of organic matter, the mesopore structure was not really affected in the nitisol, even after 3 months. These results clearly differed from those observed on andosol where the addition of compost led to a marked reduction in mesoporosity. After 90 days, the pore size distribution was still strongly affected by both composts (loss of 80% of the mesopores). Results also show a clear decrease in the specific surface area and specific mesopore volume of the andosol after addition of organic matter. This phenomenon was not observed on the nitisol. The reduction in the size of the aggregates demonstrated the collapse of the microstructure at a scale of 10 to 100 nm. The main structural result of the addition of compost was the progressive collapse of the allophane aggregates, associated with closure of the mesopores.

We demonstrated that it is possible to increase the sequestration of pesticide in soils by adding an organic fertilizer or an organic amendment. The combination of the high pesticide affinity for organic matter observed in both soils, plus the tortuosity of the pore network of andosol may be a key feature in chlordecone availability.

Keywords：*organochlorine, organic matter, pesticide sequestration, soil porosity, crop contamination*

O34-5

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Phytoremediation of Pyrene Contaminated Soils Amended with Compost and δ-Mno_2 and Planted wth Ryegrass and Soybean

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Soil contamination with polycyclic aromatic hydrocarbons (PAHs) has become a great concern. Currently, phytoremediation has been used as a widespread technology for remediating soils contaminated with organics. This study was to investigate the feasibility of phytoremediation using ryegrass (*Lolium perenne* L.) and soybean (*Glycine max*) for remediating pyrene contaminated soils. The pot experiments were conducted by taking quartz sand as a control and alluvial soil spiked with pyrene at the concentrations of 150, 300, and 450 mg kg^{-1} as samples. The pots were treated by amending with 5% compost, with 5% compost and 1% δ-MnO_2, and with δ-MnO_2 (1% of pot soil weight) and then planted with ryegrass or soybean. Correspondingly, the pots similarly treated but without plants were also used in the experiments. All the experiments including controls were carried out in four replicates. The results showed that after 90 d growth period of ryegrass and soybean the degradation percentages of spiked pyrene at concentrations of 150, 300, and 450 mg kg^{-1} in the pots containing alluvial soil amended with 5% compost were 93, 92, and 89%, and 90, 93, and 88%, respectively. The biomasses of both planted ryegrass and soybean were higher in the quartz sand and alluvial soil amended with 5% compost than in those amended with 1% δ-MnO_2. The sequence of pyrene degradation percentage was pot containing quartz sand and alluvial soil amended with 5% compost and 1% δ-MnO_2 and planted with ryegrass or soybean > amended with 5% compost > amended with 1% δ-MnO_2 > untreated but planted with ryegrass or soybean > treated but without the two plants. Because δ-MnO_2 is a strong oxidizing agent its amendment inhibited the plant growth leading to less biomass but promoted the degradation of pyrene in the quartz sand and alluvial soil. The percentages of pyrene degradation in the pot containing quartz sand and alluvial soil amended with compost and/or δ-MnO_2 and planted with ryegrass or soybean were around 90-95% while those without any amendment but planted with ryegrass and soybean were around 80-85%. Those in the pot containing quartz sand and alluvial soil amended with compost and/or δ-MnO_2 but without the two plants were less than 50%. This indicates the important role of ryegrass and soybean in promoting the degradation of pyrene in its contaminated soils. After 90 d growth period, only trace amounts of pyrene were detected in the above the ground and below the ground parts of planted ryegrass and soybean. The computed bio-concentration factor (BCF) of pyrene absorbed by plant roots from quartz sand or alluvial soil and transported to plant tissues was thus negligible. Microbial populations in rhizosphere quartz sand and alluvial soil were higher in pots planted with soybean than in pots planted with ryegrass or pots without plants. Moreover, the microbial population was higher in alluvial soil pots than in quartz sand pots. After 90 d growth period, growth of mycorrhizae was observed onto ryegrass and soybean roots with microscope indicating the role of rhizosphere symbiotic microorganisms in degrading the spiked pyrene. Further, the microbial population was positively correlated with pyrene degradation in pot containing quartz sand and alluvial soil. The amount of water soluble phenols deriving from decomposition of organics and exudation of ryegrass or soybean roots in quartz sand or alluvial soil was also positively correlated with microbial population as well as spiked pyrene concentration. To sum up, both ryegrass and soybean can grow in soil by tolerating the toxicity of pyrene up to concentration of 450 mg kg^{-1} and then promote pyrene degradation. The mechanisms of interactions of plant roots with rhizosphere microbes and the associated compounds mediated pyrene degradation in soils thus merit close attention.

Keywords：*Polycyclic Aromatic Hydrocarbons, Phytoremediation, Ryegrass, Soybean, Pyrene, δ-MnO_2*

O35-1

[DS2] B: Soil Development and Soil Properties and Functions

Interpreting Soil Organic Matter Cycling from Radiocarbon Measurements in Soils

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Organic matter cycling in soils is related to edaphic controls that operate both directly and indirectly and over a range of time scales. One of the few methods available for quantifying rates of carbon cycling in soils on decadal to millennial timescales - critical for understanding the response and recovery time for soil organic matter in disturbed, eroded or degraded soils - is the measurement of radiocarbon. Radiocarbon data indicate the mean time since the carbon in a given fraction of soil organic matter was fixed by plants from the atmosphere. However, this average is often a mixture of younger and older components, which in turn give information about the timescales of stabilization mechanisms and/or transport through the soil profile. A major effort has been placed in using analytical and modeling methods to separate and quantify components with intrinsically different stabilization modes/timescales - e.g. using the incorporation of radiocarbon produced by atmospheric weapons testing to interpret C cycling on timescales shorter than those available using the half-life of radiocarbon.

Over the past two decades, the amount of radiocarbon data collected from soil has increased tremendously, and much has been learned about both the opportunities and problems associated with interpreting radiocarbon data. This talk will summarize some of the major lessons learned, and the challenges and opportunities available as radiocarbon methods are continuously improved.

Keywords：*radiocarbon, soil organic matter, carbon cycle*

O35-2

[DS2] B: Soil Development and Soil Properties and Functions

Digital Morphometrics and Rapid Pedology

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Pedology has long been a descriptive activity with very few scientific laws. The discipline advances when increased data availability is combined with sound conceptual soil models and thinking tested across a wide range of conditions. The soil profile is at the centre of pedology. Soil profile descriptions have largely relied on morphometrics and attributes that could be mechanically measured and visually observed. These were then combined with chemical, physical and mineralogical analytical data or thin sections from horizons in a soil pit.

Proximal soil sensing tools are widely used in precision agriculture and digital soil mapping. These sensors and tools have been valuable to measure and predict soil properties, processes and behaviour in a horizontal sense, that is: across the landscape. They have been less applied for studying soils in the vertical sense and traditional pedological observations of soil profiles relies on the use of visible light and tool kits that have not changed in the past decades. Here, I review how proximal soil sensing tools can be used in pedology and in soil profiles description.

The application of proximal soil sensing tools in a soil pit description is termed digital morphometrics. It is compared to standard soil profile descriptions for 11 common attributes (horizons, texture, colour, structure, moisture, mottles, consistence, carbonates, rock fragments, pores and roots). These attributes are extensively used in soil classification and indicative for many soil functions. Different sensors and tools have been tested to measure different attributes. Compound attributes (horizons, structure) are harder to measure than properties like texture and soil moisture status. Soil attributes that have been mostly assessed by digital morphometrics in the field are: soil horizons, soil texture, soil colour, and soil moisture. No attempts have been made to quantify soil structure in the field in a non-traditional way. Several studies focused on soil horizons using ground penetrating radar (GPR), electrical resistivity (ER) or the cone penetrometer. GPR and ER are non-invasive techniques and the penetrometer is an invasive technique that can be used for the determination of some soil horizons – none of these require a soil pit. The nature of redoximorphic features (spotty, uneven) makes it highly suitable for digital morphometrics assessment using vis-NIR.

Every soil property has its own vertical distribution pattern and depth function (anisotropic character). With limited observations a stepped graph depicts the relation between a property and its depth whereby each step reflects a horizon. There are several interpolation techniques and the equal-area quadratic spline uses an average of adjacent horizons or layers in a soil profile. It gives values for every possible soil depth increment, and creates a continuous function. Recently, a spline depth function was introduced with uncertainty estimates for each depth. With digital morphometrics, measurements can be made in a soil pit at very small depth intervals, or in the laboratory at intervals in the micron range or few centimetres. In most cases, the increment is much smaller than the depth of horizons and it creates a continuous depth function of soil properties.

The combined use of in situ digital morphometrics and continuous depth functions of soil properties is coined here: rapid pedology. It complements existing description and analytical methods, and has the potential to yield new understanding about soil horizonation, and how soils form and could be classified. There has been a call for the integration of pedological knowledge into digital soil mapping; here is a call to enhance use and integrate digital morphometrics in field pedology. Rapid pedology has the potential to frame our understanding of soils and be valuable in the resurrection of pedology programs across the world.

O35-3

[DS2] B: Soil Development and Soil Properties and Functions

Changes of Soil Properties during Podzol Development in S Norway

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The Oslofjord region in SE-Norway has undergone steady glacio-isostatic uplift all over the Holocene. Hence, in the coastal areas land surface age continuously increases with elevation, providing suitable conditions for studying soil development with time. A chronosequence of soils on beach sand and sandy terraces of the Lågen River, showing progressive podzolization with soil age, was studied on the western side of the Oslofjord. 31 pedons with soil ages ranging from 85 years to ca. 10,150 years were described and analysed. Soil ages were estimated by relating elevations of the sites to a Holocene relative sea level curve based on twelve AMS 14C-dates of gyttja from the isolation contact (marine / fresh water boundary) and six marine macrofossil 14C-dates (Sørensen et al., 2012). The climate in the study area is comparatively mild, with mean annual temperatures ranging from 5.3°C (Ramnes) to 6.3°C (Sandefjord, Larvik) and a mean annual precipitation of 909 mm (Sandefjord) - 1150 mm (Stokke). The vegetation consists predominantly of mixed forest

Main changes in profile morphology over time include accumulation of soil organic matter in the top soils in the first millennium of soil development. Measured amounts of soil organic carbon (SOC) show a clear logarithmic increase over the first 1400 years (SOC [kg m-2] = 3.0589 ln (time [years]) – 13.367; R^2 = 0.997). SOC dynamics of the older soils are highly variable. Initial podzolisation is observed for the first time in the 1220 year-old soil. Soils between 1220 and 6000 years show variable degree of podzolization, whereas soils older than 6000 years generally represent well-developed Podzols. Thickness of eluvial and illuvial horizons is highly variable and shows no clear trend with soil age. Solum thickness shows a general trend of increase. It increases more rapidly in soils having a sand content higher than 95% (solum thickness [cm] = 28.056 ln (time [years]) – 135.06; R^2 = 0.89) than in soils containing 70 - <95% sand (solum thickness [m] = 15.808 ln (time) [years] – 73.367; R^2 = 0.94). Progressive weathering is reflected by increasing Fed and Ald contents, and proceeding podzolization by increasing amounts of pyrophophate- and oxalate-soluble Fe and Al with soil age. Within c. 5000 years, soil pH (in water) drops from slightly alkaline to pH 4-5 in the upper 30 cm and pH 5-6 below. Eluvial horizons generally have < pH 4.7, illuvial horizons > pH 4.7. Leaching of exchangeable base cations leads to logarithmic decreases of exchangeable Ca2+, Mg2+, K+, Na+ (calculated in kg m-2).

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Keywords：*soil chronosequence; podzolization; soil properties; exchangeable bases, SOC*

O35-4

[DS2] B: Soil Development and Soil Properties and Functions

X-Ray Photoelectron Spectroscopy (xps) as a Convincing Tool to Relate Changes in Wettability to Surface Chemical Composition during Soil Formation

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Weathering of parent rock initiates soil formation. Along with various weathering processes, the particles will be coated by biogeochemical interfaces (BGI) thru sorption of inorganic and organic compounds, which alters the physicochemical surface properties more or less pronouncedly. BGI are a major contributor to the pore surface and govern all soil processes involving interaction between the liquid (soil solution) and solid (soil particles) phase, e.g., attachment and detachment of colloids. A decisive factor are the wetting properties (quantified in terms of contact angle CA) that are, beside geometrical factors, also a function of kind and orientation of the functional groups (polar, non-polar), i.e., the surface chemical composition. BGI thickness ranges from the nm to the µm scale [1], but CA only is determined by the first nm ("CA interphase", [2]). To relate chemical composition and CA, analysis must discriminate between BGI and the underlying particle, i.e., a surface analysis is needed. With an analysis depth of about 1 µm common techniques like ATR¬FTIR and EDX involve a too great depth. X-ray photoelectron spectroscopy (XPS) offers a promising alternative. Bombardment of the surface with X-rays results in the emission of photoelectrons (PE) with element-specific binding energy (BE). Inelastic scattering of PE from depths > 10nm restricts the maximum analysis depth to 10 nm which exceeds the CA interphase far less than ATR-FTIR or EDX. The absolute BE of an element depends on the binding partner which allows an estimate about, e.g., the C species (C in polar or non-polar bonding). A soil chronosequence offers the opportunity to study soil formation. Combined CA and XPS analyses should allow to focus on changes in surface physicochemical properties, i.e., BGI formation. The Damma glacier forefield chronosequence covers 0 - 120 years of soil age and already has been studied with respect to soil organic matter formation, regarding especially microbial cell fragments covering the particles. CA analysis revealed an increase with age from 0° (completely wettable) to slightly > 90 ° (hydrophobic) that was related to increasing coverage with cell fragments [3].
To relate wetting properties and surface chemistry, XPS survey spectra have been recorded. The spectra were corrected for Si 2p (103 eV, quartz), quantified, and normalized to O 1s to calculate mean and difference spectra.
Results showed characteristic changes in chemistry – with soil age C and N concentration distinctly increased and the O/C ratio as a proxy for wetting properties [4] decreased while CA increased. Decrease of the elemental concentration of K, Ca, Mg, Si, and Al with soil age reflected soil formation processes. From the difference spectra a shift of the C 1s peak to lower BE was indicated. Peak fit probably will allow an estimation of the amount of C in polar and non-polar bonding as a further means to relate surface chemistry and wetting properties.
Despite the fact that soil particle surfaces are far from being ideal, they are neither smooth nor planar, obviously CA as well as XPS analysis can be used to characterize BGIs. Especially the distinct relation between CA and O/C ratio found for the chronosequence and further soil samples of different texture and organic carbon content reveals XPS as a fascinating tool to characterize surface chemistry separate from bulk chemistry and relate it conceptually to particle wettability as an important physicochemical surface property.

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Keywords：*Surface chemistry, XPS, Contact angle*

O35-5

[DS2] B: Soil Development and Soil Properties and Functions

Soil-Lt: Automatic and Continuous Determination of Shrinkage Behavior of Soils

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The structure of soils is characterized by the spatial arrangement of particles within a given soil volume, which results in the formation of pore space. It is well known that changes in climatic and hydrological conditions but also cultivation in agriculture and forestry amongst other activities affect soil structure and result in intense changes of soil volume. As a consequence physical properties and functions of soils (e.g. accessible surface area, porosity, mechanical soil strength, and hydraulic conductivity) as well as the prerequisite of rigidity for e.g. hydraulic modeling are affected and result in variable and undefined soil conditions amongst others concerning gas and water household, modeling of coupled processes. Especially, swelling and shrinking induced by changes of matric potential respectively wetting and drying, strongly affect soil structure. In particular, soils with a high content of organic matter or clay and silt, tend to distinct swelling and shrinking processes, which can then result in a rearrangement of particles and thus in changes in flows and storage of water, gas and temperature.

Generally, it is well known that soils undergo intense short and long term alterations of their properties, which also require a well-defined strength or hydraulic stress range of rigidity that up to date was not defined but because of an easier data application for e.g. modeling was simply neglected in laboratory and in-situ measurements. However, viable tools are needed in order to quantify the effects of volume changes and pore structural changes on soil functions: the definition of pore rigidity as well as the kind of volume change: its isotropy and anisotropy, and intensity of volume changes, crack formation (flow paths) and surface area changes (accessible surfaces) are urgently needed and will be defined in the running project.

Sophisticated methods to measure volume and structural changes of soils like height change analysis (vernier caliper) or the volume replacement method with paraffin are well described in the literature. But these methods are not only time consuming, invasive and include some difficulties but they are also limited to a specific condition but do not quantify the total process. Thus, a new approach is the application of a laser based device for the investigation of soil samples via laser triangulation. This will allow the noninvasive investigation of samples, which will also be less time consuming and should provide a higher accuracy compared with the known methods. Furthermore, the analysis can be automatically processed and allows a continuous measurement of multiple replicates and the possibility to vary in sample size and orientation. In addition, it will be possible to couple this device with measurements of other soil properties, such as soil moisture, matric potential, soil mass and unsaturated hydraulic conductivity.

The device and the software are being developed in the framework of a project, facilitated by the BMWi (Federal Ministry of Economics and Technology, Germany), in cooperation between the UGT GmbH (Muncheberg, Germany) and the University of Kiel (Germany).

The process of development of the device will be combined with X-ray CT measurements of soil samples to validate the results of laser triangulation and to give information about the accuracy.

First tests show that it is possible to quantify crack characteristics as well as the displacement of soil material at the cylinder wall with a precision close to the findings from X-ray CT. Although the laser based device is limited to a three-dimensional surface analysis, we can also link these data with corresponding measurements with X-ray CT of the internal soil structure. We can proof that the differences (laser vs. X-ray CT) of the results for total soil volume and sample diameter are remarkably low (±1%), which emphasizes the sensitivity of the new laser method .

Keywords：*laser triangulation, image analysis, structure development*

O36-1

[C2.5-3] B: Mechanism Controlling Greenhouse Gas Emissions from Soils

Microbial Diversity and Traits as a Modulating Factor of Methane Consumption in Soils

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Greenhouse gasses play an eminent role in the current climate change phenomena on earth. Despite intensive research there are still large uncertainties in global balances and explanation of dynamics therein. Especially predicted future methane dynamics are uncertain. The anomalies in atmospheric methane concentrations in late twentieth century, including the renewed increase since 2007 have been proposed to be caused by changes in microbial methane cycling. Soils (wetland as well as upland) are major sources and sinks of methane and their inhabiting microbes (methanogens and methanotrophs) are at the basis of the source or sink capacity of soils. Despite this eminent role of microbes and the processes they catalyse, the diversity of microbial communities and traits of the microbes involved are not taking into consideration in assessing potential sources of variation in the global methane budget. The consumption of methane by methanotrophic bacteria is the only biological sink of methane globally. There are many environmental factors that control these microbes which have also been extensively investigated. The advent of a multitude of culture independent techniques has resulted in a glimpse of the possible role of microbial community composition and or response in methane cycling reactions. Especially, the combined use of molecular biological techniques with the application of stable isotopes has led to valuable insight into the link between microbial characteristics and biogeochemical processes. Next to this, discoveries and isolation of new species and pathways offer new insight in the role of microbial diversity in methane cycling in soils. This paper highlights important advancements in the area of methane cycling in soils with emphasis on methane oxidation and the link between diversity and activity. Examples will be given from mineral floodplains soils, proposed to be involved in recent methane anomalies, which demonstrate that microbial minorities and their apparent traits are crucial for methane cycling in these habitats and have to be included in mechanistic explanations of methane emissions from soil ecosystems.

O36-2

[C2.5-3] B: Mechanism Controlling Greenhouse Gas Emissions from Soils

Methanogenic Activity under Dry Wet Cycles of Rice Paddy Soil

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Irrigated rice fields, whose water regime is fully controlled by farmers, account for more than a half of world rice production area. This type of rice fields represents an important anthropogenic source of atmospheric CH4, accounting for about 10% of the global CH4 emission. The production of CH4 by methanogenic archaea is the final step of the organic matter decomposition under anoxic conditions. The measurement campaigns of CH4 fluxes in the past three decades have revealed that the intermittent drainage as a water management practice is the most promising approach to attenuate CH4 emission from the irrigated rice fields. The microbial mechanisms, however, remain poorly understood.

We performed a serial of well-controlled microcosm and laboratory experiments to elucidate the response of methanogens to wet/dry cycles of paddy soil. In the microcosm experiments, the rates of methane production and emission were determined in combination with the observations on the dynamics of ferric iron and sulfate, and the abundance of methanogen mcrA genes (encoding the alpha subunit of methyl coenzyme M reductase) and their transcripts. We found that the dry wet cycles resulted in shifts of soil redox conditions, increasing the concentrations of ferric iron and sulfate in the soil. The abundances of mcrA gene copies and transcripts significantly decreased after dry wet alternation compared with continuous flooding. Correlation and regression analyses showed that the abundance of mcrA genes and transcripts positively correlated with methane production potential and soil water content, and negatively with the concentrations of ferric iron and sulfate in the soil. However, the mcrA transcript level was reduced to a greater extent than the gene copy level resulting in very low mcrA transcript-to-gene ratios after intermittent drainage. Terminal restriction fragment length polymorphism (T-RFLP) analysis revealed that the composition of methanogenic community remained stable after dry wet cycles, whereas that of metabolically active methanogens changed strongly.

In the laboratory incubation, we tested the response of methanogen community to O2 exposure. The transcripts of mcrA genes decreased by an order of magnitude after brief exposure to O2. T-RFLP analyses showed that although the community structure of methanogens did not change, the composition of transcripts dramatically shifted after O2 exposure. In the beginning, transcripts of Methanocellales were most abundant, indicating resistance of these hydrogenotrophic methanogens against O2 stress. Later, the transcripts of aceticlastic methanogens gradually increased coinciding with the dynamics of acetate.

Overall, our experiments show that the methanogenic activity is markedly suppressed by soil drainage or O2 exposure and the inhibitory mechanisms differ between the hydrogenotrophic and aceticlastic methanogens. The structure of methanogenic community remains stable, whereas the transcript levels react sensitively under dry wet cycles of paddy soil.

Keywords：*rice paddy soil, methanogens, dry wet cycle, water management*

O36-3

[C2.5-3] B: Mechanism Controlling Greenhouse Gas Emissions from Soils

The Genesis and Transport of N_2O in Soil

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Emissions of N_2O have been suggested as a major loss pathway (conversion factor of 3-5%) for agricultural N fertilisers (Crutzen et al., 2008), yet direct emissions from agricultural soils account for around 1% as estimated by the IPCC (quoted in Crutzen et al., 2008). This discrepancy may be due to the paucity of data on indirect emissions, whereby N (fertiliser) or N_2O is transported away from the agricultural site. It is suggested that N_2O sourced from agriculture and fertiliser over the last three decades may have increased markedly over previous estimates (IPPC-WG1, 2007). Global N fertiliser consumption more than doubled during this period and it continues to increase (IFA, 2011). Thus it is highly desirable to better comprehend remote fertiliser-sourced N_2O emissions. To further understand the mechanisms of N_2O genesis and transportation in soil, we established a replicated field pseudo-lysimeter (240 mm diameter and 600 mm depth) study in a highly productive Ferralsol. Although this trial was initially established to investigate the impacts of oil mallee biochar on N migration (nitrate, N_2O), results here focus on production and movement of N_2O within the soil profile. Soil gas samples were taken via diffusion into silicone tubing at 3 depths (of 11, 26 and 41 cm) and surface flux through use of a static chamber lid. Equilibration time for the silicone samples was ≤ 4 hours at measured soil temperatures.

Nitrate labelled with 60-atom % ^{15}N was injected at depths of either 75 mm or 200 mm with 5 replicates of each combination and controls. Ceramic suction caps were used to sample soil water (and mineral N) at 2 depths (of 15 and 45 cm) with soil moisture and temperature monitored at 3 depths (of 7.5, 22.5 and 37.5 cm). Soil concentrations of N_2O were highest on days of highest water content, particularly those of ≥ 80% water filled porosity. Maximum surface flux followed within 48 hours of such events. Relative to controls, surface flux of N_2O was not significantly different between treatments. Deeper injection of nitrate resulted in lower surface emissions and downward movement of N_2O in the water column was evident in all preliminary data. This raised the issue of indirect emissions, as suggested by Crutzen et al. (2008), accounting for considerable "background" N_2O production occurring beyond agricultural fields, though still related to fertiliser use. Given its high solubility, it is possible that surface flux of N_2O may be far less significant than its leaching down the soil profile. The determination of their relative importance should result from the imminent completion of analysis of soil water samples, permitting a mass balance assessment of the fate of injected 15N. Such hitherto unpublished data will assist in a better understanding of the mechanisms of indirect N_2O emissions from agricultural soils.

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Keywords：*N_2O emissions, field pseudo-lysimeter study, surface flux, indirect emissions, leaching*

O36-4

[C2.5-3] B: Mechanism Controlling Greenhouse Gas Emissions from Soils

Efficiency of Deficit Irrigation to Reduce Soil CO_2 Emissions in an Agricultural Soil

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Irrigation water restrictions in the Mediterranean area are reaching worrying proportions and represent a serious threat to traditional crops and encourage the movement of people who choose to work in other activities. This situation has created a growing interest in water conservation, particularly among practitioners of irrigated agriculture, the main recipient of water resources (>80%). For these and other reasons, the scientific and technical irrigation scheduling of water use to maintain and even improve harvest yield and quality has been and will remain a major challenge for irrigated agriculture. Apart from environmental and economic benefits by water savings, deficit irrigation may contribute to reduce soil CO2 emissions and enhance C sequestration in soils. The reduction of soil moisture levels decreases microbial activity, with the resulting slowing down of organic matter mineralization. Besides, the application of water by irrigation may increment the precipitation rate of carbonates, favoring the storage of C, but depending on the source of calcium or bicarbonate, the net reaction can be either storage or release of C. Thus, the objective of this study was to assess if deficit irrigation, besides contributing to water savings, can reduce soil CO2 emissions and favor the accumulation of C in soils in stable forms. The experiment was carried out along 2012 in a commercial orchard from southeast Spain cultivated with nectarine trees (Prunus persica cv. 'Viowhite'). The irrigation system was drip localized. Three irrigation treatments were assayed: a control (CT), irrigated to satisfy the total hydric needs of the crop; a first deficit irrigation (DI1), irrigated as CT except for postharvest period (16 June – 28 October) were 50% of CT was applied; and a second deficit irrigation (DI2), irrigated as DI1, except for two periods in which irrigation was suppressed (16 June-6 July and 21 July-17 August). Each treatment was setup in triplicate, randomly distributed in blocks. Each repetition had 15 rows with 15 trees per row. Soil CO2 emissions, moisture and temperature were monitored every 15 days. A soil sampling (0-30 cm) was carried out every three months, to determine the evolution of organic carbon, recalcitrant carbon, labile and soluble carbon, inorganic carbon, microbial biomass carbon, β-glucosidase and arylesterase enzyme activities, and organic functional groups measured by Fourier transform infrared spectroscopy (FTIR). A soil fractionation was carried out in all samples (<50, 50-250, 250-850, >2000 μm) to assess the weight and carbon content of each particles fraction in terms of irrigation treatments. Results showed that the application of deficit caused a significant decrease in CO2 emission rates, mainly in DI2, with rates 10 μg CO2-C m-2 s-1 lower than CT during this deficit period. When cumulative CO2-C released during one year was estimated, it was verified that water deficit contributed to decreases in the release of CO2, with a total release of 410 g CO2-C m-2 in CT, 355 g CO2-C m-2 in DI1, and 251 g CO2-C m-2 in DI2. This last treatment has supposed an annual reduction of 159 g CO2-C m-2 regarding CT. Soil properties, contrarily, showed no significant differences among treatments, with similar values in the C fractions and organic carbon quality, with an average organic C content of 4.5 kg m-2, 30 kg m-2 of inorganic C, a recalcitrance index of 57%, 1.40% of organic compounds solubility index and 160 g m-2 of microbial biomass C. There were no differences among particle sizes weigh and organic or inorganic carbon contents either. Thus, since no differences in quantity and quality of organic carbon was assess in soil with regard to irrigation treatment, it seems that longer periods are needed to assess shifts in soil properties related to carbon sequestration.

Keywords：*carbon sequestration, CO2 emissions, organic carbon quality, irrigation*

O36-5

[C2.5-3] B: Mechanism Controlling Greenhouse Gas Emissions from Soils

Comparison of Methane Emission Characteristics in Fresh and Composted Cattle Manure Amended Paddy Soil during Rice Cultivation

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Application of organic matter is essential to sustain health and productivity of a soil. However, organic amendments facilitate methane (CH4) emission from rice paddy soils. In this experiment, we studied the differences in the relative effects of composted and air-dried forms of different manures on CH4 fluxes from rice paddy soils. During this study, air-dried and composted manures from Korean cow and dairy cows were applied in rice paddy soils to evaluate their effects on CH4 emissions. Application of organic amendments increased CH4 emissions from soil during rice cultivation. Application of composted manures leads up to 50% reduction in CH4 emissions as compared to air-dried manures. Among manures, nature of cattle origins and their feeding behaviours may also determine the extents of CH4 emissions when those manures were applied in rice paddy soils. Carbon accumulated in light soil fractions which are easily utilized by microorganisms probably had more influence on CH4 fluxes from soil as compared to heavy fractions. Manure application leads to higher organic C accumulation in lighter fractions, which in turn facilitates more CH4 emission from those soils during rice cultivation. Therefore, chemical properties, especially potentials to generate DOC and HWEC compounds in soil, were possibly the key factors to increase CH4 emissions from organic amended rice paddy soils.

Keywords：*density fraction, labile organic carbon, methane emission, organic amendments, rice paddy*

O37-1

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Coevolution of Soil Genesis and Life

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Within the last decade, planetary scientists have increasingly recognized the great variety of mineral species on Earth, as compared to other planets and the moon, is largely the result of life. Similarly, the great variety of soils is largely the result of life, and this coevolution can be traced throughout geologic time. Early in Earth's history, for example, the Great Oxidation Event about 2.4 billion years ago began the process of pedogenic iron oxide formation after free oxygen accumulated in Earth's atmosphere as the result of cyanobacterial photosynthesis.

Plants on land in the Silurian, and even more so in the Devonian, brought forth a major change to soil genesis. Like today, vegetative cover would have slowed erosion enabling horizon differentiation. Nutrients extracted from minerals would have been carried to the land surface by plant-root-fungal complexes where they were recycled by in O and A horizons. Pedogenic carbonates in arid and semiarid regions began forming as a consequence of ecologically-induced biomineralization. Accompanying the movement of plants across landscapes, burrowing invertebrates, reptiles, small dinosaurs, and finally mammals bioturbated soils and distributed nutrients.

In the Holocene, humans had a progressively greater impact on soil genesis as the result of agriculture. Removals of native vegetation, erosion of cropland, and amendments of manure and wood ash occurred on all continents for thousands of years. Currently, industrial agriculture includes excessive additions of nitrogen and phosphorous, compaction from heavy machinery, and movement of food across intra- and inter-continental distances. Humans are now a global geomorphic agent that moves more soil and sediments than glaciers, wind, or rivers. Cities and human structures, such as interstate highways and railroads, are anthropogenic landforms easily seen from space. Without life on Earth, soil types and their genesis would be much different than in this world filled with life.

Keywords：*geologic time, paleosols, biomineralogy, pedogenic carbonate, mineralogy*

O37-2

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Soil Biogeochemical Processes in the Critical Zone

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The Critical Zone (CZ) is considered that region of the earth's terrestrial near-surface that extends from the lower limits of the weathering profile to the upper boundary of the vegetation canopy. This zone is named as such because it controls land-atmosphere and terrestrial-aquatic exchanges of water, carbon and lithogenic elements. The CZ "weathering engine" includes fractured bedrock, saprock, mobile soil and overlying vegetation. Hence, soils play a central mediating role in the CZ system as coupled to through-fluxes of water, carbon and other sources of matter and energy. Current research in the Catalina-Jemez Critical Zone Observatory (CZO) (Arizona and New Mexico, USA) is focused on quantifying the impacts that net ecosystem exchanges of water and carbon have on driving CZ structural evolution and event-based responses that both reflect long-term geochemical weathering and physical erosion. Our CZO focuses on semi-arid landscapes in the southwestern US where water limits seasonality and magnitude of primary production. Moisture limitations over biological activity are manifest as pulsed translocations of lithogenic elements and variation in weathering stoichiometry. CZO time series and spatial data sets from multiple disciplines are being superimposed to assess the impacts of ecosystem function on CZ evolution and response. Results indicate that season and aspect affect large variation in apparent CZ resilience to environmental change and episodic perturbations.

Keywords：*critical zone, soil biogeochemistry, carbon cycling, water cycling, weathering stoichiometry*

O37-3

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Shrinking-swelling Soils in Cryogenic Environment

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Shrinking-swelling soils such as Vertisols and vertic intergrades were first identified in tropical and subtropical regions with the mean annual temperature (MAT) in the range of 15-26°C. Later they were discovered in cooler regions up to 50-55°N. According to estimations of Eswaran et al. (2000) Vertisols and vertic intergrades occur also in temperate (52%) and in boreal (1%) ecosystems with the variations of MAT from 0 to 30°C .

During the field investigations in Eravna intermountain depression, (~52°39' N 112° 24'E), Buryatia we have discovered soils with various degree of shrinking-swelling activity. Eravna depression is situated at the altitude about 900-1000 m a.s.l. in the Vitim upland, and is characterized by severe ultra-continental climate (MAT -4.2°C, TJan -26.5 °C,Tjuly 19 °C). MAP is about 300 mm with dry summer and wet period in autumn, starting at the end of summer. Soils are formed on Paleogene-Neogene lacustrine, alluvial and alluvial-colluvial deposits. This is the area of the continuous permafrost, which occur at a depth about 200 cm in the bottom of depression, or deeper on the slopes (~ 240-280 cm on south-facing slopes).

Theses soils were identified as slightly vertic Luvic Vertic Phaeozem (Clayic and Turbic) and Vertic Gleyic Phaeozem (Glossic, Pachic, Clayic and) up to Gleyic Vertisol (Glossic, Gelistagnic).

Vertic features were found both at macro- and microlevel: shiny and polished slickensides in combination with wedge-shaped and parallelepiped structures, large cracks, angular blocky and wedge microaggregates, planar voids, porphyrics c/f related distribution pattern, variability of striated patterns including poro-, grano-, mono-, cross- striated, strial and mosaic. Physical attributes such as clayey texture and high smectite content were also favorable for shrinking and swelling processes.

Some attempts have been previously made in Soil Taxonomy to identify Vertisols in cold environment. Cryerts were identified as Vertisols under cryic regime, but without permafrost; vertic subgroup was theoretically described in Gelisols, but such soils have been never described in the field. We believe this is the first time that vertic features were described and Vertisol with cryogenic deformations was identified in the region with gelic regime and deep permafrost, in association with Gelisols.

The formation of such unique soils is possible due to the combination of physical properties required for physical deformations and favorable pedoclimate. Shrinking and swelling processes became possible after the degradation of permafrost only. It is known that depth to permafrost increased in this region during the last 70 years up to 100-150 cm. The second important factor of shrinking and swelling resulting in the formation of vertic properties is local temperature and moisture regimes. The strongest shrinking-swelling occur in very limited areas located in the upper part of south-facing slopes, decreasing both towards the summit and the toe-slope position in the landscape.

Keywords：*vertisol, gelic regime, permafrost, genesis*

O37-4

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

A New Data Base for Including Weathering in Landscape Evolution Modelling

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Landscape evolution modeling builds on lithological information about the susceptibility of rock for weathering. A dual step approach has been chosen to collect new lithological data based on clay- and total-mineralogy and geochemistry. The data set has been newly sampled and analysed. The sampled litho-types are typical for central European mountain ranges. A total of 200 sites were sampled and 450 analyses were conducted. Geochemical and mineralogical weathering indexes were applied. The data base has provided new insights into describing and classifying soil parent material. For the first time this data base as well as interpretations are presented. It allows the updating of mineralogical weathering sequences.

Keywords：*clay mineralogy, geochemistry, weathering indexes, landscape evolution modeling*

O37-5

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Weathering and Soil Formation in Responding to Changing Environment in an Alpine Region of the Qinghai-tibet Plateau

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Weathering and soil formation are important earth surface processes that control not only soil development but also ecosystem functions, especially in the fragile alpine ecosystems which usually see weak weathering and soil development. The Qilian Mountain in the northeast Qinghai-Tibetan Plateau, northwest China is a typical area with all kinds of ecosystems, from alpine cold desert to alpine grassland and meadows. Soils and soil development stages vary considerably among those ecological zones. The shifting of ecosystem types from one zone to another could mimic the change of soil forming environment including mainly climate and vegetation changes. The comparison of weathering and soil formation status among those zones could yield understanding on how ecosystems evolve in relation to soil development stages.

The current study investigates soils of the alpine region across the eco-zones from glacial deposit to the more stable vegetated sites. Physical, chemical, mineralogical, geochemical analyses of soil samples are conducted. Indices illustrating weathering and soil formation stages are compared and the relationships between ecosystem functional indicators and soil conditions are analyzed. It is shown that with the shift of environmental conditions, soil changes substantially in terms of weathering and soil development stages, which control greatly the establishment of alpine ecosystems and their ecological services, such as water retention capability, nutrient supply, biological activities, biomass production.

Acknowledgement: This work was supported by the Natural Science Foundation of China (No.41130530, 91325301).

Keywords：*weathering, soil formation, environmental change, cold and desert region, alpine, ecological service*

O38-1

[C3.5-4] Physical Restoration of Soils

Soil Deformation - How far are Physical, Chemical and Biological Processes and Soil Functions Irreversibly Affected on Various Scales, What are the Consequences for Reamelioration!

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The aim of this lecture is to clarify the processes of soil deformation in structured unsaturated bulk soils, within single aggregates, and on the landscape scale in order analyze the changes in soil properties and functions on all scales and its possibilities for structure reamelioration due to physical, chemical and biological processes.

Soil deformation as one of the threats also defined in the European Soil Protection Initiative changes not only the soil height by irreversible decrease of the pore volume but the internal deformation processes result in an aggregate and/or particle rearrangement within the various soil volumes but it alters in addition also the pore continuity, accessibility and tensorial functions of corresponding soil properties. These changes are not only concentrated in the top soil which would allow ameliorating this soil volume by plowing with corresponding tillage techniques but due to the furthermore increasing mass and wheel load of soil management systems (tillage machinery or forest harvesting devices) these alterations are detected in the subsoil where it must be defined as mostly irreversibly degraded.

The consequences of stress and shear induced changes in the pore system include not only the often described changes in capacity parameters like air capacity, plant available water capacity, but the soil and land use specific intensity parameters like hydraulic or air conductivity, cation exchange intensity and composition of the microbial community within the soil components are affected and though are the plant growth or the filtering an buffering processes, too.

The most visible signs of deformation are at the surface the ruts, or within the soil profile the platy structure as a consequence of stress release or the reduction in macroporosity and increasing anisotropy of soil functions. Within the structure elements such shear induced rearrangement of single particles can be also detected and result not only in a partly modified and more dense structure units but it also causes a reduced accessibility of particle surface areas and increased internal tortuosity which indeed also affects the microbial activity and composition of the community within the various compartments.

The physical properties like gas or water fluxes are to be linked to soil compaction not only concerning the total amount but also its composition which especially can be detected by the gaseous components within the soil pore system. Furthermore due to an increasing anisotropy of the pore system following processes like more frequently detectable high flooding events, water erosion on even only slightly declining slopes, increased wind erodibility of areas because of a prevented moistening of the topsoil by capillary rise and correspondingly increasing menisci forces are all signs of soil degradation due to soil deformation. How far these alterations in soil functioning can be reameliorated and how far the effects can be also forecasted with respect to the time needed and the restrictions to further land use and management depend on the site specific properties, the applied technology. The principle mechanisms based on biological, chemical and physical processes will be documented within the lecture by detailed analyses of the time dependent alterations of soil properties and functions which again are also the basis for soil management concepts. Soil amelioration by loosening machinery is also included in these considerations. Generally the consecutive landuse of those “sensitive” soils must be evaluated over long time periods in order to approach a new strength and functioning dynamic equilibrium.

Keywords：*: soil deformation, aeration; anoxia; hydraulic, pneumatic and thermal intensity properties, sustain*

O38-2

[C3.5-4] Physical Restoration of Soils

Persistent Effects of Heavy Soil Compaction on the Gas Transport Properties of a Clay Soil

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Soil compaction reduces the number of large pores, increases water retention and slows down the transport rates of water and gases in soil. This can induce oxygen deficiency and impair growth of plants. In the topsoil, the natural processes and tillage of soil are usually considered to remedy any degradation of soil structure in a few years, but in the subsoil, the compacted zones may remain unchanged for decades. The persistent impacts of heavy soil compaction on the gas transport properties were investigated in a long-term field experiment on a clay soil in Jokioinen, Finland, as part of a Nordic joint research project POSEIDON (www.poseidon-nordic.dk). The topsoil was clay loam and the subsoil horizons heavy clay by texture. The compacted plots had received a heavy wheeling with a 19 Mg load on a tandem-axle unit four times track to track in the autumn 1981, whereas no such wheeling had been done on the control plots. After the wheeling, the field had been annually mouldboard ploughed 1981-2001, stubble mulched 2002-2008, and direct-sowed since 2009. The relative gas diffusivity (D/D0), air permeability (ka) and air porosity were determined for structural soil samples taken into 100- or 200-cm3 steel cylinders in vertical and horizontal direction at 15, 30 and 50 cm depths in May 2012.

The air permeability and the relative diffusivity were in the topsoil were larger than those in the subsoil in both treatments. Despite the annual tillage of topsoil for 30 years after the heavy compaction, the horizontal D/D0 and ka at 15 cm depth were significantly smaller in the compacted soil compared with the control, but in vertical direction the differences were not significant. In the subsoil, compaction reduced both vertical and horizontal air permeability at 50 cm depth and the vertical air permeability at 30 cm depth. Compaction reduced vertical D/D0 at 50 cm depth, but the similar trend at 30 cm depth was not statistically significant. The results show that compaction of a boreal clay soil causes persistent changes in the gas transport properties lasting decades in both topsoil and subsoil. In addition, they suggest that compaction increases the anisotropy of topsoil, whereas in the subsoil, the anisotropy seems to be part of natural development of soil. In the topsoil, anisotropy was observed only in the compacted soil, whereas at 30 cm depth, anisotropy was pronounced in both compacted and control treatment. Isotropy at the deepest subsoil horizon suggests that the natural processes at those depths are too weak to have much effect on soil structure. In clay soils, the development of structure begins with vertical cracking due to shrinkage and swelling of soil. As the earthworms and roots similarly create vertical macropores in soil, the vertical gas transport properties increase more rapidly during soil structural development as compared with the horizontal ones. The strong impact of compaction on the air permeability, and the high values of air permeability in the topsoil are readily explained by the fact the compaction preferentially reduces the number of macropores in soil.

Keywords：*air permeability, anisotropy, compaction, relative gas diffusivity, soil structure*

O38-3

[C3.5-4] Physical Restoration of Soils

Physical Restoration of Compacted Soils: a Lab Experiment using Rock Fragment Addition

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In many world areas Alfisol and Entisol soils are susceptible of natural or anthropic deterioration that negatively affects crop yields. Specific geomorphological and climatic conditions can induce, for example, a massive soil structure and problems of asphyxia. We tested an alternative physical restoration method based on the addition of rock fragments performing a lab experiment with repacked soil samples.

Five concentrations of 4-8mm rock fragments were added to an Alfisol and an Entisol from South Italy which exhibit problems of natural soil compaction. The mixtures were put in pots (15cm height x 15cm diameter) and after nine wet/dry cycles the samples were impregnated with fluorescent resin. The obtained soil blocks were examined by image analysis techniques. The direct observation and analysis of the soil pore system allowed to quantify the occurred modifications.

In both soils the addition of stones improved the soil structure modifying the typical sub-horizontal pore arrangement of the compacted soils into more complex and isotropic ones. This latter amelioration effect gradually increased with depth at increasing rock fragments concentrations.

Outcomes of this work demonstrate that lab experimental studies combined with image analysis techniques have the potential to improve the quantitative understanding of the mechanisms of soil structure restoration. Overall results showed that rock fragments addition in compacted soil could be a useful technical structure restoration measure.

Keywords：*Soil structure, Soil image analysis, Soil micromorphology*

O38-4

[C3.5-4] Physical Restoration of Soils

Physical Restoration of Eroded Soils in the Northern Great Plains (na)

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Management of agricultural lands often seeks to modify or control non-human environmental factors so as to support diverse (and often conflicting) objectives, such as extraction of resources, profitability, human survival, soil and water conservation, maintenance of wildlife habitat, food security, etc. Agricultural management objectives have short and long term consequences that must be considered in devising global and national food security goals. Past soil management practices have emphasized resource extraction and profitability at the expense of the physical integrity of soils. Soil profile changes due to topsoil translocation and reduced quality of soil structure from truncated soil pore size distribution and simplified pore geometry are especially prevalent in eroded agricultural landscapes. Historically soil management in the Northern Great Plains in North America (NA) was an exploitive technology and as a result 40% of the soil organic matter has been lost resulting in reduced structural stability. Additionally extensive soil profile changes have occurred from extensive mechanical translocation of soil by tillage on convex hilltops and from water erosion on backslopes. Soil management practices evaluated for physical restoration of soil structure on eroded landscapes within the Northern Great Plains (NA) included the physical replacement of topsoil on eroded hilltops, the addition of amendments such as biochar to eroded soils, and the use of native prairie grasses to improve degraded soil structure. Soil replacement of topsoil on eroded soil significantly increased soil water contents at -0.03 MPa compared to the control. However water contents at -1.5 MPa also increased resulting in a reduced effect on plant available water holding capacity. Wet aggregate stability also improved with topsoil replacement. Studies with biochar addition to eroded soils showed an increase in plant available water holding capacity for two eroded soils, a coarse textured and a fine textured soil. This was primarily related to an increase in the upper end of the water retention curve near the air entry value of the coarse texture soil. Native grasses improved wet aggregate stability on an eroded soil three years after establishment. However a comparison with a nearby native prairie remnant indicated that significant progress is still needed to match the high structural stability of the original prairie. The efficacy of soil management practices to restore eroded soil to soil structure approaching that of the original soil will depend on the difference in composition between the eroded soil and the original soil, and the degree to which soil management practices re-enforce mechanisms that increase soil pore development, complexity, and stability.

Keywords：*Eroded soils, Soil Structure, Water Retention, Aggregate Stability, Biochar, Topsoil Replacement*

O38-5

[C3.5-4] Physical Restoration of Soils

Temporal Variability of Soil Physical Properties under Different Land Use Types of Clay Soil in the Mekong Delta, Vietnam

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Spatial variability of soil physical parameters has long been observed, although this temporal effect is neglected in several studies and applications. The objectives of this research were therefore to better understand the effect of different agricultural land management practices on selected physical properties of an alluvial clay soil in the Mekong Delta and how these properties change with time. In a long-term experiment, plots were arranged in a randomized complete block design with four treatments and four replications: (1) rice-rice-rice (control - conventional system as farmers' practice), (2) rice-maize-rice, (3) rice-mung bean-rice, and (4) rice-mung bean-maize. This study focuses on bulk density, soil porosity, matrix-porosity, macro-porosity and field saturated hydraulic conductivity. The soil samples were collected at three depths 0-10, 10-20 and 20-30 cm. Sampling and measurements were performed three times per season, i.e., 15 days after sowing (DAS), 45 DAS and 90 DAS (at harvest) for the winter-spring and summer-autumn seasons. Results show that bulk density, soil porosity, matrix-porosity and macro-porosity variation was mainly associated with treatments and soil depths. The rice monoculture showed a strong increase in bulk density, and a decrease in soil porosity, matrix-porosity and macro-porosity, with depth. This effect was smaller for the rotation of rice with upland crops. Rotating rice with two upland crops did not result in significantly different physical soil properties compared to a rotation with only one upland crop. Field saturated hydraulic conductivity showed great temporal variability, both seasonal and inter-seasonal. Seasonal variability was present for rice monoculture in both seasons, whereas inter-seasonal variability was most pronounced for rotations of rice with upland crops. The strongest temporal variability was found for the rice with upland crop rotations during the summer-autumn season, with the variability being most pronounced during the first half of the growing season. Temporal variability of bulk density and matrix- and macro-porosity during both seasons is very limited for crop rotation treatments, whereas it was especially observed for rice monoculture treatment.

Keywords：*clayed soil, soil bulk density, soil porosity, soil hydraulic conductivity,, temporal changes, Mekong delta*

O39-1

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Identifying Yield Limiting Soil Factors with Aids of Remote Sensing and Data Mining Techniques

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Soil provides crop with nutrients, water and root support. But, soils vary a great deal in terms of origin, appearance, characteristics and production capacity. Better understanding of the causality between yield and yield-limiting soil factor(s) is essential for site specific crop management. In this study, multiyear yield maps derived from satellite images and general soil survey data were utilized to explore the yield-limiting soil factor(s) of a 144 km2 paddy rice growing region located at an alluvial plain in southwestern Taiwan. Considering the complexity of data sets, classification and regression trees analysis (CART) was used to relate soil characteristics to yield classes in the spatiotemporal yield trend map, and followed by comparisons of soil characteristics between those consistent-high and -low yielding areas to explore the interactions between yields and soil properties. Through the above analysis, high soil pH, severe leaching loss of applied nitrogen fertilizers, and excessive reductive root environment were suspected to be the major soil induced low-yielding mechanisms spread within studied region. Soil characteristics that induced these low-yielding mechanisms were identified and mapped. Error analysis indicated that 61.8% of the consistent low-yield areas could be correctly identified by just several soil characteristics. Improvements of management practices to alleviate the negative effects on yields were also proposed based on the identified low yielding mechanisms

Keywords：*Paddy rice, Yield limiting factor, Soil survey, Remote sensing, Data mining*

O39-2

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Root-zone Fertilization: a Key and Necessary Approach to Improve Fertilizer Use Efficiency and Reduce Non-point Pollution from the Cropland

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How to increase fertilizer use efficiency (FUE) has been an urgent problem still unsolved for agriculture development and environment protection. In this paper, the common approaches to improve FUE were briefly reviewed, and the main reasons for the lower FUE in China were discussed. The loss of nutrients from the cropland is the basic course lead to low FUE, while adsorption or fixation of nutrients in soil is not the main reason for the low FUE. From the aspect of nutrients uptake, the large portion of nutrients distributed in the bulk soil could not be assimilated efficiently by crop roots explains the fundament of the low FUE. Based on the limited movement and diffusion of the nutrients in soil, the limited soil volume from which crop root could absorb nutrients efficiently, and the concentration of the nutrients determined nutrients uptake efficiency by roots, the root-zone fertilization technique was proposed as the key and indispensable approach for the high NUE in future. The definition of root-zone fertilization technique, where this technique is suitable, and what scientific fundaments need to be revealed in future were also discussed in this paper.

Keywords：*Fertilizer use efficiency, Fertilization technique, Root-zone fertilization, Efficient utilization*

O39-3

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

A Novel Trial to Combine Use of Azolla and Loach to Suppress Weed Monochoria Vaginalis and Increase Organically Farmed Rice Yield

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Organic farming uses alternatives to agricultural chemicals such as synthetic fertilizers and pesticides. The primary challenge in organic rice farming is controlling weeds without using herbicides. Monochoria vaginalis is one of the most common and troublesome annual broadleaved weeds in rice paddies, where it competes with rice for N uptake. For developing an effective approach to eliminate weed M. vaginalis growth in organic rice farming, we performed an in situ box experiment to study the effects of individual and combined use of Azolla filiculoides and loach (Misgurnus anguillicaudatus) to suppress M. vaginalis emergence and increase organically farmed rice yield. This study was designed with 4 treatments—control (with neither Azolla nor loach), Azolla (Azolla alone), loach (loach alone), and Az+Lo (combined Azolla and loach)—with 3 replications each. The box experiment was carried out 2 continuous rice growth seasons during 2012-2013.

In the first season 2012, before rice transplanting, soybean oil cake as basic organic fertilizer was applied in the boxes. The results show that use of Azolla alone and loach alone partially suppressed M. vaginalis emergence and improved rice yield due to the effects of both shading and N-fixation by Azolla, and aquatic bioturbation by loach. The combined use of Azolla and loach had a stronger effect, totally suppressing weed emergence and increasing rice yield to 131% that of control treatment.

In the second season 2013, no any fertilizer was applied, only the Azolla, weeds and stubbles from last season left in boxes as organic amendment. The results show the M. vaginalis emergence was suppressed in the boxes with both treatments of loach alone and Az+Lo (combined Azolla and loach). Compared with control (with neither Azolla nor loach), the rice yield was increased at 17.8, 127.4 and 127.8% in Azolla (Azolla alone), loach (loach alone), and Az+Lo (combined Azolla and loach) treatments, respectively.

It indicated that combined use of Azolla and loach may be a valuable approach in organic rice farming, especially in organically farmed rice paddies with high densities of M. vaginalis seeds. Thus the combined use Azolla and loach meets 2 of the greatest challenges in organic rice production: providing effective weed control and ensuring adequate N fertilization without use of synthetic chemical inputs.

Keywords：*Azolla; Loach; Monochoria vaginalis; Organic farming; Rice yield*

O39-4

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Decrease in Nitrogen Fertility of Paddy Soils Induced by Paddy Rice and Upland Soybean Rotation

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In Japan, rice supply has exceeded domestic demand and so rice production has been adjusted accordingly for about 40 years. A typical adjustment is the rotation of paddy rice (*Oryza sativa* L.) in paddy fields and upland crops in drained paddy fields (paddy-upland rotation) and this has been promoted to improve the self-sufficiency rates of upland crops. Soybean (*Glycine max* (L.) Merr.) is a major crop in this rotation sequence. This paddy-upland rotation causes drastic changes in soil properties in paddy fields, which have been flooded during rice crop season for hundreds of years. However, quantitative relationship between soil nitrogen (N) fertility and soil management including the paddy-upland rotation cycle is vague. The importance of the farming system based on paddy fields in Japan means that the fertility of paddy soils under paddy-upland rotation is essential. Therefore, investigation should be carried out to elucidate the status of soil N fertility in paddy fields. The objective of the present study is to clarify the level of N fertility evaluated as available soil N of gray lowland soil as well as other soil chemical properties in paddy fields where paddy-upland rotation had been conducted under different farmers' management practices in northeast Japan.

Topsoils of gray lowland soil (Fluvisols) were collected from 22 fields of five different farmers in Daisen, Akita prefecture, in northeast Japan. These fields had different profiles with respect to paddy-upland cycles, and applications of organic materials and soil amendments. Available N (mineralizable N) of the soil was measured following submerged soil incubation at 30°C for four weeks. Total N and total carbon (C) of the soil were also measured

Regardless of organic material application, a significant negative correlation was found between available soil N and an increase in the proportions of upland seasons to total crop seasons (upland frequency). In fields with repeated applications of cattle manure compost, however, the soil available N was higher than in fields where only crop residue was applied. Soil total N and total C also tended to decrease with an increase in upland frequency, indicating that the decomposition of soil organic matter was promoted by the use of paddy fields as upland fields. Thus, it was demonstrated that conversion from paddy rice fields to upland soybean fields, and crop rotation of paddy rice and upland soybean induced a decrease in soil N fertility observed by available N. The cycle of paddy-upland rotation (upland frequency) and the application of organic materials played a key role in determining the available soil N in paddy-upland rotation. In order to sustain available soil N over the minimum suitable level of 80 mg kg^{-1}, upland frequency should not exceed 60% where no organic material is applied except crop residues. In contrast, upland frequency can be raised with the application of organic materials as they maintain the available soil N. The application of organic materials ensures diverse use of paddy fields.

A significant negative correlation was also found between the soil available N:total N ratio and upland frequency, suggesting that the part of soil N related to available N was notably lost under paddy-upland rotation. This component of soil N might be relatively more susceptible under upland conditions compared with other components of soil N. It was speculated that conversion of paddy rice field to upland soybean field caused changes in the composition of soil N which had been developed in paddy rice fields. The soil available N:total N ratios in fields with repeated application of cattle manure compost were higher than those without cattle manure compost application. Application of organic materials might also play important role in maintaining the soil available N:total N ratio.

In conclusion, care should be taken to keep the N fertility of paddy soil at a suitable level in paddy-upland rotation. Upland frequency, organic materials and soil amendments are important factors to sustain and improve paddy-soil properties including N fertility in paddy-upland rotation.

Keywords：*fertility, nitrogen, paddy soil, paddy-upland rotation*

O39-5

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

An Approach to Reduce Arsenic Uptake and Accumulation in Paddy Rice through the Selection of Rice Genotypes with High Iron Plaque Formation Capability

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Arsenic (As) is a well-known non-threshold, class 1 human carcinogen. Previous studies have shown that iron plaque formed on rice plant roots are the barrier of rice plants to As uptake. Limited studies to compare different rice plant genotypes grown in As-contaminated soils, their iron plaque formation capabilities, and its effect on As uptake. This study investigates the effect of iron plaque on As uptake in different rice genotypes grown in As-contaminated soils from the Guandu Plain of northern Taiwan. The results obtained from this study are useful for selecting low As uptake genotypes of rice for growing in As-elevated soils. Using these rice genotypes will reduce human exposure to As through rice consumption.

An As-contaminated Guandu Plain soil (156.6 mg As kg-1) and twenty-eight rice genotypes including fourteen japonica and fourteen indica genotypes which commonly planted in Taiwan were used in this study. Rice seedlings were pre-cultivated in nutrient solutions for 12 days and then transplanted to As-contaminated soils and grown for an additional 38 days. The iron plaque formed on the surface of rice roots were extracted using dithionite-citrate-bicarbonate (DCB). The concentrations of As, Fe and P in soil solutions and plants (iron plaque, roots, and shoots) were measured. The speciation of As in the root's iron plaque was determined by As K-edge X-ray absorption near-edge structure spectroscopy (XANES).

The results show that the amounts of iron plaque formation on roots were significantly different among 28 tested rice genotypes, and 75.7-92.8 % of As uptake from soils could be sequestered in iron plaque. However, there was no significant positive correlation between the amounts of Fe in the iron plaque and the amount of As in the iron plaque. In addition, there were also no significant negative-correlations between the amount of Fe in the iron plaque and the content of As accumulated in rice plants (roots + shoots) of tested genotypes. There were significant differences in the contents of As in shoots of rice, and the japonica genotypes was higher than indica genotypes ($P < 0.001$), due to the translocation factor from roots to shoots of japonica genotypes was also higher than indica genotypes. XANES data showed that arsenate was the predominant As species in iron plaque, and there were difference in the distribution of As species among different rice genotypes.

The results of this study indicate that the iron plaque can sequester most of As uptake from soils no matter what rice genotypes used in this study, due to the high amounts of iron plaque formed on roots of all tested genotypes grown in Guandu Plain soils. However, the iron plaque formation capability alone did not control extent of As accumulation in rice plants from As-contaminated soils. The rice genotypes with low As uptake capability selected from this study are recommended for planting in As-contaminated soils.

O39-6

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Resource Conservation Technologies for Improved Rice Water Productivity in Indo-Gangetic Plains of India

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Rice is of immense importance for food security and livelihoods in South Asia. with 85% of the rice area located in the Indo-Gangetic Plains (IGP). The rice-wheat systems provide 85% of the total cereal production and 60% of the total calorie intake in India, where the states of Punjab, Haryana, Uttar Pradesh in northwest India are the heartland of rice cropping. The small states of Punjab and Haryana in the region contributed about 50% of the government procurements of rice and wheat. The state of Punjab (only 1.5% of the geographical area of India) contributes about 35-40% of the rice supplied to the central Government of India pool. However, this high and consistent rice productivity was possible at the cost of groundwater resource which started depleting at alarming rates (around 0.5-0.75 m year-1) recently, with the result that 103 out of 138 administrative blocks in Punjab, and 55 out of 108 blocks in Haryana are overexploited. In addition, this has resulted in deterioration of water quality and infrastructure costs. To explore the potential of improving rice water productivity in the region, many on-farm resource conservation technologies are being advocated viz. furrow irrigation, coinciding rice transplanting with low evaporative demand period, intermittent and soil-specific need-based irrigation, direct dry-seeded rice, etc. The results pertaining to some of these techniques in the region are discussed below in the light of water productivity.

Rice transplanting time: The rice transplanting during the nineties had shifter to the start of May, leading to about one and half to two months period of very high evaporative demand north-west India. This period saw a sharp decline in ground water tables in the region. Many field and modelling studies and Department of Agriculture Statistics show that the yield of transplanted rice is relatively stable over a wide range of transplanting dates from early May to mid-June or later. Thus, delaying the transplanting date to mid-June as per the Act passed in this direction by the state government did significantly reduce the ground water depletion from 0.75 m year-1 to 0.5 m year-1 while maintaining the rice yield.

Soil matric potential-based intermittent irrigation: It is a well-known fact that the irrigation interval of 2 days in rice (already recommended in the region) may get reduced or prolonged depending upon the type of soil and atmospheric evaporativity, the situation becoming more complex due to uncertain climatic conditions witnessed recently. A simple, farmer-friendly, robust and cheap tensiometer which when inserted into the soil to measure the soil matric potential. This tensiometer displays a three-colour strip on the outer tube of the tensiometer. The irrigation to rice is recommended when the water level in the inner tube just crosses the green strip (-150 cm soil matric potential). This results in reduction in the amount of irrigation water to the extent of 20-25% from that in 2-day irrigation interval.

Furrow irrigation: The studies on transplanted rice on permanent and fresh raised beds with furrow irrigation have shown lower

irrigation water amounts but lower crop yields compared to puddled transplanted rice (PTR) resulting in similar irrigation water productivity (WPI). The irrigation water savings for intermittently irrigated beds will be much higher if these are compared with PTR with continuous flooding rather than with intermittent irrigation. The magnitude of the water savings of transplanted rice on fresh beds in farmers' fields in comparison with farmer practice (probably PTR with continuous flooding) appears to be similar to the savings with intermittent irrigation compared to continuous flooding of PTR. In north-west India yields and WPI generally decline as the beds age in comparison with PTR with the same irrigation scheduling rules.

Direct dry-seeded rice: The studies in the region have shown that crop yields of direct dry-seeded rice (DSR) in fine textured soils are similar to those of PTR with considerable irrigation water savings (35-60%) but with little difference in ET water requirements. However, in coarse and medium textured soils, there was sharp decline in rice yields with little or no saving in irrigation water requirements.

There is thus a need to relook at the water balance components of all these resource conservation technologies in different soils. Irrigating the crops grown with resource conservation technologies with the similar schedules as used in case of conventional techniques may not serve the purpose of improving water productivity of the crops.

Keywords：*Water productivity, Indo-Gangetic Plains, Rice, Soil matric potential*

O40-1

[C1.6] Paleopedology

Regional Erosion Surfaces of the Midwest USA: Clues to Climatic Readjustment from Late Pleistocene Loess and Paleosols (OSI 5e-2)

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Background

In the Midwestern, USA, early Wisconsinan time was marked by a series of events that until recently were not clearly linked to post-glacial climatic readjustment on a regional scale. Areas outside the Wisconsinan glacial border and adjacent to major river divides in several Midwestern states were examined in an attempt to locate similar adjacent regions on a scale comparable to continental glaciations.

Studies in the early 20th Century in northeastern Iowa identified an extensive erosion surface [1]. Buried by late Wisconsin loess, this surface cut the entire stratigraphic section from the Wisconsin till to the pre-Illinoian till and thus established its relative age as younger than Wisconsin till and older than late Wisconsin loess deposition. Radiocarbon dates for basal Wisconsinan soils, the uppermost unit truncated by the erosion surface, indicated an age of generally greater than 18000 BP. That age indicates its development was a direct response to shifts in climate associated with glacial retreat.

Wisconsin glaciation extended through much of the upper Midwest but at that time, there was no evidence that the surface in Iowa had parallels in adjacent regions. In the 1980's, we began studies of the Ohio/Wabash stream divides in southeastern Indiana traditionally known as "Illinoian till plain' stratigraphically, late Wisconsin loess overlying Illinoian till. From the investigations, it was determined that although the loess was present in a uniformly continuous blanket across these areas, there was little or no Illinoian till beneath. The late Wisconsin loess lay directly on bedrock, pedisediment, or older tills. Borings on subdued highs revealed that these erosional outliers contained complete stratigraphic sections that had been sequentially truncated by an erosions surface [2, 3]. Hidden beneath loess, this erosion surface had cut the slopes that descend in all directions from the remnant outliers to form the floor of the 'till' plain.

Recent Regional Evidence

The Mississippi/Ohio divide in southern Illinois within the Illinoian drift border and well south of the Wisconsinan drift border were examined most recently. Multiple coring sites and soil pits were located near the divides of 3 tributary watersheds to the Big Muddy River drainage. Here in Illinois, as in Indiana and Iowa, undisturbed thicknesses of late Wisconsin loess directly overlie bedrock, pedisediment, or older drift concealing underlying erosional surfaces. Illinoian till is present only in protected coves of this subsurface landscape.

Conclusions

During the waning phases of the last glaciation in North America, a period of significant subaerial erosion occurred that remained largely unknown and undocumented, in part because of a lack of exposures and the difficulty in developing subsurface stratigraphic landscapes. The relative synchroneity, extent, and number of erosion surfaces outside the Wisconsinan drift border suggest a subaerial response to shifts in climatic events occurring during and immediately following the withdrawal of the last glacial ice sheet.

[1] Ruhe, R.V. (1969) Quaternary landscapes in Iowa, Iowa State University Press. [2] Gamble, E.E. et al. (1991) Soil Survey Inv. Rept. 41, USDA. [3] Olson, C.G. (1989) Catena Supplement 16, 129-142.

Keywords : Erosion Surfaces, Paleosols, Midwest USA, Wisconsin Loess

O40-2

[C1.6] Paleopedology

Pedosedimentary Sequences on Moscow (late Saalian) till in the Center of the Russian Plain

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Base tills are nearly ubiquitous within Moscow glacial limits and are presented by uniform mantles of 6-8 m thick that cover undulating watersheds. The mantle is continuous though often interrupted by meltwater gullies filled with sandy deposits. As a clear tendency on the highest watersheds (180 -250 m asl), base tills are covered by of mantle loams (northern variety of loess), that overlay tills with a thick mantle of 3 to 5 m. In the lower positions (130-180 m a.s.l.), base tills are covered only with a thin veneer of sands, sandy and silty loams, so that surface soils are formed on two-layered parent material.

The study of soils such soils as pedosedimentary sequences allows identifying the following set of features:

Pre-depositional. The lower units of pedosedimentary sequences are reddish-brown diamictons (sandy clays or sandy heavy clay loams). The bright reddish-brown color (up to 5YR 6/6) and high weathering through the whole strata is typical for base tills of Moscow age and are inherited from sediments mobilized by the glacier: older tills, weathering crusts, hard rocks, etc. Uniform composition of tills indicates effective mixing and homogenization of material along the ice flow path. Stones are dispersed in the matrix and presented by a big array of rock debris – granites, limestones, breccia, etc. Over consolidated matrix supported fabric with low porosity is a result of big pressure under the glacier. Till architecture includes sand lenses and heterogenic fragments due to the filling of small subglacial cavities. Glaciotectonic deformation structures include shearing features, folding, thrusting and rotational structures, tension fractures, till wedges and other evidences of emplacement of matrix within the mobile sediment.

Syndepositional. Primary structural units - big blocks that could be traced throughout the whole strata of diamictons – had been formed during sediment stabilization. Platy structure due to freeze-thaw cycles may be observed within the upper meter of diamicton. During and immediately after deposition diamictons were overlain by thin veneer of various sediments – sandy ablation layers, fluvioglacial sands, aeolian sands and loess-like loams. The minimal depth of cover layers is about 45 cm. The thickness of fluvioglacial cover layer increases in the direction of meltwater gullies. The lower unit changes coherently: in the direction of the gullies it is becoming rewashed, streaked and wedged out. Aeolian input results either in a separate cover layer or in the admixture of silty particles in the upper parts of cover layers, indicating that final depositional stage occurred in arid environment.

Pedogenic, stage I. Impact of a long pedogenesis, presumably occurring during the last interglacial is well seen in the lower unit (diamicton). It is resulted in the formation of pedogenic structural architecture (subangular blocky peds and biogenic pores) and well-developed clay cutans that together resulted in a sequence of Bt horizons. Though lithological features have not been overprinted or obliterated by pedogenesis.

Cryogenic features include stone lines, irregular network of frost fissures and signs of cryoturbation (lenses and pockets) in the upper part of diamictons. They have sandy or silty filling, depending on the cover layer. Cryogenic features are responsible for intermixing of cover layer and till deposits, resulting in the complicated morphology of EBt horizons that is characteristic for Glossisols. The sand wedge filling consists of aeolian sand and loamy streaks of different sizes, originating from the host material. Streaks of Bt horizon are presented in the frost wedge fillings, while clay cutans are absent here, indicating that cryogenic stage succeeded stage I pedogenesis, presumably during Valdai (Wurmian) glacial time.

Pedogenic, stage II. Pedogenic features of the last interglacial have not been overprinted by Holocene pedogenesis. For this reason it is difficult to differentiate the impact of Holocene and interglacial pedogenesis in the lower unit. Soil horizonation is clearly seen within the upper unit (a sequence of A and E or Bw horizons).

The study of pedosedimentary sequences allows to unravel complex interaction between lithological, cryogenic and pedogenic features since Moscow time thus allowing to derive reliable palaeoclimatic interpretation. The abundance of relic pedogenic features allows regarding such sequences as surface paleosols

Keywords：*pedosedimentary sequence, glacial till, surface paleosols*

O40-3

[C1.6] Paleopedology

The Morphological and Chemical Properties of Paleosols are used as Proxies for Reconstruction of Multidirectional Paleoenvironmental Conditions in the Late Holocene for the Region Near Caspian Sea

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The pedochronosequence including one paleosol buried under archaeological earth mound (kurgan) at the Middle Bronze Age (the end of the 3rd - the beginning of the 2nd millennium BC), twelve paleosols buried under kurgans at the end of the Late Sarmatian Time and the beginning of the era of the Great Migration (the second part of the 4th- the first part of the 5th centuries AD) and two background surface soils were studied in the Palasa-Syrt kurgan cemetery, Dagestan Republic, Russia. The area belongs to the semi-deserts and situated on the Caspian coastal plain. The mean annual temperature is +12°C, in July - +21-22°C, in January - +3°C; the mean annual precipitation is 350 mm. The solonetzic and carbonate Light Kastanozems (Calcic Kastanozems Sodic according to WRB) are dominated in soil cover. The set of morphological and analytical procedures including micro- and submicro-observations, determination of organic and inorganic (carbonate) carbon content, gypsum and exchangeable cations content, particle size distribution and density of soils were carried out and the calculation of total carbon stocks were made. The humus in the uppermost horizon and carbonates in the 25-35 cm layer of background surface soils and buried paleosols were dated by radiocarbon method.

In the Middle Bronze Age the transition to the desert bioclimatic area and the change of soil type from the Light Kastanozems to the Brown (semi-)desert soils (Endosalic Calcisols Aridic Sodic by WRB) have been reconstructed. The paleosol dated by the end of the 3rd - the beginning of the 2nd millennium BC demonstrated the most intense properties of salinisation and solonetzisation compared with all other paleosols of the pedochronosequence studied. Only in this paleosol the cianobacteria and the highest gypsum content in the surface horizon are observed. These properties are characteristic for the desert extra-arid soils. According to the paleoenvironmental reconstruction, the paleosols dated by the second part of the 4th- the first part of the 5th centuries AD developed within the semi-desert area. There was not change of a soil type, but the climatic fluctuations occurred and they had different directions. Increasing accumulation of organic matter, erasing of solonetzic properties, carbonate lowering, absence of gypsum and high biological activity signs are observed in the paleosols of the second part of the 4th century AD. The climatic conditions at that period were reconstructed as humid and similar with climatic conditions at present. At approximate boundary between the 4th and 5th centuries AD, climate became more arid, the annual precipitation decreased by about 50 mm according to our estimation. In paleosols of the second part of the 5th century the increase of the carbonate and gypsum content, the enhancement of the solonets' signs, the decrease of organic carbon stocks and signs of biological activity were noted. The paleosols of the second part of the 4th- the first part of the 5th centuries AD were grouped according with similarity of their properties. This let us to suggest the relative chronological order of the kurgans' construction and burying of paleosols in the Palasa-Syrt kurgan cemetery. The suggested order was later confirmed based on archaeological material. The regularity of appearance/disappearance of soil properties under the multidirectional climatic conditions was established. Under enhancement of arid/humid climatic conditions the signs of salinity, solotzisation and biological activity, changes of carbonate 14C-age are the first to appear/disappear. These processes are estimated to be ultra-fast taking 10-20 years for their development and appearance in a soil profile of the region studied. For the changes in content and stocks of organic carbon and carbonates, radiocarbon age of humus, 50-100 years are necessary.

Keywords：*paleosols, Holocene, kurgans, paleoenvironmental reconstructions, radiocarbon dation of humus and ca*

O40-4

[C1.6] Paleopedology

The Establishment of Paleosol Reference Profile to Aid Paleoenvironment Reconstruction of Paleosols Derived from Quaternary Loess: an Example of the Fenghuangshan Profile in Chaoyang, China

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The paleosols derived from loess, which widely distributed in north of China, were superimposed and have different colors. These paleosols, reflecting the soil types at different pedogenic stages, can provide a wealth information about paleoenvironment. There are thus merits in establishing reference profiles in different ecological areas to aid the recognition and classification of paleosols. The establishment of paleosol reference profile (PRP) is also helpful to compare the results of paleoenvironment reconstruction obtained by different scientists in different ecological region. In the paper, a PRP derived from thick loess in Chaoyang city of Liaoning province, China, which demonstrates well preserved stratigraphic sections including various paleosols types, will be established. To investigate the nature and origin of the PRP, the geographic, stratigraphical and morphological characteristics were described in the field. Paleosol loess samples in high-resolution (every two centimeters in depth) were collected, and particle size distribution and magnetic susceptibility characteristics were examined. Rare earth elements （REE ）of each pedogenic horizons in the profile for verifying the identity of deposition source were analysed. Optically Stimulated Luminescence (OSL) was used for dating the deposition, and sedimentary continuity was explored. The results show that the profile selected is 19.85 metres in depth. Except for an evidence of an erosional hiatus at 62 ~108 cm below the earth surface, aeolian loess has been deposited continuously since 423 ka BP. Four reddish stratigraphic layers are found interbedded with five yellowish stratigraphic layers, which indicate that several types of paleosols have been developed in different ecological environments. These meet the requirements of reference profile establishment. Therefore, this loess paleosol profile could be established as a PRP, which will play an important role in loess paleosol research.

Keywords：*Paleosols; Loess; Paleoenvironment; Paleosol reference profile; Establishment; Fenghuangshan profile*

O40-5

[C1.6] Paleopedology

Magnetic Enhancement and Iron Oxides in a Fluvio-lacustrine Sediments Paleosol Sequence in Southern Italy

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Pedogenesis under temperate climate conditions usually enhances magnetic signals, most often by increasing the concentration of pedogenic ferrimagnets (magnetite and/or maghemite). Climate influences also other type of Fe oxide resulting from the crystallization of ferrihydrite subsequent from the weathering of Fe-bearing minerals. Hematite and goethite are the stable form in soils in Mediterranean regions undergoing seasonal droughts, but is generally absent from soils in cold temperate areas or remaining moist throughout the year. This study aims at defining pedogenetic processes which occurred in in a fluvio-lacustrine sediments paleosol sequence the Boiano area. In order to obtain more information of the pedogenic process, we combine magnetic signals and geochemical weathering indicators related with iron oxides. The Boiano intermontane basin is located in the southern Italy. It is a large Quaternary morphotectonic depression, approximately 22 km NW-SE long and 4 km wide, between Matese and Sannio Mountains made by tectonized meso-caenozoic limestones and terrigenous sediments thick about 2 – 3 km. The Biferno River drains the intermontane basin, partially cutting its Pleistocene fluvio-lacustrine filling thick about a few tens of meters. The basin is drained from the Biferno River whose erosive action was such as to cut only partially the fluvio-lacustrine Pleistocenic basin filling which, therefore, shows almost intact its original morphology, characterized by a gentle sloping topographical surfaces. The Boiano basin consists of a complex alluvium-detrital sequence with inclusions of paleosols having different thickness and development, more specifically Vertisols and fluventic Entisols. Present-day soils consist of Andosols, which have been studied and used for correlations. The result indicated that both pedoclimate and pedogenesis duration influence the degree of weathering and depletion of ferrihydrite in soil, and hence its content in ferrimagnets and, based on our model, the width of the maghemite GSD and the Hm/χFD ratio. Other indicators related to the degree of weathering, such as the (Fed/Fet ratio) provide information detail on the integral of the effect of climate with time. However, they afford no accurate prediction of climatic variables unless the duration of pedogenesis is known. Alternative indices (particularly the Hm/χFD ratio) was used to this end. Based on these ratio depends strongly on the length of time water activity in soil is below but the soil is, at the same time, moist and warm enough to allow dehydration and internal rearrangement of ferrihydrite. This occurs in soils developed under temperate climates with dry seasons such as those of the Mediterranean region, where different combinations of temperature and water regimes can result in different iron oxides formation. In summary, accurate paleoclimatic reconstruction of paleosols in the Boiano area offer many ideas for interesting considerations: 1) the age of the alluvial bodies - some geological considerations suggest that these deposits are high-Pleistocene aged, but at present there are no radiometric dating confirming this chronological attribution; 2) the climatical origin of the alluvial sediments containing the pedogenized bands – it is possible to confirm the hypothesis that the alluvial with paleosols sequence of Boiano basin is the result of alternating regimes of resistasy and biostasy occurred during the late Pleistocene; 3) pedoclimatic significance of paleosols – from the preliminary data on the buried soils and paleosols present in Boiano basin-fill come out that the pedogenesis is occurred in the alluvial environment, set both on the volcanoclastic and epiclastic parent material, it has developed in several climatic systems with different times and different processes. The Boiano basin have so far been carried out only preliminary geomorphological and pedological observations who only allowed to grasp the pedological and chronostratigraphical potential represented by sediments examined and the contribute that they are able to offer in terms of Quaternary evolution of the Southern Apennines. So that, a detailed study of the alluvial sequence and of the soils aimed at defining the role of climate in sedimentary and pedogenic processes is desirable and would geomorphological history of the Boiano basin as a reference for the evolution of the Apennines interior areas.

Keywords：*Lacustrine basins, paleopedology, magnetic enhancement, iron oxides, clay mineralogy, southern ltaly*

O40-6

[C1.6] Paleopedology

The Applicability of Plant Biomarkers to Reconstruct Palaeo-environments from Plaggic and Driftsand Deposits

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From roughly 1400 AD to the advent of artificial fertilizers in the early 20th century, plaggic manure was applied to fertilize poor sandy soils in northwestern Europe and particularly The Netherlands and Germany. In addition, evidence of plaggic type agriculture has been found in other countries ranging from Greenland to Russia and China. Plaggic manure in northwestern Europe consisted mostly of heath sods that were used in sheepfolds as bedding and applied to the surrounding fields as manure. The resulting plaggic anthrosols are a dominant soil type containing large percentages of stable organic matter through considerable depth owing to repeated addition of organic matter for several centuries. Their Chinese equivalent are the eum-orthic anthrosols that are important for the Chinese loess plateau and have existed for millennia. In Europe deforestation and the repeated removal of heath sods to generate the plaggic manure led to the development of drift sands in the adjacent areas in the landscape. There, alternation of unstable periods with aeolian erosion and deposition, and stable periods with soil formation led to the development of polycyclic driftsand sequences.
In several studies, pollen analysis, radiocarbon dating, and OSL dating have been applied to reconstruct soil development and landscape evolution from plaggic deposits and polycyclic driftsand deposits. However, a correct reconstruction of the local vegetation during stable periods in the profile evolution cannot be based on pollen spectra alone because of the impossibility to separate pollen species produced in-situ and at distance. Here we present the results of a study of the applicability of a novel biomarker approach to expand our possibilities to reconstruct past vegetation composition in the area of polycyclic driftsand deposits and the adjacent plaggic anthrosols. The biomarkers approach consists of a semi-quantitative reconstruction of past vegetation patterns based on plant species specific n-alkane and n-alcohol patterns of higher chain lengths using the VERHIB model (Jansen et al., 2010).
We applied the biomarker approach together with pollen analysis on samples of organic rich Ah horizons of buried (initial) podzols in a selected polycyclic driftsand sequence with a well-established geochronology. Based on species matching in soil pollen spectra and biomarker patterns of (buried) Ah horizons, it was possible to distinguish pollen species produced in-situ and at distance from the study site, and consequently to determine the plant species composing the vegetation during stable periods with soil formation (van Mourik and Jansen, 2013). In a pilot study of a typical plaggic deposit, a combination of pollen and biomarker analysis by use of simple shifts in chain length ratios allowed determination of transitions from grass dominated to Calluna vulgaris dominated vegetation. However, in this case the results of the reconstructions with the VERHIB model were unsatisfactory. An explanation is found in a critical review we performed of the consistency of biomarker patterns in plant species relevant for the environment of plaggic anthrosols (Kirkels et al., 2013). We synthesized information on published n-alkane patterns of Calluna vulgaris, Betula pendula, Quercus robur, Pinus sylvestris, Lolium perenne, Deschampsia flexuosa, Molinia caerulea and Poa annua. We found n-alkanes to show predominantly distinct patterns for different vegetation species and parts in the range C17-C36. Prominent n-alkanes C27, C29, C31 and C33 allowed clear distinction between input by shrubs, trees and grasses to plaggic anthrosols. The indicated vegetation shifts match those found in our plaggic deposits study and vindicate the vegetation reconstruction. However, the review also indicated systematic variability among n-alkane patterns that will have adversely affected the VERHIB based reconstruction.

Based on the combined results from our three studies we will critically evaluate the possibilities, limitations and future challenges of (semi)quantitative reconstruction of past environments by a combination of pollen and biomarker analysis from paleosol archives.

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Keywords：*Eum-orthic anthrosols, plaggic anhrosols, biomarkers, palaeo-environments, driftsand*

O40-7

[C1.6] Paleopedology

A New Method for DNA Extraction from Allophanic Soils and Paleosols on Tephras: Insights in the Search for Ancient DNA from Past Terrestrial Environments

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Allophanic soils (Andisols) are able to sequester and protect organic matter from degradation over long time periods. The North Island of New Zealand has large stores of buried allophanic soils developed on sequences of well-dated tephras, and these buried soils (paleosols) sequester organic matter. The clays in these paleosols also potentially protect DNA from degradation, and hence may enable ancient DNA (aDNA) from decaying animals, plants, insects, and microorganisms to be preserved. Such preserved aDNA could provide a record of past environments, and thus a possible new tool for the reconstruction of palaeoenvironments from terrestrial sequences.

The extraction of aDNA from allophanic soils and paleosols has been particularly difficult. In our study, a new two-step method for DNA extraction from allophanic materials has been developed. Step 1 involves the initial use of an alkaline extraction buffer (1 % sodium dodecyl sulphate, 100 mM Tris-HCl, 200 mM EDTA, 500 mM Na_2HPO_4 (pH 8.6)), while step 2 involves treating the material remaining from step 1 with acid ammonium oxalate (pH 3). For proof of principle, we used synthetic allophane and salmon-sperm DNA to test whether it was possible to extract DNA that was strongly bound to allophane using step 1 or step 2, or both. From prior experimental work using P X-ray absorption near-edge structure (XANES) spectra with synchrotron radiation, we established that DNA was bound (adsorbed) to the allophane chemically through the phosphate group.

Our results showed that the salmon-sperm DNA could only be extracted by combining steps 1 and 2. We found that the salmon-sperm DNA was inaccessible (and hence protected) because of the formation of nanoaggregates of allophane spherules, and the addition of acid oxalate caused the nanoaggregates to collapse through dissolution, thus 'releasing' the salmon-sperm DNA. We next applied the two-step extraction technique, and several commercial DNA extraction kits (GenScript, Zymo Research, and Vivantis Soil DNA Kits), to four natural soils, three with allophanic clays and one with halloysite, to ascertain the ability of these methods to extract any natural DNA that was present in the soils. The commercial kits were ineffectual in our study. However, the use of acid oxalate (pH 3) in our two-step process was successful in releasing natural DNA from allophanic soil materials with high yields obtained.

With the new technique, we found that long DNA fragments (16-20 kb) were extracted from the allophanic soils, but only degraded and short DNA fragments (1-20 kb) were extracted from the halloysitic (non-allophanic) soil. We suggest therefore that allophane nanoaggregation helped to protect the DNA fragments better than the halloysite.

To search for natural aDNA in paleosols, allophanic materials were collected from buried soil horizons developed in a pedostratigraphic succession of three rhyolitic (silica-rich) tephras (namely Taupo, Whakatane, and Rotoma) that had been deposited about 1780, 5500, and 9500 calendar years ago, respectively. DNA fragments from these paleosols (near Mt Tarawera in central North Island) were extracted using our new method, and next-generation sequencing will be used to characterize all extracted DNA fragments to ascertain whether they are authentically ancient. If we are successful in extracting aDNA, we will evaluate the potential use and fidelity for reconstructing past Holocene environments by comparing the data with those from palynological and phytolith studies undertaken in the same region as our studies.

The new extraction method appears to solve a major problem in extracting viable (long) DNA from allophanic soils and paleosols, and will be important for paleogenetic studies on such soils or paleosols.

Keywords: *DNA extraction, allophane, halloysite, ancient DNA, paleosols, palaeoenvironmental reconstruction, tephra, P XANES, New Zealand*

O41-1

[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Is There a Role for Forest Management to Increase Carbon Sequestration and Ecosystem Services?

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To increase carbon sequestration through forest management is a recognized activity in the Kyoto Protocol for offsetting industrial carbon dioxide emissions. The Kyoto Protocol has thus been a strong incentive for regions and countries to develop effective forest management techniques to enhance carbon storage in the soil and in long-term biomass. A quick search on the Web of Science for articles with "forest management" and "carbon" as part of the title resulted in 168 publications; when those two terms were used in a topic search, 4,412 publications were found. Those indicate the intense research activities in this area.

A body of the literature reports positive effects of forest management on increasing carbon sequestration, although such effects have been shown to be site, tree species and management intensity specific. Many such studies have been focused on carbon storage in the biomass. For example, a study based on the inventory of two actively managed forest estates located in the Coast and Interior forest regions in British Columbia, Canada, showed that, over a 100-year planning horizon, management strategies that reduce harvest levels stored significantly more carbon in biomass than strategies that increase growth rates (through fertilization and the use of genetically improved growing stock) (Man et al. 2013). Taking China as an example, some even argued that the potential for increasing carbon storage in tree biomass would be greater through forest management than through large scale afforestation/reforestation projects (Gao et al. 2011). Factors and processes controlling soil carbon sequestration are much more complex. Soil carbon sequestration would be affected by changes in soil-climatic conditions, alterations in forest species composition, and changes in the amount and quality of liter returning to the soil surface, factors that are affected by forest management practices.

Many reported lack of response or negative responses of carbon sequestration to forest management. For example, a recent publication that evaluated long-term (200 years) forest management effects on soil carbon stocks in Germany showed that past and present forest management had no effect on present soil organic carbon (Waldchen et al. 2013). Some forest management practices can negatively affect soil organic carbon storage. For example, inorganic fertilizer application, tillage and understory removal reduced soil organic carbon storage in bamboo forests in subtropical China (Li et al. 2013).

Disturbance regimes such as forest fires cause some of the biggest uncertainties in forest carbon management as such disturbances can wipe out the positive effects of long-term forest management on carbon sequestration. Consideration for carbon sequestration and managing for forest fire and a range of ecosystem services such as maintenance of biodiversity (Burton et al. 2013) should be properly balanced. Non-traditional forest management practices such as integration of agroforestry systems in the agricultural landscape may offer both increased carbon sequestration and enhanced ecosystem services. Therefore, there is a clear role for forest management to play in increasing carbon sequestration and ecosystem services; however, to improve our understanding of the interactions among forest management, climate change, soil processes and forest productivity (and thus carbon sequestration) will be some of the challenges future research will have to address (Vayreda et al. 2013).

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Keywords：*Forest management, productivity, carbon sequestration, biomass, soil organic carbon*

O41-2

[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Forest Restoration Potential using Ecological Site Descriptions

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The USDA-NRCS Soil Survey Geographic (SSURGO) database has provided baseline data for land use planning since the early 20th century in the United States. In forest and range lands, SSURGO soil components are linked to Ecological Site Descriptions (ESD) to help incorporate soil, climate, floral, faunal, and human interactions into land management decision schema. Implementation of ESD is well established in the rangelands of the western US, but is currently being developed for the forested regions of the eastern US. In this study, we examine the utility of ESD state and transition model framework to determine how to estimate historical forest composition and carbon stocks, as well as predict future scenarios. We examine how different ESD-driven management strategies could provide optimal carbon sequestration, habitat restoration, and profitable forest harvest extraction. ESD were developed from field data for parts of Pocahontas and Randolph Counties, WV, USA, to examine ecological sites along a regional conifer-hardwood ecotone that runs along the frigid-mesic transition in the Appalachian Mountains. This region was extensively disturbed by clear-cut harvest and related fires from the 1880's-1930's, producing what is now a complicated mosaic of forest successional states. ESD development has provided new context into the decline in distribution of red spruce – eastern hemlock (Picea rubens - Tsuga canadensis) forest communities using podzol soil properties as historical tracers. Results show potential in constructing restoration and management plans from ESD frameworks that could sequester carbon and restore valuable habitat while still producing economically viable timber from these areas. These areas are of particular note for high biodiversity and the presence of threatened and endangered species such as the Cheat Mountain salamander (Plethodon nettingi) and Virginia northern flying squirrel (Glaucomys sabrinus fuscus).

Keywords：*Ecological Site Description, Carbon Sequestration, Forest Management*

O41-3

[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Carbon Stock Measurement to Evaluate Ecosystem Service from Carbon Sequestration

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The aim of this study is to establish parameters to evaluate ecosystem service from carbon sequestration of the actions supported by the Sustainable Rural Development Program in watersheds of the state of Rio de Janeiro, southeastern Brazil – Rio-Rural. The Rio-Rural program supports sustainable agriculture practices and the conservation of natural resources, such as rotational grazing systems, the protection of springs and streams, agroforestry and restoration of degraded areas. To do so, carbon stocks were determined under degraded Brachiaria spp pasture, as well as in a semideciduous broadleaf Atlantic Forest fragment. We measured carbon stock in the soil, aboveground biomass and liter components. The study area is located in the municipality of São José de Ubá, northwest of the state, which has a hot and humid tropical climate and clearly defined seasons (Aw in the Köpen classification). Three 50-meter long, 1.0-meter wide transects, situated at upper, middle and footslope were demarcated. Three 1.0-meter-deep trenches were made to collect samples at depths of 0-10, 10-20, 20-30, 30-50, 50-100 cm in order to quantify C-stock in soils. One 25 cm2 sampling square was used to collect liter in the forest and aboveground biomass (BAS) in pasture. We also measured the diameter at breast height and the height of all living and dead trees with diameter ≥10 cm. In the lab we measured the dry biomass, the carbon content of grassland and liter dry biomass, wood density, and soil carbon content and density. The forest area showed some 125 MgC ha-1, of which 71 MgC ha-1 in soil and 53 MgC ha-1 in BAS. In pasture area, carbon stock was 84 MgC ha-1, mostly soil carbon stock. The data analysis also showed that soil carbon stock under pastures are significantly higher compared to that of the forest, although total carbon stock is higher in the forest area due to the contribution of aboveground biomass carbon stock. Taking into account that grassland is the most typical land use in the study region, any intervention aimed to increase carbon stock should target pasture areas. For now, our study indicates that Rio-Rural actions have the potential to improve carbon sequestration. The study's next step will be to measure C stocks in improved management pasture, agroforestry, and restoration and regeneration of forest areas. It can encourage decision makers to join in a Payment for Ecosystem Services (PES) program.

Keywords：*Land use change, Carbon stock, PES*

O41-4

[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Soil Approaches for Intelligence and Evidence in Forensic Case Work

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Soils, rocks, regolith, minerals and man-made materials, such as bricks, glass and tiles (referred to 'human-made' or 'anthropogenic' soil materials), in addition to vegetation sources, are being used in forensic investigations to test for association/disassociation of a sample taken from an item, such as shoes, clothing, shovel or vehicle, with both unknown and specific locations. The majority of forensic cases involving soil materials are usually overwhelmingly complex, and the challenges of comparing relevant information from one source with another, may benefit from the use and development of a range of sophisticated field, laboratory and court methods/materials.

For many forensic applications, such as comparing samples of soil from clothing, footwear, tools, implements or vehicles to potential crime scenes, methods of analysis need to accommodate sample sizes of a few milligrams or less. This presentation will demonstrate how, in addition to the use of inorganic analyses, a range of biomarkers have been successfully used, as evidence in civil and criminal cases work. A range of compounds examined include naturally occurring long-chain fatty alcohols, aldehydes and ketones, sterols, and triterpenoids and anthropogenic substances such as PAHs, and oil-derived compounds (plasticisers, fuels). In addition, the use of some compounds (sterols, VOC's) in detection of past burials will be discussed. This presentation will also outline advances being made in the fields of molecular biology as applied to forensic soil science. Rigorous testing, miniaturization and adoption of a wider combination of analytical soil characterization approaches, coupled with complementary geographic referencing will potentially further increase the strength and range of cases where soil can be used in both search (investigation) and as evidence (evaluation) in court.

To demonstrate the importance of soil materials in forensic investigations, case studies involving complex ground searches for burials, will be presented. GIS, vegetation, and spatial sampling issues will be discussed. This presentation will demonstrate how advanced field and laboratory approaches have been applied to coherent, predictive soil models, from landscape to microscopic scales.

Keywords：*soil forensics, environmental, security, provenance, search, evidence,*

O41-5

[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Soil Surface Assessment under Plantation Forest in South Sumatra using Landscape Function Analysis Procedure

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Land use change from secondary forest into plantation forest industry often creates environmental dilemma. Soil quality mostly declines in the early forest clearance and utilization. However, after several cycles of planting-harvesting, people believe soil conditions would improve substantially. This study particularly evaluates soil surface changes following the practice of plantation forest with special reference to procedure of Landscape Function Analysis (LFA). Soil survey and field observations were undertaken in the plantation forest of PT Musi Hutan Persada in Suban Jeriji district (Muara Enim Regency, South Sumatra) in August 2008, which focused on the stands aged 1 to 4 years old. The main plant species is Acacia mangium. Fertilization is given one month after planting as much as 10 g of urea, 10 g TSP and 10 g KCl. The 1 year old plant height has reached nearly 5 m with a diameter of about 6.2 cm which increased to 11 m at the age of 2 years. Organic carbon increased rapidly with age (4:37 to 5:37 % at 0-2 cm depth). Biomass build-up occurs in every plant-harvest cycle. Plants are already entering the third cycle (more than 12 years of cultivation land). Total biomass production at the age of 14 months can reach 17.67 ton/ ha and increased markedly to 46.13 tons / ha at the age of 24 months. Contribution of nutrients from litter decomposition can reach 146 kg N/ ha, 7 kg P/ha and 95 kg K/ha at age 1 year stands although the rate of decomposition of biomass of Acacia mangium usually slow. Marked difference in the condition and abundance of litter is reflected in the diversity index of LFA at four selected sites. At the age of 2 years general conditions of ecological stability of the land surface has been similar to the value at the age of 3-4 years (stability index around 73%). The difference in the infiltration index may be partly due to local variation (depression, plant and bark residues) with the index values ranging from 31 to 57%. Nutrient cycling index increased consistently with increasing plant age (24 to 51%), along with increasing rate of soil respiration. These overall findings reveal the beneficial practice of plantation forest to improve soil functionality.

Keywords：*plantation forest, landscape function analysis, tropical soils, plant-harvest cycle*

O42-1

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Carbon Stabilization Mechanisms in Volcanic Ash Soils in the Ecuadorian Andes

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Volcanic ash soils contain very large stocks of soil organic matter (SOM) per unit area. Consequently, they constitute significant potential sources or sinks of the greenhouse gas CO2. Deforestation is an important form of land-use change affecting volcanic ash soils in the montane tropics that may alter the fate of their large organic matter stocks. However, the rate of carbon accumulation and/or release upon land-use change strongly depends on the soil organic matter (SOM) stabilisation mechanisms at work. To clarify the role of chemical and physical stabilisation mechanisms in volcanic ash soils in the montane tropics, we investigated carbon stocks and stabilization mechanisms in the top- and subsoil along an altitudinal transect in the Ecuadorian Andes. The transect encompassed a sequence of paleosols under forest and grassland (páramo), including a site where vegetation cover changed in the last century. We applied selective extraction techniques, performed X-ray diffraction analyses of the clay fraction and estimated pore size distributions at various depths in the top- and subsoil along the transect. In addition, from several soils the molecular composition of SOM was further characterized with depth in the current soil as well as the entire first and the top of the second paleosol using GC/MS analyses of extractable lipids and Pyrolysis-GC/MS analyses of bulk organic matter.

Our results show that organic carbon stocks in the mineral soil under forest a páramo vegetation were roughly twice as large as global averages for volcanic ash soils, regardless of whether the first 30cm, 100cm or 200cm were considered. We found the carbon stabilization mechanisms involved to be: i) direct stabilization of SOM in organo-metallic (Al-OM) complexes; ii) indirect protection of SOM through low soil pH and toxic levels of Al; and iii) physical protection of SOM due to a very high microporosity of the soil (Tonneijck et al., 2010; Jansen et al. 2011). When examining the organic carbon at a molecular level, interestingly we found extensive degradation of lignin in the topsoil while extractable lipids were preferentially preserved in the subsoil (Nierop and Jansen, 2009). Both vegetation types contributed to soil acidification, thus increasing SOM accumulation and inducing positive feedbacks. While carbon stocks in the mineral soil were roughly equivalent under forest and páramo vegetation, a significant amount of additional carbon were stored in exceptionally large ecto-organic layers of up to a meter thick under forest vegetation that are absent under páramo. This indicates that common land-use change in the form of deforestation results in substantial carbon loss to the atmosphere. Our results stress the urgent need to protect the Tropical Andes 'hotspot' from destructive land-use change, not only for the sake of preserving its outstanding biodiversity but also for its function as a carbon sink.

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Keywords：*Carbon stabilization, volcanic soil, Ecuador, Andes*

O42-2

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Nature of Aggregate Hierarchy and Organo-mineral Associations in an Allophanic Andisol

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Soils derived from volcanic ashes are characterized by a high capacity of stabilizing soil organic matter (SOM), stable aggregate structure, and abundance of short-range-order (SRO) minerals especially allophane and imogolite. These are metastable aluminosilicate clays of hollow spherule/tube structures with the diameter of <5 nm and with the extensive, variable-charged surfaces. These SRO minerals can strongly aggregate with one another and with organic matter. How these SRO minerals and other inorganic phases are functionally linked to the physical and biological stability of SOM remains poorly understood, however. We thus examined the particle-size distribution and physicochemical nature of the organo-mineral particles after different levels of dispersion treatments, using a surface (Ap) horizon of typical allophanic Andisol in Japan. Specifically, we compared several dispersion techniques (mechanical shaking and sonication with and without NaCl saturation pretreatment) to achieve maximum dispersion. We then characterized each size fraction recovered by selective dissolution (pyrophosphate, oxalate, and dithionite), specific surface area (SSA) before and after OM removal (N2-BET) and isotopic contents (15N, 13C, 14C).

The pretreatment with sodium saturation was necessary to disperse most of the aggregates in studied soil. The maximum dispersion level, judged from the clay and fine clay contents by standard texture analysis (after OM removal), was achieved by the combination of NaCl saturation and the sonication energy level 5-10 folds higher than normally used for non-volcanic soils (5 kJ mL-1). With the increase in dispersion energy from shaking in water to shaking after NaCl, and finally to sonication after NaCl, absolute masses of C, N, and extractable metals in <0.2 and 0.2-2 μm fractions increased by 2.1 and 5.2 folds while those of 2-53 and >53μm decreased in similar extents. We found step-wise breakdown of macro- and micro-aggregates with concurrent liberation of micron- to submicron-size particles upon the increased levels of dispersion, indicating the presence of aggregate hierarchy in Andisol.

After the maximum dispersion, we found progressive decrease in C:N ratio, increase in 15N and 13C, oxalate-extractable metal concentrations and SSA (both before and after OM removal) with decreasing particle size. The proportion of mineral SSA covered by OM gradually increased towards smaller size fraction (14-63%). 14C mesurement showed that <0.2 μm fraction had more modern C than 2-53 μm. Significant OM-metal correlations (especially pyrophosphate-extr Al, Fe vs. OC, N, r2=0.99) were found across the size fractions regardless of dispersion treatment, suggesting high stability of organo-metallic complexes. However, the amounts of N co-dissolved by oxalate and pyrophosphate extractions (following Wagai et al., 2011) accounted for only up to 41% of total N in these fractions. These results implied that more than half of the OM present in each fraction was not directly sorbed onto the extractable inorganic phases.

These results suggest that the <2 um (esp. <0.2 um) fractions were characterized by the association of short-range-order minerals, Al and Fe ions with the OM dominated by microbially-processed OM but may include relatively young OM. These organo-mineral particles likely acted as persistent binding agents that were loosen only after the hydration with sodium ion in combination with high sonication energy. The strong aggregation in micro and submicron scales found here appeared to be unique to Andisol and may be linked to the high SOM stabilization capacity of this soil type.

Keywords：*organo-mineral association, microaggregate, soil organic matter, physical stability*

O42-3

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Property Changes of Andisols in Response to Long-term Changes of Land Use and Management in Indonesia

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Changes in properties of Andisols resulting from long-term (over 100 years) changes in land use and management have not been rigorously studied in tropical ecosystems. These ecosystems provide a wide range of important ecosystem services and are currently undergoing rapid change. Thus, there is a critical need to understand the long-term effects of land use and management on soil quality. The objective of this study was to determine changes in mineralogical, chemical and physical properties of Andisols resulting from long-term land-use and management practices in Indonesia. Soil samples were collected by horizon for soil profiles representing four land use/management conditions: pine forest (PF), tea plantation (TP), and horticultural crops with either intensive cultivation (IH) or bare fallow system (FH). All soils were found on a similar interfluve landform position and derived from the same basaltic andesite volcanic ash. The pine forest and tea plantation were 0.2 km apart while the horticultural crop was 3 km from the pine forest. It was assumed that all soils had similar properties prior to land-use conversion. Soil samples were characterized for a suite of physical, chemical and mineralogical characteristics.

Evaluation of primary minerals using a polarization microscope indicated labradorite (23-34%) and hornblende (22-41%) as the dominant primary minerals accompanied by augite, hypersthenes, and volcanic glass in smaller amounts. Selective dissolution analysis with acid oxalate indicated a dominance of the clay-size fraction by short-range-ordered aluminosilicates, such as allophane and imogolite. Following oxalate treatment of the clay fraction, x-ray diffraction analyses indicated that hydroxy-Al interlayered vermiculite (HIV) and kaolinite were dominant crystalline clay mineral followed by gibbsite for soils horticultural crops, while kaolinite was dominant followed by HIV, gibbsite and halloysite for soils under pine forest and tea plantation. Halloysite was only detected in the lowest horizons under horticultural crops.

Land-use changes resulted in a decrease in organic carbon concentration relative to the natural forest and followed PF>TP>FH>IH for topsoils and TP>FH>IH>PF for subsoils. On the other hand N concentrations were greatest for the intensive horticultural treatment and followed IH>PF~FH>TP for topsoil and IH~FH>TP>PF for subsoils. Laboratory carbon mineralization rates followed PF>TP>IH>FH due to a decrease in easily decomposable organic C in the agricultural soils. Dissolved organic C (DOC) extracted by 0.5 M K2SO4 followed PF>TP>FH>IH for topsoil horizons and TP>PF>FH>IH for subsoil horizons with topsoil horizons always higher than subsoil horizons for each land-use type. P retention by reactive amorphous materials was comparable for PF and TP land uses with values of ~97% throughout the profile. In contrast, P retention was significantly decreased to 81-95% under intensive horticultural crops (IH). This resulted in an increase in P availability from <0.5 to 7.7 mg kg-1 for the IH treatment. The dominant form of dissolved inorganic N in 0.5 M K2SO4 extracts was NH4-N for all land uses, except for the IH treatment where NO3-N was dominant and accumulated in the subsoil. The high NO3-N accumulation was related to anion exchange sites associated with amorphous materials that retain NO3 inputs derived from application of mineralisable N from horse manure and/or urea fertilizer. Exchangeable cations in all soils followed the order Ca>Mg>K>Na and the concentrations were sharply increased under IH and FH compared to TP and PF. Similar trends among land-use were found for micronutrient availability (DTPA-extractable Zn, Mn and Cu). Soil water retention capacity (available water/field capacity) followed TP>FH~TP>PF while total soil porosity followed PF>TP~FH>IH. This suggests a decrease in soil macropores under tea plantation and agricultural crops.

Results of this study indicate that changes in land use and management of Andisols from pine forest to tea plantation and horticultural crops resulted in appreciable modification to Andisol properties by decreasing amorphous material reactivity for P retention, S availability and soil porosity, while increasing exchangeable cations, NO3, P availability, micronutrients (Zn, Mn and Cu), and water retention. The high accumulation of N in these Andisols resulted in greater N storage for crops and attenuates N loss from fertilizer additions that have the potential to cause water pollution. The Andisols examined in this study display a high resiliency for soil quality and remain highly productive 100 years after land-use conversion to agriculture.

Keywords：*Volcanic soil, mineralogy, land use, nutrient availability, organic carbon*

O42-4

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

P Dynamics in Volcanic Soils - Sorption Reactions and Fertilizer Management

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Volcanic soils are typically rich in active Al and Fe (Arnalds et al., 2007; Darlgren et al., 2004; Shoji et al., 1993), and they are classified as Andosols or Andisols. Major active Al materials are allophane, imogolite and Al-humus complex, and the major active Fe is ferrihydrite. Because these active Al and Fe sorb a lot of P, high P input management is common in order to obtain high crop yield, although volcanic soils are not very low in total P content intrinsically.

Significant amount of P is contained in fresh tephra and the major P bearing mineral is apatite. During the process of andosolization, apatite is gradually dissolved, and the dissolved P is sorbed by active Al and Fe. In the matured Andosols, the amount of the active Al and Fe materials is much more than that of P which they originally have. Thus, capacity to sorb P by the matured Andosols is large and P deficiency is caused for agricultural plants.

P sorption reactions include formation of covalent bonds between P and active Al and Fe because a pattern of infra-red (IR) absorption bands due to P-O stretching vibration significantly changes between dissolved P in water and sorbed P by active Al and Fe. Other reactions associated with P sorption reaction are a decrease in positive charges and an increase in negative charges of adsorbate, etc.

Sorbed P by active Al shows a broad absorption band in the 1000 – 1200 cm-1 region. This pattern suggests P-O bonds are mostly associated with Al resembling those of non-crystalline Al phosphate. This IR absorption pattern does not change with heating at 373 K. The P sorption reaction is somewhat slow under relative humidity of 30-100 % while it proceeds fast with the addition of water.

Sorbed P by iron hydroxide gel, a model substance of active Fe, shows split absorption bands in the 1000-1200 cm-1 region. This result suggests that sorbed P is a surface complex. With the addition of reducing reagents, the half-width of the absorption bands decrease. After separation of the adsorbate from the reaction mixture followed by H2O2 treatment, the absorption bands changes to a broad band at 1060 cm-1 which is close to that for non-crystalline Fe phosphate. This observation suggests that the product formed after the reduction treatment is a material similar to vivianite. Vivianite was found to form in the plow layer soil of paddy fields under reducing conditions while it dissolves when the plow layer is oxidized after drainage (Nanzyo et al., 2013). However, vivianite is hardly found in the paddy field of Andosols.

In order to obtain high crop yield, high input of P fertilizers is needed especially in the temperate and cold regions. As a result, large amount of sorbed P is accumulated in the agricultural Andosols due to low P recovery rate by crops. However, with accumulation of sorbed P, P availability for plants is gradually enhanced. The cultivated Andosols in which P is highly accumulated is important agricultural resource because Andosols have good physical properties for production of upland crops. In the P-deficient soil environment of Andosols, Brassica plants and buckwheat show interesting root plasticity for P fertilizer particles. These plant roots cover P fertilizer particles almost completely in about 3 weeks, and the P recovery rate is around 40 % which is roughly two times higher than the ordinary rate (Nanzyo et al., 2004).

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Keywords：*phosphate, andosol, andisol*

O42-5

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Soil Genesis and Mineralogy across a Volcanic Lithosequence in Northern California

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Lithology is a master variable of soil formation; interacting with climate, organisms, landscape position and time to define soil physiochemical properties and clay mineral neogenesis. A volcanic lithosequence of varying silica composition, existing in the same late-Holocene climatic conditions, was used to investigate the effects of lithology on soil physiochemical properties and the neogenesis of silicate minerals. The Clear Lake Volcanic Field is an active volcanic center in the northern California Coast Range where regional deformation associated with the San Andreas Fault system activates mafic to silicic eruptions associated with slab window melting. This late-Pleistocene lithosequence, set in a mesic/xeric climate, provides a unique environment for studying mineralogical transformations and pedogenesis across a range of silica compositions experiencing a similar weathering environment. Pedons formed in different lithologies, consisting of rhyolitic obsidian, dacite, andesite, basaltic andesite and basalt, were investigated. Soil samples were collected by genetic horizon, size fractionated, and the clay fraction analyzed via x-ray diffraction. Selective dissolution in acid ammonium-oxalate and citrate-dithionite was used to characterize Fe, Al and Si in pedogenic pools. CEC and exchangeable cation saturation were measured in 1M ammonium acetate, pH was measured in 1:1 in H2O, 1:2 0.01M CaCl2 and 1:1 in 1M KCl, and phosphate retention was determined via the method of Blakemore et al (1981).

X-ray diffraction data showed similar trends in clay mineralogy across the lithosequence, with clay fractions dominated by kaolin minerals (kaolinite and halloysite), with lesser amounts of hydroxy-aluminum interlayered vermiculite and gibbsite. The upper portion of the profiles were predominantly kaolinite (0.7 nm), and clay mineralogy tended to shift from kaolinite to halloysite (1.0 nm), with an increase in the degree of kaolin hydration, with increasing depth. Thus, lithologies of divergent silica compositions converged on clay mineral assemblages dominated by kaolin minerals. However, soils diverged in iron oxide content and phosphate retention. Citrate-dithionite extractable Fe (Fe_d) diverged sharply between lithologies, demonstrating the influence of the initial composition of the parent material on Fe-oxide content. Soils formed from the most mafic end-member, e.g. basalt, had the greatest amount of Fe_d, while soils formed in the most siliceous lithologies, e.g. rhyolitic obsidian, had the least amount of Fe_d. Phosphorus retention also diverged between lithologies; soils with higher amounts of Fe_d retained greater amounts of phosphate. Fe_d and phosphorus retention showed a strong correlation ($P<0.001$), demonstrating that, through the influence of parent material on iron oxide content, soil properties related to management were influenced by parent material. Conversely, CEC was well constrained between soils in the lithosequence, demonstrating the convergence of soil properties most strongly influenced by clay mineralogy, and the unifying influence of climate on silicate clay mineral formation and related soil properties. Despite the divergent initial silica composition of the lithosequence, a common weathering environment results in the formation of a similar silicate clay mineral assemblage, demonstrating the dominance of climatic control on the neogenesis of silicate minerals in the xeric climate of California. Conversely, as silicate clay minerals are formed, Fe is conserved, resulting in soils with a suite of Fe-oxides strongly showing the imprint of the initial parent material composition. Thus, in volcanic soils formed in the mesic/xeric climate of northern California, climate exerts ultimate control on silicate mineral neogenesis and related soil physiochemical properties, while parent material strongly influences pedogenic iron oxide content and related soil physiochemical properties.

Keywords：*volcanic soils, halloysite, soil genesis, weathering, phosphorus retention, Fe-oxide, lithosequence*

O43-1

[IDS5A] Biochar Soil Amendment for Environmental and Agronomic Benefits

Usda-ars Biochar Research: Targeted Biochar Utilization for Soil Remediation, Climate Change, and Bioenergy Production

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Biochar is a byproduct from the bioenergy processing of agricultural crop residues, manures, green wastes and industrial wood by-products. Pyrolyzing these feedstocks causes biochars to be concentrated with inorganic and organic compounds. It is through the assemblage of a myriad of organic structures and inorganic elements that imparts biochars with special multi-functional roles. Biochars are being used as a soil amendment to sequester soil carbon, improve soil nutrient levels, mitigate anthropogenic greenhouse gasses, and as a sorbent for organic and inorganic pollutants. To capitalize on its functions, biochar is under intensive evaluation by many USDA-ARS scientists and cooperators. The agencies goals are to understand, predict and manage biochars various roles in the agricultural, environmental, and energy sectors.

Biochars ability to interact with pollutants, stabilize carbonaceous mixtures, and function as a soil amendment is dependent on feedstock selection, pyrolysis conditions, activation, and associate volatile components. Recent ARS laboratory experiments have shown that biochars can be engineered to have chemical and physical properties tailored to improve particular soil limitations. Furthermore, ARS scientists have utilized biochars to sorb environmental pollutants, reduce nutrient levels in animal waste streams, and as a composite mix for tires and rubber products. This presentation will provide highlights of the USDA-ARS biochar research efforts and will discuss results for the varied utilization of biochar

Keywords：*Biochar, climate change, bioenergy production, soils*

O43-2

[IDS5A] Biochar Soil Amendment for Environmental and Agronomic Benefits

Differential Effect of Biochar on the Reduction-induced Mobility and Bioavailability of Arsenate and Chromate

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In this work, the effects of biochar on the reduction, and subsequent mobility and bioavailability were compared between arsenate [As(V)] and chromate [Cr(VI)] using both spiked and field contaminated soils. The effects of biochar-induced reduction on the mobility and bioavailability of As(V) and Cr(VI) were examined using leaching, earthworm, and soil microbial activity tests. The reduction of As(V) and Cr(VI) by biochar was also monitored using FTIR and XPS techniques.

The rate of reduction of As(V) was much less than that of Cr(VI) both in the presence and absence of biochar addition. Biochar addition increased the rate of reduction of both As(V) and Cr(VI) and the effect was more pronounced in the case of As(V). The FTIR and XPS data provided evidence for the contribution of various functional groups of biochar to the reduction of these metal(loid)s. The leaching experiment indicated that Cr(VI) was more mobile than As(V), and biochar-induced reduction decreased the mobility of Cr but increased that of As.

The microbial activity was less in the As(V) and Cr(VI) spiked, and field contaminated soils than the uncontaminated control soil. The addition of biochar increased the microbial activity in Cr(VI) contaminated soils, but decreased that in As(V) contaminated soils. In contrast, biochar addition decreased Cr concentration in earthworm tissue in Cr(VI) contaminated soils, but increased As concentration in earthworm tissue in As(V) contaminated soils. The results suggest that while the biochar-induced reduction increased both the mobility and bioavailability of As it caused an opposite effect in the case of Cr.

O43-3

[IDS5A] Biochar Soil Amendment for Environmental and Agronomic Benefits

Understanding Biochar Role in Soil Quality and Functioning: Where to Go?

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Use of biochar for soil amendment had been recommended primarily for enhancing soil C storage and mitigating of nitrous oxide gas emissions from agricultural soils. Available data of pot and field studies suggested varying biochar effects on soil quality and crop productivity with feedstocks, pyrolysis temperature as well as soil conditions of nutrient, texture as soil pH. However, the changes in these effects with soil amendment of a single type of biochar across wide conditions of soils had not yet assessed. Field studies had been conducted at the authors institute for consecutive years with wheat straw biochar across wide conditions of croplands from China. Results suggested a great effect on decreasing N_2O emission as well as stabilizing CO_2 emission with a smaller effect on crop productivity. Yield increase with biochar soil amendment was smaller in rice paddies compared to in dry croplands though soil quality improvement was observed with similar extent between the two types. Whereas, reduction in N_2O emission was consistent with biochar rates and soil types in rice paddies though much variable across biochar rates and soil types of dry croplands. While a liming effect was consistently observed across soils, changes in soil pH were shown inconsistent with biochar rates and years after amendment. Moreover, less remarkable yield increase observed in subsequent years after amendment despite of a sustainable effect on soil C and N_2O emissions across sites. Biochar amendment caused metal immobilization, which could be explained with a pH rise in the first year but the effect on metal extractability varied with years. All these observations suggest inconsistent changes with biochar between soil and crop productivity, between carbon storage and N_2O emission as well as between years after application. Nevertheless, the changes in soil biophysical and biogeochemical processes with biochar had been poorly understood with the complex interactions with soil components under site conditions. Therefore, biochar reactivity should be addressed in a more robust way with specific biochar and soil conditions for addressing its ecosystem functioning in long term. In particular nano-scale characterization of biochar reaction with soil particles and changes in soil microbial community and structure are urgently deserved.

Keywords：*biochar, field study, biochar reactivity, soil quality, crop productivity, ecosystem functioning, cr*

O43-4

[IDS5A] Biochar Soil Amendment for Environmental and Agronomic Benefits

Influence of Dissolved Organic and Inorganic Compounds on the Function of Biochar in Amended Soils

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Considering the longevity of biochar in agroecosystems, biochar application must be carefully evaluated and engineered to achieve agricultural (e.g., minimum impact on efficacy of agrochemicals) and environmental (minimum runoff contamination) benefits. Heavy metals and agrochemicals are the key targets for biochar-induced mitigation of runoff/groundwater contamination. Inorganic and organic contaminants interact differently with biochars as well as soil components. For heavy metals, stabilization (capping/solidification) and dilution (e.g., washing, chelate-assisted phytoremediation) represent non-removal and removal remediation options. Depending on the pyrolysis temperature, biochar can contain soluble and insoluble carboxyl and other ligands; these properties can be attenuated for stabilization and dilution technologies. This presentation will first explore the chemical structures of biochar-borne dissolved organic carbon (DOC) and phosphorus species. Parallel factor (PARAFAC) modeling of fluorescence excitation-emission (EEM) was conducted for almond shell, broiler litter, lignin, cottonseed hull, and pecan shell biochars pyrolyzed at 350-800 °C. Five components were assigned to: (C1) (poly)phenolic pyrolysis products and other water-soluble aromatic structures similar to fulvic-like SOC; (C2-C3) aromatic structures similar to humic-like SOC having low water solubility that decomposed above 350 °C; (C4) carboxyl and other transient thermochemical conversion intermediates that decomposed above 500 °C; and (C5) thermally stable DOC fraction of lignin-rich biomass (pecan shell and lignin). Relative contribution of fulvic-like component exceeded that of humic-like components, and increased as a function of pyrolysis temperature. The C4 showed disproportionately high contributions to 500 °C broiler litter and cottonseed hull biochars. The carboxyl-enriched DOC of biochars pyrolyzed at 350-500 °C can have diverse environmental consequences, including the mobilization of heavy metals. In addition to DOC, pyrolysis of plant and animal wastes produces a complex mixture of phosphorus species in amorphous, semi-crystalline, and crystalline inorganic phases, organic (char) components, and within organo-mineral complexes. Solution phase 31P NMR analysis of plant (cottonseed hull) and manure (broiler litter) wastes pyrolyzed at 350, 500, 650, and 800 °C showed the conversion of phytate to inorganic P by pyrolysis of manure and plant wastes at 350 °C. Inorganic orthophosphate (PO_4^{3-}) became the sole species of ≥500 °C manure biochars, whereas pyrophosphate ($P_2O_7^{4-}$) persisted in plant biochars up to 650 °C. These observations suggested the predominance of (i) amorphous (rather than crystalline) calcium phosphate in manure biochars especially at ≥650 °C, and (ii) strongly complexed pyrophosphate in plant biochars (especially at 350-500 °C). Correlation (Pearson's) was observed between (i) electric conductivity and ash content of biochars with the amount of inorganic P species, and (ii) total organic carbon and volatile matter contents with the organic P species. Subsequent discussion will focus on the influence of these dissolved components on the stability of heavy metals (Pb, Cu, Ni, Cd) in biochar-amended contaminated and agricultural soils.

O43-5

[IDS5A] Biochar Soil Amendment for Environmental and Agronomic Benefits

Pyrolytic Temperature Affects Sulfamethoxazole Adsorption by Plant-derived Biochars

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Occurrence of antibiotics, a class of emerging contaminants, in water and soil has been causing global concerns due to their potential risks to the public health and environment. The lack of information on the fate of antibiotics in water and soil is one of the main reasons for the difficulty of assessing and reducing their potential risks. Biochar, a carbon-rich product produced from biomass through pyrolysis, can control the fate of many contaminants in soils via adsorption. Application of biochars into soils for soil improvement and carbon sequestration has generated great interest for scientists and policy makers. With increasing amount of biochar added into soils, predicting the magnitude of sulfonamides sorption onto the biochars and identifying the controlling sorption domains become important and urgent for assessing the environmental exposure and risk associated with sulfonamides. However, sorption mechanisms of sulfonamides on biochars are poorly understood. Therefore, sulfamethoxazole (SMX) sorption on biochars produced at 300-600 °C was determined as a function of pH and SMX concentration, as well as the inorganic fractions in the biochars.

The observed effects of pH on sorption correlated well with the pH-regulated distribution of the neutral SMX molecules (SMX^0). SMX^0 was the main species to adsorb at pH 1.0-6.0. The sorption around pH 1.0 may be dominated by the specific driving force, π^+-π electron donor-acceptor (EDA) because of the strong electrostatic repulsion between the dominant cationic SMX (SMX^+) and positive surface of biochar. Above pH 7.0, although biochars surfaces were negatively charged, anionic SMX (SMX^-) species sorption increased with pH and is regulated via charge-assisted H-bonds. SMX sorption was accompanied with the changes of pH, which may lead to different contribution of SMX species to the overall sorption. In general, the apparent sorption coefficient order was $K_d^0 > K_d^+ > K_d^-$.

SMX^0 sorption at pH 5.0 was nonlinear and adsorption-dominant for all the biochars via hydrophobic interaction, π-π EDA interaction and pore-filling. However, the respective contribution of partitioning and adsorption to the overall SMX sorption on the biochars is different from those of hydrophobic organic compounds (HOCs) by biochars, which generally are evolved from partitioning-dominant for low temperature biochars to adsorption-dominant for higher temperature ones. Compared with untreated biomass, the sorption coefficient K_d values of SMX significantly increased after charring. The K_d values increased with pyrolytic temperature at low SMX concentration (C_e = 0.5 mg L^{-1}, r = 0.995, P < 0.01), whereas decreased at high SMX concentration (C_e = 50 mg L^{-1}, r = -0.958, P < 0.05). The observed K_d values (686-1356 L kg^{-1} at C_e = 0.5 mg L^{-1}) were much larger than the reported literature values on soils, minerals, sediments and plant/sediment-derived biochars (e.g., bamboo, wood and sugarcane bagasse), but lower than those of the biochars from wheat straw burned in the air, and functionalized carbon nanotubes.

The contribution of inorganic fractions to SMX sorption on biochars was assessed using de-ashed biochars at pH 5.0. The results indicated that the inorganic fractions in the biochars had different contribution to the overall sorption, enhancing the sorption in the low-temperature biochars (e.g., 300 °C), but reducing the sorption in the high-temperature biochars (e.g., 600 °C). This is probably because the inorganic fractions in the low-temperature biochars were mainly non-crystalline and distributed in the carbon matrix, but crystalline and discrete in the high-temperature biochars

These data are useful for producing designer biochars as engineered sorbents to reduce the bioavailability of antibiotics and/or predict the fate of sulfonamides in biochar-amended soils, and thus could be useful for assessing the environmental risks of antibiotics.

Keywords：*Biochar, Sulfamethoxazole, Antibiotics, Sorption*

O43-6

[IDS5A] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar in Zambia, Indonesia, Malaysia and Nepal: Biochar Technologies, Mechanistic Field Trials, and Socio-economic Aspects

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The Norwegian Geotechnical Institute (NGI) and the Norwegian University of Life Sciences (UMB) have set up four biochar field research initiatives in Zambia, Indonesia, Malaysia and Nepal. Total funding of the multidisciplinary research projects is around 5 million US$. The agronomical soil work is combined with research on biochar generation technologies and socio-economic aspects of biochar implementation, through life-cycle and cost-benefit analyses. Laboratory work is carried out on nutrient availability, plant-available water, GHG emissions and PAHs/dioxins in biochar. The main overall goal is to come to an evaluation of the overall potential of biochar in Asia and Africa.

A complete life-cycle analysis of biochar implementation in tropical countries showed that traditional earth-mound kiln technology is not to be recommended because of PM10, methane and CO emissions. Thus small-scale stoves and retort kilns have been introduced. The results of these are being integrated in life-cycle analyses and implemented via business concepts and cost-benefit analyses.

Agronomic field trials in all 4 countries have shown that biochar addition leads to up to 400% increase in yield in some places at dosages as low as 4 tons/ha, whereas it is not effective on others. The reason that the low application rate was so effective is the combination of poor, sandy soils with conservation farming, where planting is done in basins that only cover 10% of the soil surface. We find that the biochar is so effective because of a doubling of plant-available water, as well as a decrease in available Al.

A combined life-cycle and cost-benefit analysis in Indonesia showed that using biochar as fuel briquettes is a far inferior alternative to using it as a soil amendment, even if increases in crop yield are no more than 20-30%. The reason is that the C sequestration effect is beneficial in a complete life cycle perspective. From a monetary perspective, briquetting involves too much labour to be a viable option.

Keywords：*biochar, tropics, implementation, mechanisms, agronomy*

O43-7

[IDS5A] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Biochar Amendment on Greenhouse Emissions from Rice Paddy and Sugarcane Soils in the Subtropical Region of USA

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Mitigation of global greenhouse gas emissions has been identified as an urgent world task. Methane emission from rice paddies is considered as one of major agricultural and soil management contributions to the global warming gases. On the other hand, nitrous oxide emission following nitrogen fertilization accounts for as much as 90% of all global sources. Therefore, developing effective agricultural strategies to reduce these greenhouse emissions is critical and necessary. Recently, biochar as a soil amendment has been shown to potentially increase carbon sequestration while reducing emissions of greenhouse gases. However, little information is available about the effect of biochar application in rice paddy and sugarcane fields on the reduction of greenhouse gas emissions in the subtropical region of USA. The purpose of the present studies were to examine the influence of biochar amendments on total emissions of CO2, CH4, and N2O over the whole growing season from rice paddy and sugarcane fields. In addition, biochar effects on CO2, CH4, and N2O emission under three different type of N fertilizer, namely urea, urea ammonium nitrate (UAN), and coated urea were investigated through laboratory incubations at field capacity in a rice paddy soil and sugarcane field soil. In laboratory incubation studies, biochar additions suppressed N2O emission under all tested N fertilizers in both rice paddy and sugarcane soils compared to unamended soil. Biochar additions also significantly suppressed CH4 emission at all types of N fertilizers. For rice fields, biochar of rice straw was applied at rates of 0 and 11.2 Mg ha-1 and N fertilizer was applied at rates of 0 and 134 kg N ha-1 as urea. Both biochar and N fertilizers were broadcast on soil surface and then incorporated to a depth of about 10 cm. The field experiment followed a randomized complete block design and consisted of four replicates. Prior to flooding experimental plots, a background greenhouse gas emission was measured until the rice seedlings were mature enough for flooding. After flooding, static gas chambers were instituted to monitor greenhouse gas emissions. On the other hand, for sugarcane experiment, two different biochars produced from sugarcane harvest trash/leave biochar and yellow pine wood biochar were evaluated respectively. Biochars were applied at rates of 0 and 8.9 Mg ha-1, and N fertilizer was applied at rates of 0 and 134 kg ha-1 as liquid UAN. The results show that total CH4 and N2O emissions were significantly affected by biochar application, N fertilization, and their interaction. Overall CH4 and N2O emissions were significantly reduced by 27 % and 43%, respectively, by biochar application to rice field. In sugarcane fields, total CH4 and N2O emission was significantly reduced by both two different types of biochar applications. The reductions of N2O and CH4 emissions with sugarcane trash/leave biochar and pine wood biochar were 18% and 26%, and 64% and 41%, respectively. There was no overall difference in CO2 emission between biochar-treated plots and control plots. These field observations were also supported by laboratory incubation studies of biochar effects on greenhouse gas productions.

Keywords：*Biochar, Greenhouse gas emission, Rice Paddy, Sugarcane fields*

O43-8

[IDS5A] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Bamboo and Rice Straw Biochars on the Bioavailability of Cd, Cu, Pb and Zn in Soils

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Soil contamination with heavy metals has become a global concern because of its adverse effects on the ecosystem health and food security. Some types of biochar can reduce the bioavailability of heavy metals in contaminated soils and reduce their risk of entering the food chain. A pot experiment was conducted to investigate the effects of biochars derived from bamboo and rice straw on bioavailability and plant growth in a soil co-contaminated with Cd, Cu, Pb and Zn. Bamboo and rice straw biochars (pyrolyzed at 500°C) with two mesh sizes were applied at three rates (0, 1% and 5%, w/w). A metal-tolerant plant, Sedum plumbizincicola X. H. Guo et S. B. Zhou sp. nov. was harvested after 3 months of growth. The results showed that the addition of biochars to soil significantly ($P < 0.05$) increased the dry weight of S. plumbizincicola. The pH of soil increased significantly ($P < 0.05$) with biochar application, and the highest soil pH was observed in the 5% fine rice straw biochar treatment. Biochar application decreased the concentration of extractable Cd, Cu, Pb and Zn, especially at the higher application rate. Both biochars significantly ($P < 0.05$) reduced the accumulation of Cd, Cu, Pb and Zn in S. plumbizincicola. Rice straw biochar reduced the concentration of Cu and Pb in the shoots by 46% and 71%, while bamboo biochar reduced concentration of Cd in the shoot by 49%. Finer biochar was more effective on reducing the concentrations of Zn in shoot than the coarse ones, while particle size had no effect on the concentrations of Cd, Cu and Pb in the shoot of S. plumbizincicola. In conclusion, the influence of biochar on heavy metal bioavailability varied not only with the feedstock and application rate of biochars, but also with different metals. Therefore, biochar should be carefully designed to maximize the reduction of the bioavailability of a given heavy metal in a soil.

Keywords：*Bioavailability; Biochar; Contaminated soil; Heavy metals.*

O43-9

[IDS5A] Biochar Soil Amendment for Environmental and Agronomic Benefits

Groundwater Pollution Potential and Greenhouse Gas Emission from Soils Amended with Different Swine Biochars

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Although there exist numerous research studies in the literature on greenhouse gas emission and groundwater pollution potentials of soils amended with plant-based biochar made from traditional dry pyrolysis (hereafter referred as pyrochar), a very few such studies exist for hydrochar made from hydrous pyrolysis or hydrothermal carbonization (HTC). HTC decomposes the organic matter in the biomass by heating anaerobically in the presence of subcritical, liquid water. HTC can convert wet feedstock biomass into carbonaceous solids at relatively high yields without the need for an energy-intensive drying before or during the process. Potential HTC feedstocks include wet animal manures, sewage sludges, and municipal solid waste streams, as well as aquaculture residues. While these feedstocks represent large, renewable residual streams that require some degree of treatment to protect environment, HTC may be used to eliminate or at least reduce the burden of the treatment while producing value-added hydrochar. The objectives of the present paper were to 1) compare physicochemical characteristics of swine manure-based hydrochar and pyrochar and 2) investigate CO2 and N2O emissions and nutrients leaching from soils amended with these biochars. Dewatered swine solids were obtained from a 5,600-head finishing swine operation in Sampson County, NC, which were further dried and stored in a refrigerator until experiments. Swine pyrochar was prepared using a skid-mounted pyrolysis system which heated the dried swine solids to 620 oC for two hours. Swine hydrochar was prepared by hydrothermally carbonizing the swine solids at 250 oC for 20 h. Some of the hydrochars were mixed with 200 mL acetone and agitated for 2 hours in order to remove labile compounds adsorbed on the hydrochar surface. Two soil pot incubation experiments were conducted approximately 4 months apart. Hydrochar or pyrochar was mixed with a 50/50 mixture of Norfolk Ap and E horizon at a rate of 20 g kg-1. Sufficient deionized H20 was added periodically so that each pot would be maintained at 10 % moisture content (w/w). Triplicate pots containing soil without biochar served as controls. During the incubation periods of 42 to 127 days, greenhouse gas (CO2 and N2O) emission fluxes were measured by nonlinearly regressing time-series headspace gas concentrations. Volatile matter (VM) of the raw swine solids (69.5%) decreased to 60.3% (hydrochar) and 14.1% (pyrochar). When the hydrochar was washed with acetone, its VM further decreased from 60.3% to 49.9%. The opposite trends were observed for fixed carbon and ash contents. When the swine solids were pyrolyzed at 620 oC, the oxygen content was decreased to negligible amounts. Mehlich 1 extraction of the initial soils amended with both pyrochar and hydrochar showed significant increase in nutrients such as K, P, Ca, Mg, Zn, and Mn. As a result, the soils amended with pyrochar leached significantly higher amounts of nutrients than control soils, suggesting potential groundwater pollution from the pyrochar-amended soils. In contrast, the hyrochar-amended soils leached very little of these nutrients probably due to high surface functionalities binding these nutrients. Throughout the incubation period, the control soils produced 0.16 g CO2 m-2d-1CO2. The hydrochar-amended soil, however, emitted 3.0 g CO2 m-2d-1, much higher than 0.32 g CO2 m-2d-1 from the pyrochar-amended soils. The control soils produced 0.31 mg N2O m-2d-1, while the pyrochar-amended soils did not produce any N2O. The hydrochar-amended soil produced 0.24 mg N2O m-2d-1. Addition of swine solid hydrochar dramatically increased soil CO2 emission; however, N2O emission was not significantly affected.

Keywords：*pyrochar, hydrochar, swine manure, greenhouse gas, groundwater pollution*

O43-10

[IDS5A] Biochar Soil Amendment for Environmental and Agronomic Benefits

Evaluation of Biochar as a Medium for Underground Reactive Barrier to Attenuate Chemicals from Agricultural Drainage

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Typical animal feeding operations (AFOs) produce large quantities of manure which are often stored in lagoons then land applied to nearby crop fields. Off-site movement of the manure as well as other fertilizers through storm water runoff or percolation to groundwater has been recognized as a source of contamination of water bodies. This is especially true in east Tennessee with high rainfall, karst landscapes and substantial topographic relief. One control technology for remediating agricultural chemicals, such as nitrogen (N), is the promotion of denitrification using denitrification beds, also called underground reactive barriers. A denitrification bed is constructed by mixing an organic carbon (C) source (typically sawdust or woodchips) with the soil below the water table in order to intercept groundwater flow. The increased and continued supply of C to denitrifiers enhances denitrification of the groundwater, thus reduced NO3- in the discharge. Due to the decade long drive of bio-energy industry, the disposal and reuse of byproducts (i.e., biochar) have been a new challenge. Biochar (and charcoal) is carbon-rich product when biomass (such as wood, manure or crop residues) is heated in a closed container with little or no available air. It can be used to improve agriculture and the environment in several ways and its stability in soil and superior sorption capacity provides a promising application as soil amendment and water treatment. We believe that 1) underground reactive barrier using combined sawdust and biochar will increase the level of NO3- removal, 2) the addition of biochar will also remove phosphorus (P) and other organic chemicals such as veterinary antibiotics and pesticides from the agricultural drainage, and 3) with an appropriate design, underground reactive barrier can also be used to treat surface runoff as well as groundwater. Our research findings will create science-based recommendations for the use of biochar in underground reactive barriers in challenging environmental conditions.

Keywords：*biochar, nitrification bed, underground reactive barrier, nitrogen remediation*

O43-11

[IDS5A] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar and DCD Effect on Nitrogen Dynamics in Soils Amended with Organic Amendments

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Organic amendments (OAs) such as manures, biosolids and plant residues are rich sources of nitrogen (N) and their use in agriculture is rapidly increasing. Nitrogen in OAs undergo a series of transformations in soils that include ammonification (conversion of organic N to inorganic N, ammonium (NH_4^+)), nitrification (conversion of NH_4^+ to nitrate (NO_3^-)), and denitrification (conversion of NO_3^- to nitrogen or nitrous oxide (N_2O) gas). Both NH_4^+ and NO_3^- are plant available forms of N; N_2O is a major greenhouse gas (GHG). Though, application of OAs is regarded as one of the most promising options to enhance plant growth and yield by improving soil physical, chemical, and biological properties, improper and excess application can lead to nutrient eutrophication (NO_3^- leaching) and GHG emission. Suppression of nitrification to retain N in the NH_4^+ form is considered as a significant approach in extending N residence time in the soil. Synthetic compounds such as nitrapyrin and dicyandiamide (DCD) are used in agriculture to enhance nitrification inhibition (NI), thereby reducing NO_3^- leaching and N_2O emission. Recently, biochar has been tested for its efficiency in reducing N_2O emission from soils. However, there is no comprehensive study in which the effects of biochar and DCD on N transformation, ammonia (NH_3) volatilization and N_2O emission in range of OAs treated soils have been examined.

The objectives of this study include: 1) to study the effect of biochar and DCD on N transformation (ammonification and nitrification) in soil amended with various N sources; and 2) to study the effect of biochar and DCD on NH_3 volatilization and N_2O emission from soil amended with various N sources.

A range of N sources including horse, sheep, cow, and chicken manures, blood and bone mix, green waste compost, biosolids, and urea were used in this study. Macadamia nut shell biochar (pH 8.66) and DCD were used as NIs. A surface soil sample (1-10cm depth; pH 7.51) from a broadacre farm was used to examine the effect of NIs on N transformation and losses. Nitrogen sources were applied at 300 mg N/kg soil; biochar at 9.6 g/kg soil; and DCD at 25 mg/kg soil.

To examine N transformations, 200 g soil treated with various N sources in the presence and absence of NI sources were incubated in zip lock bags at water holding capacity and room temperature (22 ℃) for 60 days. Sub-soil samples were collected at various intervals and analysed for soil pH and mineral N content (NH_4^+ and NO_3^-) using Skalar autoanalyzer. To examine NH_3 volatilization and N_2O emission, 100 g soil samples were incubated in gas sampling jars for 60 days under similar temperature and moisture conditions described above. Concentrated H_2SO_4 (0.2 M) was used to trap the NH_3 volatilized from the soil. The gas samples and acid trip for NH_3 volatilization were collected at various intervals. Nitrous oxide concentration in the gas samples and N concentration in the acid traps (for NH_3 volatilization) were analysed using Agilent GC fitted with 63 Ni- electron capture detector and Skalar autoanalyzer, respectively.

Our results indicate that ammonification occurred within day 7 of incubation study with NH_4^+ concentration reaching a maximum of 195 mg NH_4/kg soil accompanied by increase in pH reaching a maximum of 8.66 in urea treated soil with DCD. After day 7, nitrification commenced in all the treatments accompanied by NH_3 volatilization. However, soils treated with DCD showed lower NO_3^- concentration compared to other treatments. Dicyandiamide amended soils showed slightly higher NH_3 volatilization (average - 8.3%) than soils without DCD. In contrast, biochar application reduced cumulative NH_3 volatilization by 47% (average) compared to control soils without biochar. Nitrous oxide emission decreased by 48% in biochar amended soils compared to control soils without biochar. Similarly, DCD application reduced N_2O emission by 71% compared to control soils without DCD. The study demonstrated that while biochar was efficient in reducing NH_3 volatilization, DCD was found to be more effective in reducing N_2O emission. Biochar can be used to reduce N losses through NH_3 volatilization and N_2O emission in soils treated with OAs.

Keywords：*Biochar, Dicyandiamide (DCD), Nitrogen (N), Nitrous oxide (N_2O),, Ammonia (NH_3) volatilization*

O44-1

[IDS11] Nanotechnologies in Environmental Soil Science

Nanoporous Minerals, Nanophases and Nanocomposites in Environmental Soil Science

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Slow release fertilizers were designed and developed using nanoporous minerals in order to improve the efficiency of fertilizers. Nanoporous mineral-based slow release fertilizers are useful because they have a rigid or flexible structure and are environmentally friendly and compatible in a soil. Nanoporous zeolites, montmorillonite and layered double hydroxides were developed as slow release fertilizers. Natural zeolites were occluded with ammonium nitrate and potassium nitrate by molten salt treatment and could be used as slow release N-K fertilizer because of increased capacity to store N and K nutrients in addition to exchangeable cations. Urea was successfully stabilized in the interlayer space of montmorillonite by the formation of urea-Mg or Ca complex, $[(Urea)_6Mg \text{ or } Ca]^{2+}$ protecting its rapid degradation in a soil. Also, montmorillonite was used to form urea slow-release nanocomposite based on urea intercalation into montmorillonite by an extrusion process. Moreover, nanoporous layer double hydroxides could be designed as slow release fertilizers of nitrate or phosphate because they have positively charged layers to retain anions.

Nanophase iron metal particles and green rust are effective in remediation of chromates.Nanophasebirnessite (Mn-oxide) is effective in reducing the bioavailability of metals such as Pb, Cs etc. and is also useful to catalyze the degradation of pesticides.We synthesized nanophasemetal powders using ethylene glycol under microwave hydrothermal conditions and tested them for this purpose. Synthetic nanomicas may also be useful for decontamination of Cs from the environment.

Nanocomposites such as organoclays and organobirnessitewere found to be effective for remediation of pollutant anions and cations, respectively. The former were found to be effective for anions such as perchlorate and nitrate while the latter were found to be effective for metals such as Pb. Development of green fertilizers and remediation of contaminated soils and soil water using nanotechnologies is thus possible.

O44-2

[IDS11] Nanotechnologies in Environmental Soil Science

Release Behaviour of Fullerene Nanoparticles from Soils Amended with Sewage Sludge

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Carbon-based NPs include buckminsterfullerene (C60) and carbon nanotubes (CNTs), have received considerable attention due to their unique characteristics, and numerous potential applications in commercial and scientific industries. Consequently, there has been increasing interest in the fate of nanoparticles (NPs) in waste streams. Being highly hydrophobic both C60 and CNTs are expected to concentrate in the sewage sludge (biosolids) during the treatment of sewage effluent. However, their release behaviour from sludge materials is unknown. Application of biosolids (treated sludge) as soil amendments/fertilizers, hence, presents another important route for NPs to be remobilized and enter the environment. In this study, we studied the release of fullerenes (C60) from biosolids spiked with different forms of fullerene nanoparticles (nC60) and applied to a wide range of soils. Results showed that varying levels of C60 could be released from different biosolid-soil systems, suggesting that soil properties influence the mobilization of C60 in the terrestrial environment. The form of nC60 used, on the other hand, had negligible effect on the levels of C60 detected in released fractions. Prolonged contact (ageing) of nC60 with biosolid-soil only slightly increased the release of C60. Even after 8 weeks of aging, majority of the biosolid-soil systems only released approximately 3% of the initial nC60 spike. The application of biosolids to soil favored the retention of C60 rather than release. Although the mechanisms governing the release of C60 from these complex systems is still unclear, both pH and natural organic matter in soils seem to play an important role in controlling the binding and release behavior of fullerenes in soils.

Keywords：*nanomaterials; fullerenes; nC60; terrestrial nanoparticles; biosolids*

O44-3

[IDS11] Nanotechnologies in Environmental Soil Science

Al and Fe Nanominerals Dominate Organic Carbon Preservation in Soil

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Soils are the largest and most stable terrestrial carbon (C) pool, and are often assumed to be a major C sink for future C sequestration. Yet, the mechanisms that govern soil C sequestration and stabilization remain poorly understood. Reactive nanominerals are ubiquitous in soil and are proposed as a primary driver for organic C retention. However, direct evidence is meager. Here, with emerging cutting-edge technologies of both the near-edge X-ray absorption fine-structure (NEXAFS) and nano-scale secondary ion mass spectrometry (NanoSIMS), we show that soil Al and Fe nanominerals were significantly higher in both 22-yr and 150-yr long-term organically- than inorganically- fertilized soils. Results from NEXAFS indicated that organic matter inputs increased the concentrations of octahedral Al (VIAl), tetrahedral Al (IVAl) and more oxidized octahedral Fe(III), facilitating the formation of Al and Fe nanominerals. Also, NanoSIMS imaging and mapping visualized the preservation of organic C by both Al and Fe nanominerals under the no fertilization and organic fertilizations, but not under the inorganic fertilization that might have hampered the formation, or their organic C binding capacity, of Al and Fe nanominerals. Together, these findings demonstrate that long-term organic C inputs are able to facilitate the formation of Al and Fe nanominerals and in return promote the preservation of organic C in soil, which provide new insights into how soil nanominerals could help global C sequestration in agricultural systems.

Keywords：*Al and Fe nanominerals; Global carbon cycling; Inorganic and organic fertilization; Soil C stabiliza*

O44-4

[IDS11] Nanotechnologies in Environmental Soil Science

Nanoscale Chemical Analyses of Biochar from Ancient Amazonian Anthrosoils

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The anthropogenic Amazonian soil ‘‘Terra Preta de Indio’’ (Amazonian Dark Earth) provides a potential model for a sustainable land-use system in the humid tropics. A large amount of carbon-based materials in this soil is responsible for its high fertility and stability over long periods of usage, and soil scientists are trying to create New Dark Earth by adding charcoal (Biochar) as a soil conditioner. Therefore a deep knowledge about these structures provides the grounds for reproducing artificially such natural events.

By applying materials science tools, including scanning and transmission electron microscopy, energy dispersive X ray, electron energy loss spectroscopy, X ray photon electron spectroscopy and computer simulation we show that these millenary carbon materials exhibit a complex morphology, with carbon particles ranging in size from micro- to nanometers, from the core to the surface of the carbon grains. While most chemical methods are known to cause chemical modifications on soil organic matter, as well as to give poor or no information about the real spatial structure of soil aggregates, here we show that specific carbon-oxygen functional groups dominate over different spatial regions varying in size over 20 nm2 to hundreds of nm2 areas, demonstrating a highly inhomogeneous redox process. In addition, the presence of calcium and oxygen within carbon nanoparticles surrounded by other chemical elements such as aluminum and silicon were observed. Therefore molecular models based on graphene oxide nanostructures in which calcium cations are strongly adsorbed at the oxide sites suggests to substantially enhancing chemical stability as well as recalcitrance

From one side, our results might elucidate how nature solved the problem of keeping high levels of ion exchange capacity in these soils. From the other side, chemical elements spatial distribution, morphology and dimensionality are the key issues in nanotechnology, and the structural aspects revealed here may help generating the New Dark Earth, effectively improving world agriculture and ecosystem sustainability

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Keywords：*Biochar, Black Carbon Oxidation, Amazonian Dark Earth, Terra Preta de Indio, Electron Microscopy, X-ray Photon Electron Spectroscopy, Computer Simulation*

O44-5

[IDS11] Nanotechnologies in Environmental Soil Science

New Biofilter Media Modified with Nano-engineered Metal-organosilica Hybrid Composites: an Innovative Solution for Remediation of Stormwater Runoff and Prevention of Soil Pollution

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The negative consequences of excessive stormwater runoff generated from urban, industrial, and agricultural areas have increasingly caused concern. This excessive runoff not only degrades surface water resources by altering hydrologic patterns in natural streams and groundwater, but also contaminates both soil and surface water with increased loads of pollutants such as nutrients, sediments, heavy metals, herbicides, pharmaceuticals, and pathogenic bacteria. The presence of excessive nutrients, heavy metals, herbicides, and pharmaceuticals in soil and surface water through runoff has been of particular concern due to their persistence and toxicity. Green remediation practices using biofiltration systems including rain gardens, bioswales, vegetated buffer strips, and constructed wetlands have been one of the most promising tools for stormwater runoff capture, treatment, and reuse. General features of a biofiltration system include a soil medium (a mixture of sand, soil, and/ or compost), a mulch layer, and vegetation for infiltrating and treating stormwater runoff. In studies to date, biofiltration systems have proven to reduce runoff volumes and concentration of sediment, heavy metals, and phosphorus from urban and agricultural runoff. However, one of the key challenges when implementing these biofiltration systems is mitigating damage to the localized ecosystem due to the influx of toxic chemical contaminants from runoff. Furthermore, treatment performance of these systems for urban, industrial, and agricultural runoff is often less effective in the long-term due to the limited adsorption capacity of soil filter media and potentially increases risks of soil and water contamination. Thus, the efforts of alternative best management practice applications and development of soil filter media with improved sorption capacity of multiple runoff pollutants are crucial. New biofilter media have been developed to remediate pollutants from stormwater runoff and protect the soil ecosystem by integrating a novel sorbent nanomaterial called “Osorb®” with reactive metal composites. The Osorb-based materials with embedded reactive metals can be viewed as tiny chemical reactors to remediate runoff pollutants such as herbicides, hydrocarbons, endocrine disruptors, metals, and pharmaceuticals. The sand-like grains of Osorb capture runoff pollutants, degrade the pollutants to non-toxic forms, and then release inert compounds to the biofilter media where they are generally mineralized or biologically consumed. The overall technological approach consists of using the Osorb-based materials to buffer contaminant loads in biofiltration systems and assist in the degradation of anthropogenic compounds over a +10-year life cycle. The Osorb-based materials work in conjunction with biology by helping to maintain the health of the microorganisms in the filter media due to overexposure to chemicals. The results from three pilot scale biofiltration systems and multiple column scale experiments will be described. Data indicate significant reductions in nutrients, atrazine, 2,4-D, estradiol, and petroleum hydrocarbon levels by implementing Osorb-enhanced biofiltration systems. This study funded by the National Science Foundation demonstrated that the Osorb-enhanced bioretention system has the potential for being a cost-effective best management practice for enhancing remediation of stormwater runoff and minimizing risks of soil contamination.

Keywords： *Biofiltration systems; Green remediation; Nano-engineered metal-organosilica (Osorb) composites;, Stormwater runoff*

O44-6

[IDS11] Nanotechnologies in Environmental Soil Science

Bacterial Biofilms (Extracellular Polymeric Substances): Role in Geosorbents Mobility and Reactivity

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Colloidal nano particles (CNP) act as mobile geosorbents and causes mobility and solubility of nutrients and pollutants. In recent years, pure and organically modified Fe- and Mn-oxyhydroxides are of particular importance due to their ubiquitous presence and due to their progressive use for environmental cleanup. Stability and aggregation behavior control the mobility of CNP and depend on pH, ionic strength, and the presence of monovalent or divalent anions.

In natural systems like soils, sediments and aquifers, Biofilms and Extracellular polymeric substances (EPS) are an important component of the soil organic matter pool. A biofilm is an assemblage of microbial cells enclosed in a matrix of EPS. EPS are a complex mixture of biopolymers consisting primarily of polysaccharides and proteins, with variable amounts of lipids and nucleic acids. Direct microbial effects, caused by redox reactions, may result in production of corrosive compounds like acids, resulting into corrosive action and also destabilize colloids. EPS and its components are known to form coating of sub micrometer spaced protein-rich and lipid-rich domains with iron oxide which will affect adsorption and co-precipitation (Liu, Eusterhues et al. 2013). Biofilm and EPS may also interact with the porous material altering the transport of geosorbents.

The objective of our study was to quantify the effect of EPS and biofilm coatings on the colloidal stability, mobility and reactivity of hematite by column experiments. Columns (10 cm x 5 cm) were filled with glass beads (0.25 mm ø) as porous medium and operated in sterile closed flow conditions. The porous media was coated with Bacillus subtillis biofilm and with EPS extracted from, liquid cultures of Bacillus subtillis respectively. The pH was kept constant at 7. The attachment efficiency of glass beads coated with biofilms decreased significantly from 21.03x10-3 to 5.36x10-3 on coating with biofilm. Hematite was colloidally stable and mobile in EPS and biofilm coated porous media, whereas uncoated porous media, hematite nanoparticles loose its colloidal stability and are deposited on the porous media. The reactivity of hematite particles to the porous medium is reduced due to the masking of the reactive surface sites on the porous media with EPS. Also the reactive site on hematite may be altered by EPS depositions. AFM studies are carried out to study the masking of reactive sites of Hematite. EPS also leads to remobilization of sorbed hematite. 8% of sorbed hematite was remobilized by EPS.
Different concentrations of EPS were tested for its effect on colloidal stability of hematite. Lower concentrations of EPS resulted in loss of colloidal stability while higher concentration increased the colloidal stability. This might be due to steric stabilization by EPS polymers. Critical colloidal concentration (CCC) of the particles increased from 41 mM NaCl for uncoated particles to 250 mM NaCl for coated particles. The presence of biofilms and EPS, affects the mobility and reactivity of geosorbents like iron oxides, thus altering contaminant transport.

Liu, X., K. Eusterhues, J. Thieme, V. Ciobota, C. Höschen, C. W. Mueller, K. Küsel, I. Kögel-Knabner, P. Rösch, J. Popp and K. U. Totsche (2013). 'STXM and NanoSIMS Investigations on EPS Fractions before and after Adsorption to Goethite.' Environmental Science & Technology 47(7): 3158-3166.

Keywords：Hematite nanoparticles, Biofilm, EPS, colloidal stability

O44-7

[IDS11] Nanotechnologies in Environmental Soil Science

Evaluation of Phytotoxicity Effects of Nano Zero-valent Iron (nZVI) on Plants Growth in Soil Culture; Seed Germination, Chlorophyll, Carbohydrates

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Nano technology has emerged as a topic of considerable interest in various filed. Nano Zero-Valent Iron (nZVI) is one of the most prominent materials in environmental remediation of groundwater contaminants due to its strong reactivity compared to that of its micron-sized counterpart. Although it was reported that thousands tons of nZVI was injected into subsurface for remediation, there is no study that reveals effects of nZVI on plant in soil culture. Thus, three comprehensive physiological parameters were used to determine phytotoxicty of nZVI that suppressed plant growth (Alfalfa) in this work. The concentration of nZVI/soil was 0.5 g/kg, and water contents and pH values of the soil used were 70-75% and 5.6-6.0, respectively.

First, effect of nZVI on germination index and biomass was evaluated from 5 days old seedlings. The nZVI-treated plants showed slightly higher value in germination index (1.4, control=1) and biomass, respectively. Second, chlorophyll and iron content in the plant were measured. The result confirms that content of chlorophyll and iron ion in plant grown in soil was increased by nZVI. Additionally, concentration of plant-available Fe ion in soil was also measured using 0.005 M DTPA (diethylenetriaminepentaacetic acid) plus 0.01 M CaCl2 solution. Those levels between control and RNIP-treated soil were not significantly different. Lastly, composition of carbohydrates (Glucose, xylose) and lignin in plants were determined according to method of NREL (National renewable energy laboratory, USA) laboratory analytical procedure.

These results suggest that nZVI within concentration of 0.5 g/kg of soil can give effect slightly on chlorophyll synthesis of plants. Especially, the concentration of plant-available Fe in soil was comparable to that of control. Therefore, that application of nZVI is not likely to suppress plants growth causing Fe ion toxicity. Overall, these data suggest that these evaluated phytotoxicity parameters could be useful for investigations of phytotoxicity effects of nZVI on plants grown in soil as well as for researches aimed at identifying damages on plants induced by other nano materials exposed to soil.

Keywords：*Nano zero-valent iron (nZVI), phytotoxicity, germination index, chlorophyll, carbohydrates*

O45-1

[IDS8] Soils, Land Use and Heat

Soils, Land Use and Heat

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Land use change and intensity of usage are the result of an increasing demand for soil and has become a global dimension. Land grabbing is an extremely negative consequence of global soil economics. The driving forces are not only the growing world population and its increasing need for space and food production. It's also an expression of the increased demand for energy and material resources leading to an excessive, worldwide production, transport and trading of biomass, wood, energy, and other soil bound materials.

Both using soils more extensively in order to avoid environmental problems and using landscapes for nature protection become more important - but more difficult.

This contribution gives three examples of how soil and land use with respect to heat have become more relevant within the last decade. In the first one, peat soils should be placed in the centre of interest because they stand exemplarily for a global trend of soil loss and soil degradation because of increasing utilization. Both loss by CO2-release and degradation of peat substrates are not only the consequence of an intensively worldwide trend to drain wetland areas. They are also a result of global warming. In order to calculate the reduction of carbon storage (i.e. the CO2 release as a function of climate, soil properties and groundwater depth), we developed an easily manageable numeric model that (i) enables us to quantify ecological interactions and (ii) helps us to encourage better management practices.

Another global trend can be observed in poor and rich countries alike. The growth of cities and appearance of new mega cities implies an increasing demand for settlement areas carrying infrastructure such as streets, pathways and buildings. One of the environmental consequences is an increasing soil consumption and soil sealing, yielding dramatic changes in the water cycle and heat balance. One of the city planner's questions is how to manage and efficiently use urban areas and to what extent ecological functions may be preserved. Within this urban context, studies are presented to show how soil hydraulic functions are changed by surface sealing and whether vertical greeting might be a suitable instrument to cool down urban heat.

In the last example, we look at how soil is a carrier of infrastructure such as electric cables and show how our discipline (soil physics) can influence soil engineering problems. In highly developed countries electric cables are more and more installed into the subsoil. However, the maximum power transported in cables depends, among other things, on the question of how effective the cable heat can be transported into and controlled by the surrounding soil and site conditions. A limiting factor for cable lifetime is a threshold temperature of the cable coating that should not exceed 80 C°. Our numerical model helps not only optimize cable geometry such as diameter and installation conditions, but also determines to what extent temperature changes in the topsoil by heat transport. These questions address ecological conditions for plants and animals that also have to be answered before new cable terraces are approved by environmental agencies.

Keywords：*role of heat, soil degradation, urban soils, heat and electric cables*

O45-2

[IDS8] Soils, Land Use and Heat

On the Relation between Soils and Climate

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Soil scientists have had a great interest in the climate. Initially, the focus was on the climatic effects on the formation of the soil. Since the mid-1980s research attention has focused on the effects of the soil on the climate.

Until the mid 1800s soils were seen as weathering products of the underlying rock. This geological perspective was demystified in Russia the late 1800s and later in the USA when the importance of climate and vegetation was realized. Soils were seen as zonal, intrazonal or azonal products and these views existed dominated in the first part of the twentieth century. With growing knowledge on soil distribution across the globe and in particular the unravelling of the interacting state factors of soil formation, it was recognized that the zonal theory was not valid across the globe.

Until the 1900s, most research took place in the temperate regions of Western Europe, the Russian Empire, North America and Australia and relatively little research was conducted in regions with a tropical climate. The result was that views and theory development on soil formation and distribution was largely dominated by experiments and research conducted in the temperate regions. Soil properties and processes in tropical regions were considered different. It was assumed that the spatial distribution of soil types across the globe could be explained by climatic parameters like annual rainfall and temperature. The climate and the resulting vegetation were seen as major factors affecting the type of soil in a given location. Other factors were considered important but the climatic factor dominated much of the pedological thinking in the first half of the 20th century.

Jenny (1941) considered moisture and temperature the most critical in the climate state factor. Total rainfall has limited value and Jenny used the classification of Penck from 1910 linking evaporation (E) and precipitation (P), climate is grouped into arid (E>P), arid-humd (E=P), and humid (E<P). There have also been other rainfall factors (e.g. Lang, Meyer's NS quotient, Crowther's percolation factor, Thornthwaite PE Index, Transeau ratio, De Mortonne's indices d'aridité) but Jenny concluded that attempt to correlate these factors with soil features have not been very succesful. This is mainly because runoff is neglected and because there is microclimatic differences and seasonality in the rainfall. Generally, runoff increases exponentially with increasing rainfall. Also annual data are not the most suitable in areas with diurnal rainfall. Jenny reported that N and SOC content of the soil often increases with increase in rainfall (all other factors the same). The low nitrogen content of soils in the arid regions is not because of the high decomposition but mainly because of scarcity of the vegetation. In humid regions leaching is more pronounced and clay content of the soil is generally higher than in the arid region. In arid regions there is a carbonate horizon (C. Marbut), less leaching and a higher pH.
In warmer regions biochemical processes proceed faster (van 't Hoff law) including soil weathering and in tropical regions soils are generally deeper. Also the colour is yellower or redder whereas in areas with lower temperatures grey or brown dominates.

Research on the effects of climate on soil and its genesis continues to date, but it has been overtaken by research that focuses on the effects of soil on the climate. Such research began in the early 1980s when it was realized that the soil was a source and sink for greenhouse gasses and that these gasses affect the climate. A review of the effects and interaction between climate and soils is given. It is concluded that for proper quantification of the effects of soils on the climate, detailed understanding of pedogenesis and soil distribution is essential.

O45-3

[IDS8] Soils, Land Use and Heat

Numerical Modeling of Vadose Zone Processes using Hydrus and its Specialized Modules

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Modern human society uses an unprecedented number of chemicals, such as in plant and animal production, making agriculture one of the most important sources for non-point source pollution. Many mathematical numerical models evaluating the fate and transport of these chemicals were developed over the last three or four decades, and these models are now readily available and widely used. In this presentation we will review various versions of the HYDRUS models modeling one-, two-, and three-dimensional water flow, chemical movement, and heat transport through variably-saturated soils.

Early versions of the HYDRUS models considered the transport of only one chemical species and assumed that the behavior of this solute was independent of other species present in the soil solution. Physical nonequilibrium transport could be accounted for in later versions of HYDRUS by assuming a two-region or dual-porosity type formulations that partition the liquid phase into mobile and immobile regions. Chemical nonequilibrium transport could be accounted for by assuming kinetic interactions between solutes in the liquid and solid phases. Physical and chemical nonequilibrium formulations were extended later also to particle transport by including provisions for filtration theory, and time- and/or depth dependent blocking functions. Subsequent versions of the HYDRUS codes also considered the transport of multiple solutes, which either could be coupled by means of a unidirectional first-order degradation chain, or move independently of each other.

While this approach proved effective for evaluating the subsurface transport of many chemicals (e.g., nitrogen species, pesticides, radionuclides), many environmental problems require analyses of the transport of multiple chemical species that could interact mutually, create complexed species, precipitate, dissolve, and/or compete with each other for sorption sites. Various specialized HYDRUS modules intended to simulate these and other processes not available in the standard HYDRUS versions, such as the transport of multiple interacting solutes (the HP1/HP2 and UnsatChem modules), preferential flow (the DualPerm module), colloid-facilitated solute transport (the C-Ride module), the processes in wetlands (the Wetland module), and transport of fumigants (the module), are now available. These specialized modules substantially expand the capabilities of the HYDRUS (2D/3D) software package by accounting for processes not available in the standard HYDRUS version.

All these modules simulate flow and transport processes in two-dimensional transport domains and are fully supported by the HYDRUS graphical user interface. Additionally, the DualPerm module implements the dual-porosity and dual-permeability modeling approach of Gerke and van Genuchten [1993] simulating preferential flow and transport. The C-Ride module implements colloid transport and colloid-facilitated solute transport [Simunek et al., 2006], the latter often observed for many contaminants, such as heavy metals, radionuclides, pharmaceuticals, pesticides, and explosives. This module can be used to simulate the transport of various particle-like substances, such as colloids, viruses, nanoparticles, and/or bacteria.

HP2 is a two-dimensional alternative of the HP1 module [Jacques and Simunek, 2005], currently available with HYDRUS-1D, that couples HYDRUS flow and transport routines with the PHREEQC geochemical model of Parkhurst and Appelo [1999]. These relatively comprehensive simulation modules can be used to simulate a broad range of low-temperature biogeochemical reactions in water, the vadose zone and/or ground water systems, including interactions with minerals, gases, exchangers and sorption surfaces based on thermodynamic equilibrium, kinetic, or mixed equilibrium-kinetic reactions.

The Wetland module includes two alternative approaches (CW2D of Langergraber and Simunek [2005] and CWM1 of Langergraber et al. [2009]) for modeling aerobic, anaerobic, and anoxic biogeochemical processes for organic matter, nitrogen, phosphorus, and sulphur during treatment of polluted wastewater in natural and/or constructed subsurface wetlands. The Unsatchem module simulates the transport of major ions and their equilibrium and kinetic geochemical interactions, such as complexation, cation exchange and precipitation-dissolution in a soil profile. Possible applications include studies of the salinization/reclamation of agricultural soils, sustainability of various irrigation systems, and the disposal of brine waters from mining operations. And finally, the Fumigant module include such special options needed to simulate the fate and transport of fumigants, such as presence or absence of a surface tarp, temperature dependence of tarp properties, and removal of tarp at specified time.

A brief description and several demonstrative applications of each module will be presented. Further development of these modules, as well as of several other new modules (such as Overland, Slope Stability, and Meteo/Freezing), is still envisioned.

Keywords：*HYDRUS, HP1, vadose zone, modeling*

O45-4

[IDS8] Soils, Land Use and Heat

Monitoring and Mathematical Modeling of Water and Thermal Regime of Urban Soil Influenced by Various Surface Covers

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Different soil cover influences water and thermal regimes in soils within the urban areas. Knowledge of these regimes is needed particularly when assessing affectivity of energy gathering from soils using horizontal ground heat exchangers. The soil water and heat regime within the soil profile of the Technosol covered by grass was monitored and simulated using HYDRUS-1D. Observed water regime in the soil profile (measured soil-water contents in depths of 10, 20, 30, 40, 60 and 60 at 5 spots) was impacted by construction waste. Simulations using the soil hydraulic properties (which were measured in the laboratory and field or optimized using the measured soil-water contents) resulted in different simulated soil-water contents within the soil profile and variable simulated water fluxes cross the top and bottom boundary, which did not noticeably impact simulated temperatures within the soil profile, but influenced simulated heat fluxes cross the top and bottom boundary. Simulated temperatures in depth of 20, 40 and 80 cm corresponded to measured values. A slight delay of simulated soil cooling in the depth of 120 cm in comparison to measured one, which increased with the depth (150 and 180 cm), was observed. This delay was caused by the simplified bottom thermal boundary condition (zero gradient).

Next, the impact of different soil cover on a water regime and heat transport in soil was studied. Soil water contents and temperatures were also measured underneath various soil covers (grass, bark chips, sand, gravel, concrete paving) and used to define boundary conditions when simulating variably influenced water and thermal regime in soil using HYDRUS-1D. Measured temperatures at the soil surface and simulated temperatures at various depths showed that the larges temperature oscillations during each day were detected for concrete paving and decreased as follows: gravel, sand, grass and bark chips. The largest temperatures in various depths during the warm periods were simulated for concrete paving and decreased again as follows: gravel, sand, grass and bark chips. Scenario with paving showed also the fastest response to temperature changes at the soil surface and in different depths. Response time for other scenarios decreased similarly to previously discussed variables. Heat fluxes simulated at the soil surface were similar in all cases. Heat discharge at the bottom decreased as follows: gravel, bark chips, grass, concrete paving and sand. The heat transfer at the top was affected by both, surface temperatures and water fluxes. The heat transfer at the bottom was mostly affected by water fluxes. From a point o view of the soil heat utilization for heating systems, the simulated results indicated that the largest heat accumulation in the soil was obtained for the gravel scenario. The grass scenario (which is often situation) showed the lower heat accumulation in comparison to gravel, but relatively high temperatures were obtained during the cold period (i.e. period of soil heat utilization) in comparison to other 3 scenarios (sand, concrete paving and bark chips). Thus both scenarios (grass and gravel) seems to be the most favorable when designing effective ground heat exchangers. Finally the impact of the heat exchangers installed within the study area on the soil thermal regime was simulated using HYDRUS 2D/3D and compared with observed data.

Acknowledgement: Authors acknowledge the financial support of the Technology Agency of the Czech Republic (TA02020991).

Keywords：*water flow, heat transport, soil cover, grass, bark chips, sand, gravel, concrete paving, heat transport, grass, bark chips, sand, gravel, concrete paving*

O45-5

[IDS8] Soils, Land Use and Heat

A New Technology to Secure a Congruent Temperature Regime inside the Lysimeter Vessel and the Surrounding Soil

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Lysimeters provide free accessibility and extensive monitoring possibilities for defined soil sections. Therefore lysimeters are convenient tools to monitor the processes between soil, plant and atmosphere in its entirety and research the relation between particular parameters. Especially the actual evapotranspiration can only be measured with a highly sophisticated weighable lysimeter.

To get significant data from lysimeter tests it is necessary to know and control the boundary conditions of the monitored system, because the soil column inside the lysimeter vessel is cut off from its natural surroundings.

A newly developed temperature control system (patent number 10 2010 020 339) for lysimeters enables to control the temperature inside the lysimeter to a maximum variance of 0,5°C compared to the present temperature of the surrounding soil. To make the system energy efficient the temperature of the outside soil is directly transferred to the lysimeter bottom. The cooling fluid is pumped through a long tube system in the soil outside the lysimeter to adapt the temperature and transfer it to the lysimeter bottom. Therefore a 12 V energy supply (e.g. a solar panel or a rechargeable battery) is sufficient for the temperature control system. Using additional heating or cooling elements which require a connection to the local electricity network as power supply, the temperature can be controlled according to scenarios.

The controlled temperature at the lower boundary condition and the natural temperature of the atmosphere at the upper boundary condition cause natural temperature gradients within the soil column provided that there is no remarkable heat flux through the lateral boundary given by the lysimeter vessel. Therefore the lysimeter vessels should be insulated or made out of materials with low thermal conductivity such as polyethylene (PE).

The simple design of this technology makes it cost and energy efficient and provides the possibility to refit existing lysimeters.

Data gained from an application of this technology in a lysimeter station near Borovce (Slovakia) showed a maximum temperature difference of 0,2 °C and proof the functionality of this system even under rough climatic conditions. Another test of the described system at a lysimeter station in Müncheberg (Germany) proved an almost real-time response to changing temperature conditions in the surrounding soil even in times of high temperature changes. In the presentation the system will be described in detail and explained on practical examples.

Keywords：*Lysimeter, Soil temperature, Temperature control, Boundary condition*

O45-6

[IDS8] Soils, Land Use and Heat

Long Term Trends in Some Australian Soil Temperature Records

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At Cowra in New South Wales soil temperatures at a depth of 1.8 m were recorded daily at 9am from 1942 to 2010, and also at shallower depths from 1971 to 2010. At 1.8 m the seasonal temperature variation is greatly attenuated, leaving longer term variations. Fourier analysis of the annual temperature wave at the various depths, first used in 1861 by Everett to analyse Scottish soil temperature data, gave two estimates of soil thermal diffusivity from the way the amplitude and phase shift of the wave varied with depth. The closeness of these estimates showed that there was no significant transport of heat by vertical soil water movement. The annual average soil temperatures were calculated, and there is no long term trend from 1942 to 1968, but there is a steady long term rise from about 1968 to 2010. A linear rise in soil surface temperature corresponds to a delayed and lower rise at any particular depth. The estimate of soil thermal diffusivity and an analytical solution were used to calculate the temperature rise at 1.8 m corresponding to a linear surface increase, and this was fitted to the data. This gave a surface temperature rise of approximately 0.06 K per year at the Cowra site from 1968. Soil temperature records at a depth of 1 m at Gunnedah and Inverell from about 1970 to the present time were analysed, and they both gave a smaller surface temperature rise of about 0.02 K per year over this period. A preliminary analysis of soil temperature data from other Australian sites over the last 40 years shows a general rise, complicated by local variations and missing data.

Keywords：*soil temperature, global warming, Fourier analysis*

O45-7

[IDS8] Soils, Land Use and Heat

Quantifying Small-scale Variability in Water Storage and Root Water Uptake on the Edwards Plateau, Texas

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On the karst Edwards Plateau in central Texas, woody plants, especially Ashe juniper and honey mesquite are invading grasslands and savannas. These plants typically have deeper roots than grasses and can potentially exploit more stable sources of water. Quantifying the water loss through tree roots to water uptake is crucial for understanding how much soil water eventually recharges groundwater. However, karst ecosystems are often characterized by soils that are shallow and rocky overlying bedrock or other substrates that limit water storage capacity and root growth, and create high spatial variability in plant available water. This complex below-ground structure, while not uncommon, has of not been adequately characterized by most hydrological models. In particular, we tested the hypothesis that shallow roots provide the most of water consumed by the woody plants on the Plateau. We evaluated water storage and root water uptake in the karst of the Edwards Plateau, at a typical savanna site with ~50% woody cover, mainly Ashe juniper (Juniperus ashei) and honey mesquite (Prosopis glandulosa). Water content profiles to a depth of 1.6 m were measured by neutron thermalization and time domain reflectometry at 36 locations in a 25 m × 25 m grid (5 m node spacing). Bulk density profiles were measured by gamma densitometry. Temporal changes in water storage were compared with eddy covariance measurements of evapotranspiration (ET) to evaluate relative amounts of ET originating from root water uptake at various depths. Water storage capacity in the measurement grid ranged from 185 to 401 mm, and coupled with heterogeneous distribution of trees created high spatial variability in root water uptake. Water uptake was higher beneath trees than beneath grass, in part because tree roots were able to extract water from regions of the root zone with high rock density. On average, 81% of the water uptake occurred from the upper 1 m of the profile with the greatest uptake occurring at depths of 0.4 to 0.8 m. An estimated 10% of the uptake occurred from below the maximum measurement depth of 1.6 m. While this result confirms the hypothesis that trees on rocky substrates take up water from greater depths compared to similar ecosystems on soil, it also refutes the view that trees in karst regions have greater access to groundwater.

Keywords：*Root water uptake, rocky soil, spatial variability*

O46-1

[IDS3] Soil Information and Food Security

Healthy Soils and Soil Information: a Prerequisite for Sustainable Food Production

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The importance of soil for food security should be obvious. From the origins of civilization in early farming communities to present, we can see how societies have prospered thanks to healthy soils and declined when their lands became degraded or infertile.

Soils constitute the foundation for healthy food production and thus contribute to food security globally and locally. Continuing rapid population growth is placing further alarming pressure on already depleted soils, a situation which - if left unchecked - will frustrate any objectives to increase food production substantially and in a sustainable manner over time. There is an urgent need to address its sustainable management for feeding the growing population by 2050.

However, there is a misconception that healthy and fertile soils are everywhere. Our recent findings show that one third of our soils globally are facing moderate to severe degradation affecting productivity of the one billion smallholders who depend on natural resources for their livelihoods as well as the commercial farming and forest sectors.

We all, particularly soil scientists/soils community, have a responsibility to shift this trend by preventing further degradation and restoring degraded soils if we are to successfully eliminate hunger which affect some 842 million people today in order to reduce food insecurity and malnutrition worldwide.

Moreover, little is known about key functional soil properties in many areas; so that many programmes fail to generate higher yields as the common response - fertilizers - do not work in the absence of well-informed long-term management strategies. The threats from climate change also affect soil properties and the ability to produce food, so greater resilience is needed to avoid disasters such as the one experienced in the Horn of Africa in 2010-2011.

Evidence based decisions are crucial for boosting healthy soils. That implies monitoring the conditions of soils in general and their properties on a regular basis. This type of soil information requires the use of modern tools and sound methods that will aid the production of reliable soil information, benefiting sustainable management of this vital resource.

Thanks to the interest of FAO member states a new body, the Global Soil Partnership, has been put in place by FAO and its members. It acts as a major vehicle to catalyze effective and concerted actions against soil degradation and to promote sustainable soil management as a priority in relation to the food security. Under the GSP, a global soil information system is mentored as part of Pillar 4 related to enhancing soil data and information. This system will be developed as a joint collaborative effort by GSP partners and will include SoilSTAT, a global soil health monitoring system.

Soils, which have been overlooked for some time are now under discussion in global agendas and are being given higher attention. With the UNGA endorsement of 5 December as World Soil Day and the Year 2015 as International Year of Soils, there is real momentum for a collaborative and effective action towards achieving sustainable soil management at country, regional and global levels, thus improving food security.

O46-2

[IDS3] Soil Information and Food Security

Global Soil Carbon Assessment

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Climate change including change in temperature, elevated CO2 concentrations, increased rainfall variability, and altered land-use will have a great impact on soils. The influence of these factors will create a dynamic feedback between soil and the environment. Because of the inherently long-term nature of soil change (carbon and other nutrients), addressing these questions requires empirical data over decades. There is a crucial need to evaluate the responses of soil to global environmental change at large scales that occur along natural environmental gradients over decadal timescales. While there are efforts to collect soil data round the globe for estimation of soil carbon stocks, the results are still fairly uncertain.

This paper will provide a suite of new data on global soil change which will for the first time utilise the world's prior investment in soil data infrastructure gathered over the past half-century and beyond. It will provide a comprehensive global assessment of soil carbon dynamics in different biomes and ecozones of the world accounting for impacts of climate change and other environmental factors.

Using legacy soil data collected worldwide, we modelled the distribution of carbon stock on the soil surface and 1 m depth globally. The model was generated using global covariates such as climate, topography, and satellite imagery.

Keywords：*soil security, global soil carbon*

O46-3

[IDS3] Soil Information and Food Security

The Good, the Bad and the Ugly - Experiences from Trying to Establish Soil Monitoring Networks within the UK

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Since the mid 1990's, there has been much research with respect to developing and implementing soil monitoring across the UK. Indicators have been reviewed and tested, sampling strategies have been designed and trialled and overall schemes constructed and costed. So far there has been, at best, mixed success in getting monitoring activity on the ground with little substantive Government commitment to progressive monitoring. The UK experience is not unique within Europe. This talk will reflect on why it is proving challenging to establish soil monitoring even although there are clear environmental, economic and social imperatives for getting new schemes started or invigorating historical schemes. Given the efforts to date, it is timely to reflect on progress so far, and consider whether soil science needs to take a new approach to soil monitoring to make it more palatable for Government support and funding. There will be a review of the approaches used to design monitoring schemes to suit different end-users and budgets, and in selecting indicators that can provide information for different purposes, from food security, water quality and biodiversity conservation. Lessons learnt from implementing monitoring in national and targeted schemes across the UK will be presented. Ultimately the talk will discuss how an evolution in end-users requirements alongside Policy changes has resulted in a new approach to Soil Monitoring within Scotland. The aim of the talk is to open up the debate on how we devise and promote soil monitoring to ensure that we can provide the soil information needed to ensure food security alongside other societal goals.

Keywords：*soil monitoring, policy, implementation, lessons,*

O46-4

[IDS3] Soil Information and Food Security

Soil Health in Southern Africa and Implication on Sustainable Intensification: How much is the Gap?

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Abstract

Food insecurity is one of the biggest challenges of farming households in sub-Saharan Africa (SSA). Many ascribe this to poor soil conditions, less use of fertility enhancing inputs, and climate change, mainly rainfall variability. These confounding issues complemented by heavy population pressure ultimately lead to a food insecurity-low in put use-food insecurity spiral. This syndrome means that resource degradation will continue undermining land productivity and ultimately aggravating food insecurity as the ability of farmers to apply inputs will be much more restricted. Considering the fact that population pressure will not allow increasing the size of farmlands, the better option available for SSA farmers is considered to be sustainable intensification. Sustainable intensification is an approach where out put per unit of input will be maximized while keeping the off-site impacts of additional inputs on the environment. This implies that more has to be produced from the existing agricultural land available. This can be achieved through tackling land degradation, restoring degraded areas and replenishing soils with necessary nutrients. To achieve this knowledge of the types and amount of 'inputs' required is necessary by assessing the soil quality and comparing it with expected thresholds. In this study, we make use of soil laboratory analysis results available from the Africa Soil Information Service (AfSIS) project to evaluate the critical limits, evaluate deficient nutrients, determine overall soil health and analyze possibilities of integrated approaches for effective and efficient sustainable intensification in Southern Africa. Both top soil (0-20 cm) and subsoil (20-50 cm) sample from over 4500 plots of about 0.1 ha each were collected and analyzed for six countries of Southern Africa (Angola, Botswana, Malawi, Mozambique, Zambia and Zimbabwe). Standard soil analysis for chemical properties was used to analyze 10-20% of the samples (reference samples) while mid-infrared spectroscopy approach was used to predict soil properties for the remaining samples. The results show that there are significant differences in most of the elements analyzed between depths. The results also show strong variability in major soil properties (e.g., Al, Fe, ExMn, pH, ExK, SOC, total N) within and between sites as well as countries while ExCa, ExNa, and P show relatively low variability. Among the various soil nutrients analyzed, results indicate that there is huge potential 'soil nutrient gap' especially elements such as nitrogen, potassium, Zinc being the most limiting in the region. The observed spatial variability in soil quality shows that 'bulk' fertilizer application generally implemented in different countries will not bring the intended yield gain and could rather have negative effect on farmers' technology adoption. The potential of PCA as well as soil quality index approaches are assessed to further explore the soil health status of sites in the region to determine the gap and the potential amount of investment requited to fill it. Farmers' willingness and ability to add required inputs and alternative options of improvement are also investigated and the implication on sustainable intensification discussed.

Keywords：*Food insecurity, soil health, landscape restoration, sustainable intensification, Southern Africa*

O46-5

[IDS3] Soil Information and Food Security

Variability of Top Soil Saturated Hydraulic Conductivity (kfs) Affected by Mixed Land Use on Two Volcanic Environments in Central Mexico

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To reach an acceptable understanding of the earth critical zone, hydropedology (Kutilek, 1966, Lin et al., 2008) consider a new scientific paradigm facing the current need of reference frameworks to integrate, conceptual and methodologically, the components and processes of the hydrological cycle and its relation with structural components of terrestrial systems, such as the edaphic environment. This study was conducted in a basin (~5500 has) with high importance for the conservation of hydrological resources of Morelia city (population=~1 500 000), in central México, where agriculture and cattle rearing are major drivers of land degradation. A top-bottom approach was carried out with the following objectives, to generate relevant information for land planning, to disaggregate the study area in terms of environmental information, identify potential scenarios of soil similarity and, relate them with soil hydrological properties. A 15m DEM was constructed using topographic contours and river lines. Derived attributes were calculated using open source platforms. As a context to kfs, morphometric and hydrographic analysis were performed. A geo-morphometric map was delineated by using aerial photography and stereoscopic pairs. Land use was also digitized. Soil and geology type polygon maps were down scaled from its original resolution to study area by correcting limits from field observations, agricultural terraces and road cuts. Simple maps algebra allowed definition and identification of more than 500 environmental units different in at least one of the components mentioned above. Two contrasting units (representing ~13% of total surface) were selected for transect based sampling design of soil hydro-physical properties (N=93 observations), agriculture and secondary forest. Sampling distances in this study vary from 0.15 to 73m. At each point, a soil sample was extracted for laboratory tests of soil organic matter content, aggregate stability and texture. Soil properties were statistically related using Bayesian network approach with the EM algorithm to train it with the data sample. This relation was interpolated by simple kriging to represent a possible scenario of the local soil variability. A continuous raster coverage was generated with a 15 cm of spatial resolution according to minimum distance between observation points at the hill-slope level. A set of more than one hundred Gaussian stochastic simulations were performed until variation stabilized, we used a simple average of all simulations to produce an hypothesized soil hydraulic variability, and the variance at each pixel as a proxy of uncertainty of prediction. As reported in previous work, soil hydraulic behavior is dependent of any factor affecting soil porosity, the quantity and quality of water and can greatly vary in short distances (e.g. meters). The highest values of kfs (~30000 mm/hr) were found in the agricultural field associated to gopher's biological activity and the lowest values (~38mm/hr) in the forest cover associated to an old road (more than 40 years) used for wood extraction. Bayesian network was useful to identify the influence of soil properties in soil hydraulic conductivity. However, in both units, the mixed effect of current and previous land use was a distinction that we could not delineate, for example, compacted soil by cattle and wood extraction related activities in the forest, bioturbation and the temporal nature of agricultural activities were factors that decrease expected statistical relationship between soil properties and its water conduction capacity. We finally discuss the consideration of such wide local variability for the realistic assessment of hydrological services, the need of periodical data as a tool for land planning and management, as well as the components of soil variability at several scales.

Keywords：*soil variability, hydropedology, Mexico, Bayesian network , kriging*

O46-6

[IDS3] Soil Information and Food Security

Spatial Landuse Planning of Soybean Plantation as Analyzed by Land Evaluation and Dynamic System: a Case Study of Karawang Regency, West Java, Indonesia

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Indonesia is actually faced with serious problems in terms of food supply due to it's high population. One of the public commodity which was still can not be fulfilled from domestic agricultural production is soybean. The data of Indonesian Bureau of Statistics showed that soybean plantation has declined in the last decade. As an illustration, if in 1996 and 1997 Indonesian soybean planting area is 1,277,736 Ha and 1,118,140 Ha, the planting area of 2011 was only 622,254 Ha, and even decrease again in 2012 to become 567,624 Ha. Although the average productivity has successfully been improved significantly, from 1,186 kg.Ha-1 in 1996 to 1,485 kg.Ha-1 in 2012, however the production decline can not be avoided, from 1,515,937 tonnes by half, to become 843,153 tonnes in 2012, due to continued decline in planting area. As an illustration, the Indonesian local soybean production in 2011 was only 851,286 tonnes, it was able to meet 29% only of the total national need of soybean. With that situation and background, this research was done in Karawang Regency, West Java, Indonesia, a regency of agricultural center. The main food crops in this region was rice, hence, the research was done in the context of developping soybean as a crop rotation of rice. The objective of the reseach were: (i) to identify the suitable area for soybean plantations in the rice field, (ii) to place the development of soybeans in the context of land use and socio-economic factors of the regency, and (iii) to plan the spatially soybean plantation. Several methodology were used in order to get an integrated manner of soybean plantation landuse planning. A soil survey and land evaluation for soybean plantations of the research area was done. Soil samples were taken for laboratory analysis. Land evaluation was done using Automated Land Evaluation System (Rossiter, 1997). The delineation of rice field area was done using IKONOS imagery. A dynamic system of soybean production and consumption was developped using Powersim 2.5 software. The factors which were taken into account in the dynamic system of soybean production and consumption include the result of soil survey, as well as the sosio-economic factors of soybean production and consumption. A spatial landuse planning was then developped, taking into account the soil information and scio-economic aspects. Results of the reseacrch indicate that in Karawang Regency, there were still a vaste area in paddy field plantation which are suitable for soybean plantation. The land suitability class vary from S1 (very suitable) to N1 (currently not suitable). More than 50% of the rice field cultivated area has a land suitability order for soybean, suitable. The limiting factors of this land were generaly nutrient retention and nutrient availability. According to the analysis of dynamic system of soybean, there are many factors that cause a decrease in soybean planting area in the region and in turn to lower production. The main cause is a lack of interest of farmers in planting soybean because of less supportive economic benefits. Based on such result, a spatial land use planning was then developped to delinate the priority area of soybean plantation in crop rotation with paddy. A suggestion in term of increasing the farmer's interest in soybean plantation was also done.

Keywords：*soil survey, land suitability, land characteristics, soybean production, soybean consumption*

O46-7

[IDS3] Soil Information and Food Security

Werise: a Farmer-friendly Decision Support Tool for Climate Change Adaptation in Rainfed Rice Areas

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One-third of the total rice-growing area in the world is rainfed, where abiotic stresses such as drought and submergence have profound effects. Rice production in rainfed lowland environments account for 19% of the world's total rice production. Low soil fertility and unpredictable water availability are the major limiting factors in rainfed rice production systems, thus adversely affecting resource-use efficiency and destabilizing rice production. Improved rice production by farmers that result in an adequate, stable, and reasonably priced supply of rice for consumers is crucial to a significant proportion of the world's continually growing population.

Unlike irrigated environments, rainfed environments rely heavily on rainfall, hence, water management for a high and stable production is hardly achievable. Farmers have used empirical or indigenous methods to predict seasonal rainfall to guide decision-making in crop production. However, inter-annual variation of rainfall is increasing that is why farmers are finding it more difficult to anticipate the nature of upcoming rainy seasons, leading to haphazard decision-making. Aside from difficulties in managing water availability, soil nutrient management of highly weathered soils, such as Acrisols, the dominant soil family in most rice-growing areas in Asia, is a major constraint to rice production. Overlying these biophysical constraints is that rice production is becoming unprofitable and pays the least average daily wage compared to non-agriculture sectors. Hence, the incidence of poverty among rice farmers is higher than average and young people shun rice farming as a source of livelihood.

To change current conditions and trends and make rice farming more profitable, measures and tools to enable a stable, efficient, and effective production system should be designed and implemented. Knowledge of the rainfall pattern of an upcoming rainy season is crucial not only for risk avoidance, but also for the formulation of strategies to optimize production in rainfed environments. The IRRI-Japan collaborative project on Climate Change Adaptation in Rainfed Rice Areas, funded by Japan's Ministry of Agriculture, Forestry, and Fisheries (MAFF), is developing the Weather-Rice-Nutrient (WeRise) decision support system to help rainfed lowland rice farmers to be more strategic in their use of resources and attain better and more stable rice yields. Seasonal weather forecasting is one of the important tools in this system.

WeRise adopted the SINTEX-F ocean-atmosphere coupled general circulation model for this purpose because of its demonstrated ability to predict significant Asian monsoon phenomena, such as El Nino-Southern Oscillation and Indian Ocean Dipole with one month to one year lead time. Through a bias reduction procedure, weather forecasts are produced and used as an input in the ORYZA 2000 rice growth model to determine attainable rice yields of different modern rice varieties as a function of sowing dates. These serve to guide farmers on optimal sowing dates to attain better yield. Combining the power of a reliable seasonal weather prediction and the rice growth model with a decision tool for fertilizer management (Nutrient Manager) enables farmers to receive recommendations for appropriate rates, splits, and timing of fertilizer application for efficient nutrient use to promote rice growth and development. WeRise provides crucial information for rice production 3 months before the rice-growing season. Its development is being done in a participatory manner with potential users from national agricultural institutes and extension agencies in Indonesia and Lao PDR. Farmers and extension workers need easy-to-use information at the correct time to match location-specific needs and rice-growing conditions.

Keywords：*climate change adaptation, unfavorable environment, fertilizer management, decision support system*

O47-1

[WG9] Steps made toward a Universal Soil Classification

Towards a Universal Soil Classification System

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In September 2009, in Hungary, several events were organized to celebrate the 100th anniversary of the 1st International Conference of Agrogeology. A symposium to overview the 100 years of advances in soil sciences and a seminar entitled "From the Dokuchaev School to Numerical Soil Classifications" were organized. As result of these discussions, a resolution (known as the "Godollo Resolution)" was prepared and forwarded to the IUSS Council for discussion at the 2010 World Congress of Soil Sciences in Brisbane, Australia. The resolution stated that there is a need to develop common standards, methods and terminology in soil observations and investigations and a universal soil classification system and for a new Working Group to coordinate the efforts of this global undertaking. Many of the scientists who participated in the wording of the "Godollo Resolution" had a formal meeting in May 2010 in Rome, Italy during "Digital Soil Mapping 2010" workshop. There was a general agreement that there is a need for evaluation of current spatial soil definition and classification systems and new innovative approaches should be investigated to develop a common universally accepted system. It was also agreed that a new working group should be set up to coordinate the work and that the development of a Universal Soil Classification (USC) may need several years, hence national systems and the official correlation system of IUSS, the WRB (World Reference Base for soil Resources) should be maintained. During the 2010 World Congress of Soil Sciences in Brisbane, Australia, the IUSS Council unanimously accepted the "Godollo Resolution" and formally accepted the proposal for a new Working Group to carry out the proposed investigations and development of common standards, methods and terminology in soil observations and investigations and a universal soil classification system.

The Working Group began engagement in early 2011 and built a core team that held their first workshop in May of 2011. From the discussion at this meeting the core team has put together a a framework of task groups, and priorities for moving forward with the effort to provide harmonized criteria for describing, sampling, and analyzing soil and work needed to understand gaps in existing soil classification systems. The framework is built into three
distinct categories:
- Soil classification issues.
- Diagnostic and soil profile information harmonization.
- Important information relating to soil classification.

Each of these categories has specific task groups that have a designated chair, team members and a goal for what the group is to achieve.

As the working group looks to the future of a USC system, a centroid-based approach is being considered. This would involve analyzing databases to make allocations into logical clouds of points designed to recognize "Great Soil Groups." The great soil groups will be equivalent to the great group level from U.S. Soil Taxonomy, along with similar levels in the World Reference Base, Australian Soil Classification, and other defined soil classification systems. The Great Soil Groups will have taxa developed that will document more and less detail. Lower taxa in the system will potentially recognize anthropogenic features, family criteria, and other important use and management characteristics. Higher taxa in the system will be developed for meso- and macroscale applications. As more data are added to the system, taxonomic distance calculations can be used to determine if new categories are needed based on tolerances that are set. This system can then be more scalable based on the objective analyses of the data that are collected and entered into the system.

Keywords：*Universal Soil Classification, Centroids,*

O47-2

[WG9] Steps made toward a Universal Soil Classification

Approaches to Define the Elements of a Universal Soil Classification System

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Existing soil classification systems were developed to provide information on soils to communicate information about the natural properties and provide a better understanding of soil differences. All of the current development of taxonomic systems took place before the recent boom of observation technologies, data storage and data processing developments that can be used to determine soil differences. In the past, Agricultural soils received more attention than other soils, such as anthropogenically modified or urban soils, or soils of the cold regions. The broader view of soil functions and the understanding of global environmental processes require a better understanding and description of all soils to place soils in natural divisions.

The soil science community is challenged to apply the accumulated knowledge on soil formation, soil differences and related functions in modernized and simplified and to the extent possible, a global unified system(s). This challenge stimulated the establishment of the IUSS Working Group Universal Soil Classification System (WG USCS).

This paper is briefly summarizing the approaches and the progress to define some of the basic elements of an envisioned in the Universal Soil Classification System.

One of the major principles of the effort is to base on the experiences of current systems, the collected data and the understood needs of the users.

The initial efforts were concentrated on internationally accepted classification guidelines such as the USDA Soil Taxonomy (ST) and the World reference base for soil resources (WRB) and some national systems.

One of the major early agreements of the WG was the review diagnostics (horizons, materials, properties) as potential building elements of the USCS. Significant effort was performed to evaluate the terms of definition, limits and applicability. Simple statistics and data evaluation complemented the expert evaluations. The overviewed information include soil data with broad geographical coverage, such as soil Characterization Data and the National Soil Information System of the US (USDA, NRCS, NCSS) and the ISRIC-WISE Harmonized Global Soil Profile Dataset (Ver. 3.1) and some national data bases.

One major conclusion of the evaluation is that many of the definitions are unnecessarily complicated, and not always consistent throughout the systems. This makes interpretation and also computation of categories difficult. With the globally available data and mathematical tools, there is a great opportunity to improve definitions and correct arbitrary set limits.

Some of the initial results will be presented in the paper.

Numerical approaches were applied to study taxonomic relationships of different soil groups to define natural populations of soils. The calculated centroid values of the Great Groups (GGs) of the US Soil Taxonomy and selected Reference Soil Group (RSGs) of the World Reference Base for Soil Resources (WRB) were the applied units for the distance studies and calculation of clusters of soil types. The centroids were calculated on 41890 profiles from the mentioned datasets. Profiles were divided up to 5 cm layers to a depth of 50 cms, 10 cm layers between 50 and 110 cms and to 20 cm layers from 110 to a depth of 150cms. Values were calculated on a weighted mean bases with the R package aqp. The following properties were included in the calculations: coarse fragments (percent), clay, silt and sand content (percent), color RGB values, presence of redox features (a binary value: any corresponding information in the description resulted a value of 1), evidence of permafrost (binary, similar to previous one), organic carbon content(percent), calcium carbonate content (percent), pH water, cation exchange capacity, exchangeable Ca, exchangeable Mg, exchangeable Na, exchangeable K, exchangeable acidity, base saturation, electrical conductivity and gypsum content.

Mahalanobis distance metrics was performed for to study taxonomic relationships between the GGs and RSGs. Specific clustering algorithms were developed to define the potential soil groups of the USCS.

The mentioned methods and results as well as the shortcomings and optimistic visions will be presented.

Keywords：*Universal Soil Classification, taxonomic relationships, numerical methods*

O47-3

[WG9] Steps made toward a Universal Soil Classification

Toward a Global System of Soil Horizon Nomenclature

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We have entered an age of instant communication, global agriculture, and environmental problems that cross national boundaries. Consequently, there is a need for improved international communication about the nature and properties of soil and harmonizing the way we classify and describe soils. A task group established within the Universal Soil Classification System working group has the objective of comparing soil-horizon and horizon suffix nomenclature used by existing classification systems. From this comparison, much commonality is apparent. Nomenclature for eluvial, illuvial and organic horizons is almost universal. Pedogenic carbonates, gypsum, silica, soluble salts, slickensides, concretions, buried genetic horizons, gleying, strongly weathered horizons, strong cementation, ploughing, and weak development are also widely recognized, although symbols for these properties often differ. Other properties are less cosmopolitan, such as anthropic disturbance, human-induced soil formations, cryoturbation, phosphorus accumulation, sulfides, unweathered material, low bulk density, lamellic features, and dry permafrost because of different environments among countries – e.g. cryogenic features are important for Canada and Russia and sulfides are important in Australia. In the majority of systems, a very limited number of uppercase letters are used for master horizons, which are combined with one or more lower case letters used for indexes. Still, these symbols are often inadequate to reflect the up-to-date knowledge of soil features of the world. So, there is much potential for advancing soil horizon nomenclature for the Universal Soil Classification. We anticipate that this compilation and blending of existing systems, taking advantage of their diversity, will not only enhance international communication, but will also provide a greater understanding of soils across the globe.

Keywords：*Universal Soil Classification, Soil Morphology, Horizon Properties, International Classification Sys*

O47-4

[WG9] Steps made toward a Universal Soil Classification

Cold Soils in Universal Soil Classification

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Permafrost-affected soils are recognized as very important ones in several classification systems of the world. In the Canadian system and in the US Soil Taxonomy soils of the world are divided into those with permafrost and other soils. In WRB system permafrost-affected soils are also very high. In Chinese and Russian classification systems the permafrost are recognized only on the3rd-4th taxonomical levels. However since that time when all these classification systems came into being community of soil scientists got new challenges for the classification of cold soils in a wider sense than just permafrost-affected ones. It is very important for the Universal Classification System. 1. The problem of shallow soils of cold climates, whether we can accept them as Gelisols, as they theoretically have permafrost within 1 or 2 m of solid rock, or they should be classified as Gelorthents as nobody can see permafrost in the profile because of shallow lithic contact. 2. The contrary problem on the classification of soils in loose materials which have permafrost below 2 m, but this permafrost results in cryoturbations and salinity of soil horizons because of impermeability of the deep permafrost. 3. The problem of soils with well-pronounced cryoturbations but without permafrost. 4. The problem of soils of highly continental climates – they may be very productive but with low MAST. 5. The problem of Antarctic soils – they may have same names as tundra soils but they are microsoils.

The new draft list of cold soils on the middle level of classification is proposed for wide discussion to be used in the future Universal Soil Classification. It includes all the soil features that Gelisols/Cryosols have in Soil Taxonomy and WRB soil classification systems. Several amendments are proposed – AHUMI- (for soils with <0,02% organic carbon content), CAMBI- (with cambic horizon), CRUSTY- (for soils with crusts on the surface that is typical for arid landscapes), HOMOGENI- (for soils where cryoturbations result in soil mass homogenization), MUCKY- (for soils with mucky organic horizon), ORNITHI- (for soils enriched by bird guano), PAVI- (for soils with stony pavement), PROTI- (for soil profiles without macro-horizons).

Keywords：*permafrost-affected soils, soil classification systems, Cryosols, Gelisols*

O47-5

[WG9] Steps made toward a Universal Soil Classification

Creating Numerical Horizon Classes For The Usa

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As part of the Universal Soil Classification System work we are investigating numerical soil horizon classifications as well as profile classifications. This report is primarily concerned with horizon classifications, possibly as a prelude to profile classifications. Hierarchical methods such as Fuzzy k-means have been able to cluster soil into logical groups, but can be hampered by outliers. Fuzzy k-means with extragrades has been able to solve many of the outlier problems, but estimation of extragrade numbers can lead to misclassifications. In response to these challenges, we have developed a new algorithm called akromeson (literally edge, centre), which categorizes data into two types of cluster; end point clusters and central clusters (Hughes et al, in press). This algorithm has been first developed and tested on a small data set and then up scaled to a larger collection of data retrieved from USDA Natural Resource Conservation Service databases (http://ssldata.sc.egov.usda.gov/).

Twelve soil properties (pH, CaCO3, CEC, clay, silt, sand, organic carbon, thickness and three colour coordinates) were identified from the US data. These were selected on a basis of usefulness (how well they discern horizons) and prevalence (how frequently they are populated in the database). The complete dataset contains over 300,000 individual entries, but in order to achieve coherent results, only complete pedon sequences that contained all the necessary soil properties were used.

71728 compatible soil horizon descriptions were extracted from the US data. From these, a total of 93 clusters (horizon classes) were identified. Of these, 35 were surface horizon classes and 58 were lower horizon classes. These classes could be further differentiated into fixed end point clusters and central clusters. Analysis via dendrograms indicated the clusters were primarily demarcated by textural changes but a number were also differentiated by extremes in pH and organic carbon.

We are currently interpreting the results in terms of pedological knowledge. In future experiments it has been determined that in order to properly analyse clusters using the new akromeson method, particular attention needs to be taken with the weighting factor. This variable controls how much data is relegated to end point clusters. A new method of estimating missing data will be tested, making larger analysis of existing data possible, and more objective methods of analysing end point clusters will be explored. This new approach will also be applied to some world databases.

Keywords：*Numerical classification, Fuzzy k-means, clustering*

O48-1

[C2.3-2] A: Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

The Moisture Response of Soil Microorganisms: Old Topic, Present Challenges and New Approaches

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Next to temperature, soil moisture is a main driver of soil C and N transformations in soils, because it affects microbial activity and survival. The basic concepts and mechanisms relating soil water to microorganisms were identified early. However, accounting for how moisture controls soil microbial activity remains essentially empirical. Furthermore, it is often complicated by the existence of different components of the water potential and different units. However, the moisture sensitivity of C decomposition may be a source of uncertainty of similar magnitude to that of the temperature sensitivity and receives much less attention. In fact, soil functions used to model the heterotrophic response of soil respiration have limited experimental support. We performed a data driven analysis of soil moisture respiration relations and showed how these are consistently affected by soil properties. We developed empirical models including the effects of soil texture organic carbon and bulk density which improve the functions currently used in different soil biogeochemical models [1].

Partially responsible for the present state of knowledge may be the idea that, in biogeochemical models, time- and spatially averaged or approximate relationship of microbial activity with moisture, is sufficient to reliably predict C fluxes. However, soil microorganisms live in a complex 3-D framework of mineral and organic particles defining pores of various sizes, connections with adjacent pores, and with pore walls of contrasted nature, which result in a variety of microhabitats. The water regime to which microorganisms are exposed can be predicted to depend the size and connectivity of pores in which they are located. Experimental approaches associated with PLFA stable isotope probing showed that there is a microbial biogeography at the pore scale, as pores of different sizes host distinct microbial communities with contrasted mineralisation rates of C [2,3]. Several experiments demonstrate how soil water controls the decomposition of C and N in via its impact on the diffusion rates of substrates, enzymes and oxygen, which are controlled at a microscopic scale by the size and spatial arrangement of soil particles.

Most promising perspectives in this area are based on mechanistic approaches, where theoretical linkages between substrate and gas diffusivity in soil pores and heterotrophic respiration are explored in different soil matrices [4]. A new generation of pore scale models of C dynamics in soil are based on an explicit representation of soil structure (i.e. soil particles and voids), microorganisms and organic matter localisation [5-7]. Using modern approaches to describe the soil system (microCT tomography, imaging of microorganisms in soil), these models can describe how heterotrophic respiration is affected by microscale distribution and processes in soils and are adapted to develop and compare scenarios regarding water regimes in a changing climate.

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Keywords：*soil, microorganisms, water, respiration, C dynamics, pores, model*

O48-2

[C2.3-2] A: Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

X-Ray Tomography and in Situ Detection Technique used to Quantify Spatial Distribution of Bacteria in Soil

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A practice of introducing bacteria in soil has been carried out since a decade because of its compelling beneficial activities in soil. They stimulate plant growth by providing nutrients and inhibiting plant pathogens, degrade organic pollutants and improve soil structure. However, soil is a complex heterogeneous environment which comprises of highly variable and dynamic micro-habitats that has a significant impact on the growth and survival of these bacteria. Bacteria are known to occupy only a small portion of the total available pore space in soil. This indicates that the spatial arrangement of bacteria has an immense consequence on the way they approach their target.

Most of the studies done were carried out at macroscale whereas bacteria function at microscale in their environment. Other studies involved destructive sampling of soil, thereby destroying the characteristic of soil that underpins all processes including access to carbon, movement of water, availability of air and diffusion of gasses. But there is a need to understand the spatial organization of bacteria and its interaction with soil structure to get an idea of the bacterial response to the changing environmental conditions.

Therefore, the aim of this work was to get a better understanding how the distribution of bacteria is affected by different soil structure overtime. In this work different bulk density of soil was considered. Two techniques, fluorescence microscopy and X-ray tomography was combined to visualize and quantify the distribution of bacteria in soil structure.

Soil of aggregate size 2-1mm was packed to 1.3 g/cm³ and 1.5 g/cm³ bulk density in polyethylene rings (4.25 cm³). Pseudomonas fluorescens SBW25 used in this study was introduced in centre of each soil rings. A subset of samples was fixed with 4% formaldehyde on day 14, and impregnated with polyester resin. After polymerization of resin, samples were scanned under X-ray microtomography at 14 μm resolution. The samples were grinded after scanning and specific molecular stain was applied in situ to visualize bacteria. Epifluorescence microscopy was used to enumerate bacterial distribution, they were mainly observed near the soil-pore interface and on the clay humus complex. The internal structure of soil was quantified using 3-D volumetric images obtained from scanning.

Thus the presented work is a significant step towards understanding how environmental change and soil management can have an impact on bacterial diversity in soils. The future prospect of this work is to study the interaction between two bacterial species at microscale.

Keywords : *Bacteria ; bulk density ; Epifluorescence microscopy; X-ray tomography ; Impregnation*

O48-3

[C2.3-2] A: Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

The Microbial Landscape Iin Soils - Biogeography of Soil Microorganisms at Different Scales

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Studies of microbial biogeography can provide key insights into the physiologies, environmental tolerances, and ecological strategies of soil microorganisms that dominate in natural environments. In comparison with aquatic systems, soils are particularly heterogeneous. Soil heterogeneity results from the interaction of a series of hierarchically interrelated variables that fluctuate at many different spatial and temporal scales. Although the spatial dependence of chemical and physical soil properties is well known at scales ranging from decimetres to several hundred metres, the spatial structures of microbial communities and soil enzymes are less clear. Previous work has primarily focused on spatial heterogeneity at a single analytical scale using the distribution of individual cells, specific types of organisms or collective parameters such as bacterial abundance or total microbial biomass. Fewer studies have examined variations in function and activity of soil microbial communities. This presentation will discuss environmental factors shaping the biogeography of soil enzymes at the micro-, plot- and regional scales.

Keywords：*soil microorganisms, biogeography, soil enzymes, scales*

O48-4

[C2.3-2] A: Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Soil Habitat Structure and Crop Management Influence Functional Diversity and Activity of Soil Microbiota

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With the current focus on security of food to feed the growing global populations through sustainable agricultural production systems there is a need to develop innovative cropping systems that are both economically and environmentally sustainable. Cropping sequence and stubble management practices provide options to improve and better manage soil biological functions by modifying populations and activities of beneficial and plant pathogenic microorganisms with consequences to production and soil biological health. Soil habitat structure and carbon availability can affect the functional capability of soil microbiota by influencing microbial functional diversity. Plant type can affect the functional capacity of different groups of biota in the root microbiome. Spatial location of microorganisms in the heterogeneous field soil matrix can have significant impacts on biological processes due to variation in the accessibility to energy and nutrient sources and habitability.

Surface soils (0-10 cm) collected from field experiments on Alfisol, Calcarosol and Vertosol soils in South Australia and New South Wales during non-crop season and in-crop were analysed for microbial genetic and catabolic diversity, activities of soil enzymes involved in C, N, P and S cycling and populations of beneficial and pathogenic soil fungi. Cropping sequence experiments at Karoonda (Calcarosol) were conducted at different landscape positions and soils ranged between deep sands on dunes and red sandy loam on swale. Genetic diversity of microbial communities involved in a range of soil functions was analysed using a functional microarray (EcoGeonomix terreArray, www.ecogeonomix.com). Soilborne fungal pathogen R. solani AG8 and mycorrhizal DNA concentration was quantified using a TaqMan RT PCR (PredictaB®, SARDI, Adelaide, Australia). Soil enzyme activities in wheat rhizosphere soils, collected at anthesis, were determined using standard colorimetric assays.

In short-term incubation experiments, substrate induced respiration was measured using macro-aggregates of varying size (0.25 – 2 mm dia.) collected from a field experiment. The composition and activity of microbiota in macro-aggregates can vary depending upon the forces of aggregate formation. Results indicated that accessibility to C source regulated the level of microbial activity in macro-aggregates of increasing size. We found significant changes in the functional diversity of microflora in root induced macro-aggregates following the death of the root. These results suggest that soil aggregates need to be considered as dynamic entities in terms of microbial composition and biological processes.

The EcoGeonomix terreArray analysis of DNA from field samples gave the required signal intensity for more than 75% of the total 14,677 probes in 7 different functional categories. Results showed a significant crop type based difference in functional gene diversity, e.g. approx. 7.2% of the probes showing significant differences between the crop types i.e. wheat, canola, medic pasture and cereal rye. Significant differences were observed for probes associated with a wide range of biological processes involved in C turnover, nutrient (N, P and S) cycling, N fixation, methane oxidation etc. Pair-wise comparisons showed that wheat-canola had the highest between-crop difference, followed by wheat-pasture and wheat-rye. Phylogenetic annotation of probes indicated clear differences in the taxonomic association for functional gene probes related to various biological processes between crops suggesting plant-type based differences in the phylogenetic makeup of communities involved in a biological process. Soil enzyme activities were also influenced by crop type and the effects varied with soil type at different landscape positions. For example, after canola dehydrogenase and glucosidase were higher on dunes and chitinase and urease activities were higher on swale, compared to that after wheat. Crop type effects were also observed in populations of soil fungal populations, e.g. canola and mustard reduced populations of plant pathogens such as Rhizoctonia solani and beneficial fungi such as arbuscular mycorrhizal fungi. In general, removal of stubble, conventional tillage and fallow had negative effect on the catabolic potential and diversity in soil. This is because stubble retention and tillage modify the physico-chemical properties of soil habitat and the location crop residues.

In summary, an improved understanding of the dynamics of functional gene diversity and biological processes can assist with matching soil biological capacity to agronomic management for sustainable productivity and ecosystem health.

Keywords : *functional diversity, biological function, crop sequence, aggregates, microarrays, enzymes*

O48-5

[C2.3-2] A: Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Processes and Filters Shaping Soil Microbial Diversity Assessed by High throughput Sequencing

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Biogeography is the study of the distribution of biodiversity over space and time in order to understand the processes and rank the environmental filters involved in shaping this biodiversity. One way to discriminate the spatial processing of microbial diversification is to evaluate the Taxa-Area Relationship, one of the oldest and most relevant empirical relationships, which corresponds to the turnover of biodiversity with increasing distance or area. Based on this approach, recent molecular fingerprinting studies demonstrated that soil microorganisms are not strictly cosmopolitan since their distribution is systematically heterogeneous and structured into biogeographical patterns. This leads to rejecting the first part of Baas Becking's postulate (1934): "Everything is everywhere, but, the environment selects". These studies also allowed an estimation of the relative importance of diversification processes: selection and dispersal limitation; and the identification of the environmental filters shaping soil microbial diversity: mainly pH, trophic resources (Organic Carbon and Nitrogen contents, C:N ratio), texture and land use. Nevertheless, the impressive power of new high-throughput sequencing technologies allows more detailed information on soil microbial communities which may lead to better evaluate the relative importance of the relevant diversification processes and identify the associated environmental filters.

Here, soil bacterial communities were characterized by means of molecular fingerprinting (A-RISA method) and 454-pyrosequencing (targeting the 16S rDNA gene) approaches on 411 soils from four French regions of contrasting environmental heterogeneity (Landes<Burgundy≤Brittany<<South-East, area range: 13800 to 33500 km²) using the systematic grid of the French Soil Quality Monitoring Network. The main objective of this study was to evaluate both molecular methods in regards of: (i) the estimation of soil bacterial communities' diversification (Taxa-Area Relationship), (ii) the relative importance of diversification processes, (iii) the identification of environmental filters involved in shaping soil microbial diversity.

Both molecular methods demonstrated significant turnover rates of soil bacterial communities, supporting that these communities were heterogeneously distributed and structured into biogeographical patterns in the four regions. Interestingly, although turnover rates estimated with high-throughput sequencing data were at least two-times significantly higher than those estimated with molecular fingerprinting data, differences between regions were independent of the characterization technique. Both molecular methods demonstrated also significant influence of dispersal limitations and environmental selection as processes shaping soil bacterial communities, except in Landes region where only environmental selection was involved, but the relative importance of each process was not influenced by the approach within regions. Regarding filters shaping soil microbial diversity, a larger set was identified with high throughput sequencing data than with molecular fingerprint approach, but similar spatial scales were determined for dispersal limits (coarse scales: 80 to 120 km; medium scales: 40 to 65 km).

Altogether, these results showed that molecular fingerprinting and high-throughput sequencing approaches are both relevant to highlight the spatial structuration of soil microbial communities and to estimate the relative importance of the processes shaping their diversity. Nevertheless, high-throughput sequencing provides more detailed information about microbial communities' composition and therefore a potentially more precise estimation of soil microbial community turnover rates, together with a more detailed identification of the environmental filters underlying environmental selection and spatial scales at which soil microbes may be dispersal limited. In addition, this will help to define the ecological attributes of soil microbial taxa and model soil microbial communities' composition over multiple spatial scales.

Keywords：*high-throughput sequencing, Taxa Area relationship, environmental selection, Dispersal, soil microbial communities*

O49-1

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Plant Residue Decay in Diverse Canadian Soils

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The decay of plant residues is tied to many ecosystem functions, affecting atmospheric CO2, plant-available nutrients, microbial diversity, soil organic matter quality, among others. The rate of decay, in turn, is governed by a range of management, soil, and environmental variables, some of which may be changing in coming decades. To describe mathematically the importance of these variables across a broad scale, we established in 2007 a long-term study at 10 sites across the agricultural regions of Canada, spanning a range of climate and soil properties. At each site, barley straw enriched with 13C (10 atom%) was applied at 200 kg C m-2 to soil microcosms (15 cm long, 10 cm diameter) inserted to 10 cm depth. All microcosms received additional unlabelled residue every fall (200 kg C m-2) and ammonium nitrate every spring (40 kg N ha-1). Hourly soil temperature was logged throughout the year at each site, and soil water content was also monitored during the frost-free period at one of the sites (Ottawa). Four replicate microcosms were removed from each site about 0, 0.5, 1.0, 2.0, and 3.0 years after applying residue to estimate decay using isotopic analysis. At all sites, recovery of applied 13C initially declined quickly – roughly half of the 13C was lost within a year – but the rate of loss then slowed. After 3 years, the amount of applied 13C remaining ranged from 13 to 28%. Much of the difference in observed loss among sites was related to variation in soil temperature. These findings illustrate the differences in initial decay rates across diverse sites, but suggest that prediction of decay rate can be improved with a simple algorithm based on cumulative thermal units. Future research, involving additional sites in an international network, will explore ways of integrating also other variables such as soil moisture and clay content.

Keywords：*13C, residue decomposition, soil carbon*

O49-2

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Physical Protection of Soil Organic C in Soil Aggregates: LTA Approach

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The relationship between soil structure and the ability of soil to stabilize soil organic matter (SOM) is a key element in soil C dynamics. Protection offered by aggregate structures and mineral surfaces is critical for building and maintaining soil C and N stocks. Techniques, that physically disrupt the soil structure, were generally used to study the relation between soil structure and C dynamics. In some cases images techniques (TEM, X-ray microtomography) or thin sections were used for "in situ" studies.
An alternative approach, based on Low-temperature ashing (LTA) technique, that let "in situ" studies, was employed to evaluate the C stabilization in the aggregates. LTA by oxygen plasma is a technique used for the removal of OM from soil samples with minimal or no damage to mineral constituents and without affecting the soil aggregate fabric.
The LTA treatment was applied until a constant residual C content in the aggregates is attained (measured by elemental analyser). Acting on the assumption that plasma oxidation mimics natural oxidative processes we consider the residual C as physically protected at the current conditions. In fact, after grinding the treated aggregates the residual C dramatically decreases.
In this study the stabilization of organic C was assessed in afforested (21 years earlier) spoil banks through the evaluation of the physical C-sequestration of soil aggregates and their water-stability.
The study site, Vincesimo, is located in a lignite-mining district of Tuscany, Central Italy. The lignite extraction caused the removal of large amounts of silt–clay lacustrine sediments and their deposition in neighbouring areas. Once the mining ceased, spoil banks were afforested using several indigenous species.
Undisturbed calibrate aggregates (0.5-1mm in size) were collected from both A1 (0-5cm depth interval) and A2 (5-15 cm) horizons of three soils under adjacent and coetaneous stands: 1) English oak; 2) comprising unmanaged Italian alder and oak, ratio 1:1; 3) comprising managed (thinning), Italian alder and oak, ratio 1:1, were compared with aggregates from a cultivated soil (field crop) of an adjacent spoil bank soil and from a natural soil under the adjacent forest.
In the top 5cm (A1 horizon) of the afforested soils it has been accumulated about more the 5% of C and less then 1.5% in arable soil (manure fertilization). On the other hand, in the deeper horizon, the accumulation of organic C ranged between 0.5% to 1.5%.
The physically protected C ranged from the 63% of the managed Alnus/Quercus to the 40% of the Cropped soil of surface horizon with reference to a total of 6.7% and 1.4 % of accumulated C, respectively. In the subsurface horizon only no managed Alnus/Quercus and Cropped soil stabilized around the 40% of C but with reference to a total of 1.5% and 0.6% of accumulated C, respectively. In the natural soil the stable C measured was around 57% in both horizons.
The strong positive correlation (R2 0.91) between residual C and the average diameter of the residual aggregates measured after immersion in water (slaking) by laser diffraction of samples 48h-LTA treated in comparison with the low correlation (R2 0.28) of bulk samples (control) indicates the positive effect of the protected organic matter in aggregate water-stability.
Moreover, the studied forested coal mine soils displayed to be a positive sink of C, in fact, these soils accumulated stabilized C, in the surface horizons, in spite of few years of forest growth.
The LTA approach could give an important help for the assessment of the potential C sequestration of soils and\or of the responses of individual ecosystems to changes in land use and management. In addition, it could be useful for the establishment of baselines of organic C levels in different soils.

Keywords：*Soil C stabilization, Physical protection, Soil aggregates, LTA, Coal mine soil*

O49-3

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Impact of Time and Land Use on Vertical Carbon Distribution and Soil Structure in Chernozems of Central Europe

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Soil organic carbon (SOC) based on solar energy is one of the two important non-living components of soils. Content and distribution of SOC influence the physical, chemical and biological soil characteristics and are the main driving force of mineral weathering and soil formation.

Soil studies across substrate age gradients (chronosequences) have enhanced our understanding of the directions and the rates of biogeochemical processes under different ecological conditions. However, SOM dynamics in the initial stages of soil development as well as the stabilization of SOC bound in aggregates and adsorbed on soil mineral surfaces are still poorly understood. Even less is known about the impact of different land uses on stabilisation processes and their influence on microbial decomposition with time.

Based on a chronsequence of alluvial soils in the Danube River Basin near Vienna/Austria (ranging from approximately 50–6000 years of soil formation (Lair et al., QGC, 2009), we assessed (1) SOC accumulation in function of the time of soil development, (2) quantity of SOC, its radiocarbon age and chemical composition in the clay sized fraction as well as in the bulk soil, (3) SOC content of various (ultrasound-) stable aggregate size fractions of genetic soil horizons in Fluvisols and Chernozems, developed under forest, grassland and cropland. (4) Additionally, we evaluated the soils of a small plot field experiment located in the study area, which had received C-14 labelled organic matter in form of straw and cattle manure in 1968 and allows for investigating the decomposition and translocation of the C-14 within different aggregate/particle size fractions and within the soil profile.

During the first stages of soil development SOC accumulates very quickly and approximately 4-5 mm of soil depth/year are formed, decreasing to less than 0.4 mm/year within the first 1000 years. Similar to bulk soil, the SOC content in clay sized particles under forest indicates a rapid accumulation during the first 350 years of soil development as well, which levelled off during the following some hundred years.

Soil management like tillage enforces SOC depletion and a low SOC content (<15 g/kg). However, a small but steady increase of about 1.5 mg C/kg/year could be observed in the clay sized fraction of the ploughed soil layers, which we relate to the co-evolution of organic matter and mineral surfaces (Fe- and Al-oxides).

The chemical composition of the SOC in the clay sized fraction, characterised by 13C NMR and thermal gravimetric analysis, showed concomitantly a steady accumulation of Aryl-compounds and a decrease of O-Alkyl compounds, especially in the soils under cropping, followed by soils under forest and grassland. In line with these results, we observed a maximum average radiocarbon SOC age of 1800 ± 35 years in the clay sized fraction in the ploughed layer of cropland, in contrast to only 840 ± 35 years, measured in the topsoil under forest (soil age >5000 years for both sites).

The SOC content of subsoils were much lower compared to topsoils, but the radiocarbon age reached more than 3500 years in the clay sized fraction as well as in the bulk soil, revealing clearly different SOC turnover rates at different soil depths. The vertical distribution of amended C-14 in the soil profiles revealed a small but deep translocation through seepage water and indicates a process of SOC-C14 stabilisation, because most C-14 had migrated from the silt sized fraction into the clay sized fraction during 44 years.

Our results show, that ecosystems progressively evolve through biogeochemical processes at different time scales and can be strongly altered by anthropogenic land management. We conclude, that organic matter becomes increasingly resistant against biological decomposition with time and forms stable microaggregates as shown in topsoils under agricultural cropping.

Keywords：*organic matter accumulation, soil chronosequence, clay sized particles, C-14 labelled manure*

O49-4

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Fate of Biochar in Chemically- and Physically-defined Soil Organic Carbon Pools

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Biochar is charcoal produced to use as a soil amendment in order to reduce emissions from waste organic material that would otherwise rapidly degrade to greenhouse gases. Carbon (C) sequestration potential of biochar is mainly attributed to its condensed aromatic structure. However, the success of biochar as a C sequestration strategy also depends on its interactions with soil. These interactions may involve physical protection of biochar within soil aggregates, chemical protection of biochar mostly through surface reactions, and the influence of native organic matter (OM) characteristics on biochar decomposition i.e. co-metabolic reactions. The objective of this study was to elucidate the fate of biochar in physically- and chemically-defined fractions of organic carbon (OC) of two distinct soils after 510 d of laboratory incubation. Fresh corn stover and biochars produced from corn stover at 350 and 550 °C (CS-350 and CS-550) were incorporated in a Typic Fragiaqualf (Tokomaru soil; TK) and a Typic Hapludand (Egmont soil; EG) at a dose equivalent to 7.18 t C ha–1. After 295 d, two undisturbed subsamples from each pot were taken: (i) in one subsample, lucerne (Medicago sativa L.) was seeded; (ii) in the other, the incubation was continued without plants. Soil samples at 0 (T0), 295 (T295) and 510 d (T510) were physically fractionated into coarse free particulate organic matter (fPOM), fine fPOM, silt+clay and heavy fractions, and analysed for δ13C and total OC. Furthermore, the bulk soil and soil physical fractions were chemically fractionated into oxidisable and hydrolysable fractions using 0.17 M K2Cr2O7 and 6 M HCl, respectively. After 295 d, δ13C fractionation revealed that >74 % (TK soil) and >64% (EG soil) of the biochar-C was recovered in the coarse fPOM fraction; 13 – 18% (TK soil) and 21 – 30 % (EG soil) in the fine fPOM fraction, and minor amounts in the silt+clay fraction. The same pattern was observed after 510 d, both with and without plants, although a significant increase ($P<0.05$) in the recovery of biochar C in the silt+clay fraction was observed, especially in the presence of plants. Most of the biochar particles thus concentrated into the fPOM fraction, so-called “unprotected pool”, which is generally considered as “labile C”. Treatments including the presence of both biochar and plants induced an additional accumulation of OC in the TK-350 and EG-550 soils ($P<0.05$), compared with the treatments with plants but no biochar. A method to improve the physico-chemical fractionation of biochar-amended soils is proposed in this study. The use of long-term incubations in studies of soil OM turnover (including biochar) where no inputs of fresh detritus are made is discouraged.

Keywords：*Biochar, corn stover, fractionation, particulate organic matter (POM), microaggregates, silt and cla*

O49-5

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

δ13c Values of Aggregates and Density Fractions Reflect Carbon Fluxes During Soil Organic Matter Formation

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Aggregate formation is a key process of soil development. Besides various important effects on physical soil properties, aggregates promote carbon (C) stabilization, e.g. by hindering decomposition of particulate organic matter (POM) and its interactions with mineral particles. C stabilization processes may lead to 13C fractionation and consequently to different δ13C values of soil organic matter (SOM) fractions. Differences in δ13C within the aggregates and fractions may have two explanations: 1) preferential stabilization of organic compounds with light or heavy δ13C and/or 2) stabilization of organics after passing one or more microbial utilization cycles, leading to heavier δ13C in remaining C. The first mechanism is partly dependent on the second. We hypothesized that: 1) 13C enrichment between the SOM fractions corresponds to successive steps of SOM formation; 2) during longer periods of SOM formation during continuous C input, the 13C fractionation (but not the δ13C signature) depends mainly on the transformation steps and not on the C precursors. Consequently, minimal differences between δ13C of SOM fractions under various ecosystems correspond to maximal probability of the SOM formation pathways.

We tested these hypotheses on three soils formed from cover loam during 45 years of growth of coniferous or deciduous forests or arable crops. Organic C pools in large macroaggregates, small macroaggregates, and microaggregates were fractionated sequentially for four density fractions to obtain free POM with ρ<1.6 g cm-3, occluded POM with two densities (ρ<1.6 g cm-3 and 1.6-2.0 g cm-3), and a mineral fraction (ρ>2.0 g cm-3). The total C as well as δ13C were measured in bulk soil, aggregate size classes, and separated SOM fractions.

Based on δ13C values of aggregates, we concluded that C in macro- and microaggregates has similar origin. δ13C values of the density fractions were enriched in the order: free POM < light occluded POM < heavy occluded POM < mineral fraction. This as well as C/N ratios of the fractions provided evidence that free POM is close to initial plant material, whereas the mineral fraction is the most microbially processed. These results agree with the existing concept of SOM pathways within the aggregates.

To draw conclusions about the successive steps of SOM formation, the Δ13C values between δ13C of SOM fractions and δ13C of bulk SOM were calculated. The calculated Δ13C values indicate that, parallel with biochemical transformations, the physical disintegration strongly contributes to the formation of free and occluded light POM. Furthermore, similarities of Δ13C in the heavy occluded and mineral fractions showed that biochemical transformations are more important than physical disintegration during the formation of heavy occluded POM from light occluded POM. Accordingly, the successive steps of SOM formation are: fLF<1.6= oLF<1.6→ oDF1.6-2.0 = MF>2.0. The obtained C steps were independent of the initial precursors (coniferous forest litter, deciduous forest litter, grass litter).

To test the second hypothesis, we proposed an extended scheme of C flows between the 3 aggregate size classes and 4 SOM fractions based on: 1) existing aggregate hierarchy concepts, and 2) confirmed hypothesis one. Based on Δ13C enrichment of the SOM fractions, the main direction of C flows within the aggregates and SOM fractions was determined: from the macroaggregate-free POM to the mineral microaggregate fraction. This confirmed the earlier concept of SOM turnover in aggregates, but for the first time quantified the C flows within the aggregates and SOM density fractions based on δ13C values.

Keywords：*Soil aggregates, Isotope fractionation, 13C natural abundance, Carbon stabilization*

O50-1

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Rhizosphere Management in Intensive Crop Production Systems of China

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How to achieve synchronously high nutrient-use efficiency as well as high crop productivity has become a challenge in the intensive agriculture of China. Here, the principle and practice of rhizosphere management for improving nutrient-use efficiency and crop production in intensive crop production systems were investigated. There is strong evidence indicating that plants exhibit large differences in their capacity to use soil nutrients through modifying root growth, particularly root morphology and root exudation. We found that root morphological development could be highly inhibited when excessive N was supplied in the intensive farming system. If N supply intensity is too low, root biological potential is difficult to be explored for efficient N use. Only at the critical level of N supply, there was a powerful development of root system, resulting in increased nutrient use efficiency.

The capacity to better match root systems to the soil nutrient supply offers the potential to improve nutrient use efficiency and crop productivity. The ideal root architecture for maize in our study is characterized by high sensitivity of enhanced root growth to both homogenous nutrient supply and localized nutrient patches. In China localized applications of N and P fertilizers have been recommended by soil scientists. Phosphorus banding near the root zone is recommended over conventional broadcast applications because banding fertilization saturates the soil with P in a relatively small area within the root zone, increasing P availability and stimulating root proliferation. Applying P with or near the seeds or starter-band N and P fertilizers at early stages is recognized to be a very effective strategy for stimulating root development and establishment of ideal root architecture, and increasing yields, particularly in the early spring season at low temperatures. Localized application of P combined with NH4+-N addition can significantly increase maize growth and acquisition of N and P in the early growth stages by stimulating root proliferation and rhizosphere acidification.

Rhizosphere processes are the linkage between plant processes and soil processes, which are a critical bottleneck controlling nutrient transformation and nutrient flow from soils to plants. A better manipulating of rhizosphere processes may provide an effective approach for improving nutrient use efficiency and crop productivity simultaneously through exploitation of biological potential for efficient acquisition and utilization of nutrients by crops, and reducing the over reliance on increased soluble nutrients from application of chemical fertilizers. The root-induced rhizosphere efficiency can be enhanced through optimize nutrient supply intensity to an optimal critical level; the rhizosphere efficiency can be repressed by nutrient-deficiency and excessive supply. This approach can modify rhizosphere processes and efficiency by regulating root development, carboxylate exudation, proton release, and acid phosphatase activity.

Our study shows that in intensive farming system, excessive nutrient input enhances the available nutrient concentration in root zone, which greatly inhibits the gene expression relative to P mobilization and acquisition. To increase the P-efficient gene expression by regulating nutrient supply intensity to a proper level through reducing excess fertilizer application is important to enhance P use efficiency. Small changes in rhizosphere processes can cause with big effect on rhizosphere efficiency, resulting in increased nutrient use efficiency.

The regulation of soil phosphorus-solubilizing bacteria-arbuscular mycorrhizal fungi interactions by starter fertilizer can improve P acquisition of plant from soil. The competition for acquiring organic P between AM fungus and bacteria inhibited the growth of alfalfa; such a competition may be conciliated by adding small a portion of soluble phosphate. In a soil of low inorganic P, the organic P mineralization by bacteria was less than bacterial immobilization and the AMF hyphae got less P. But if a portion of soluble phosphate was added, the condition changed. Adding small a portion of soluble phosphate as starter significantly increases P use efficiency.

The rhizosphere management reflects a shifting emphasis away from the conventional nutrient management with high inputs of inorganic nutrients to regulating root morphology and managing rhizosphere processes towards improving nutrient use efficiency and crop productivity. The rhizosphere management can maximize the efficiency of root/rhizosphere processes in nutrient acquisition by optimizing nutrient supply in root zone, regulating root morphological and physiological traits, and manipulating rhizosphere interactions. The strategy of rhizosphere management has proved to be an effective approach in increasing nutrient-use efficiency and crop productivity synchronously.

Keywords：*rhizosphere management, root manipulation, nutrient use efficiency, crop yield, intensive farming*

O50-2

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Phosphorus is Temporally Immobilized in the Rhizosphere of Crop Plants under Elevated CO_2

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Phosphorus (P) is an essential macro-nutrient for plant growth. As atmospheric CO_2 concentrations inevitably increase, the demand for P is also expected to increase to meet expected increases in plant biomass. However, in many soils the low availability of P may limit the positive response of plant growth to elevated CO_2 (eCO_2). Understanding the mechanisms of plant P acquisition under eCO_2 is important for developing P management strategies to cope with global climate change. This paper summarises our recent findings on the impacts of eCO_2 on plant P acquisition from soil.

Using a Free-Air CO_2 Enrichment facility (FACE), we demonstrated that increasing P supply increased the growth and total P uptake of two legumes: chickpea and field pea, with the increase being greater under eCO_2 than under aCO_2. Total P uptake under eCO_2 resulted from increased biomass production, rather than from changes in specific P-uptake capability.

Elevated CO_2 enhanced the accumulation of organic P (Po) in the rhizosphere of wheat and chickpea grown in soils with high P status. The two crop species however did not differ in their ability to access soil P pools irrespective of CO_2 treatment. Furthermore, the ability of plant access to P from sparingly soluble P sources was not affected by eCO_2.

To elucidate the mechanisms behind the increased Po under eCO_2, plants were labelled with $^{13}CO_2$ to quantify the plant-originated C flow in the plant-soil continuum. Elevated CO_2 increased ^{13}C enrichment in the rhizosphere and the number of rDNA copies from ^{13}C-DNA fraction. Furthermore, microbial biomass C and respiration in the rhizosphere exhibited the same increase trend with Po under eCO_2. The results suggest that eCO_2 increases root exudation which in turn stimulates microbial population and activity, leading to P immobilization in the rhizosphere.

In conclusion, eCO_2 increased P demand by crops but did not affect specific P-uptake capability of roots nor the utilization of P sources. Elevated CO_2 stimulated microbial activity which in turn immobilised P in the rhizosphere.

Keywords：*Rhizosphere, P immobilization, elevated CO_2, FACE*

O50-3

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Turnover and Losses of Phosphorus in Swedish Agricultural Soils: Long-term Changes, Leaching Trends and Mitigations Measures

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Transport of phosphorus (P) from agricultural fields to rivers, lakes and marine environments causes deteriorating water quality and eutrophication, often leading to severe algal blooms. Much attention during recent years in Sweden has been focused on eutrophication of the Baltic Sea for which the gross P load from agriculture is estimated to contribute about 45% of the total anthropogenic P load. Therefore, one of the most important actions for reducing P loadings to the Baltic Sea is to minimize non-point source emissions of P from agricultural land.
To reduce P losses, and to optimize phosphorus-use-efficiency by crops, we need to improve our knowledge of P turnover in soil. This was done in ten Swedish soil fertility trials which have been run for more than 50 years, consisting of two cropping systems including additions of farmyard manure and mineral fertilizer. Since 1950, there has been an accumulation of fertilizer P in Swedish arable soils amounting to, on average, 700 kg P ha-1. Questions addressed in the trials are: Which changes in organic and inorganic P occur in soil over time? How is extractable soil P (0.5 M ammonium acetate lactate) affected by different fertilizer P regimes over the long-term? How much soil P must be present in exchangeable form to ensure optimum crop yields? To what extent is fertilizer P utilized by crops?

At all sites, changes of extractable P were linear over time. The inorganic soil P pool was most important for the long-term P turnover. Fertilizer P accumulated as inorganic soil P and mining of soil P depleted inorganic soil P; soil organic P remained constant during accumulation and depletion. Depletion/accumulation of inorganic soil P takes place mainly through strongly bound P. One major finding was that replacement of P removed by crops through fertilizer P was not sufficient to maintain concentrations of extractable soil P. Correlations between rates of change in extractable P and different soil properties showed that only soil pH had a significant effect (R2=0.97**). Critical levels of extractable P to maintain high yields differed between crop types being highest for sugar beet and canola, and lowest for winter wheat. Efficiency calculations using the balance method revealed that as much as 100% of fertilizer P was recovered in crops over time.

To test best management practices (BMPs) to reduce P leaching losses via tile-drains, several Swedish research projects have been started during the past decade. Mitigation practices that have been tested include catch crops, constructed wetlands, liming of subsoil and various manure application strategies. Results from these studies showed that of the 8 catch crops tested, none was able to significantly reduce P leaching before they were exposed to freezing/thawing, whereas constructed wetlands reduced total-P loads by 36%, and incorporation of pig slurry in a clay soil by 50% as compared with surface application. However, the losses were overall rather small. The average diffuse P leaching load in Sweden is only 0.4 kg P ha-1 yr-1 and detection of small changes in P-loadings over time due to implementation of BMP practices requires long monitoring periods.

Long-term trends in phosphorus and other nutrient levels in surface waters have been monitored in small Swedish catchments since the 1980s. Results from these catchments provide important information on the effects of changing agricultural policies and preventive measures. In a trend analysis, it was shown that for dissolved reactive phosphorus (DRP), significant ($P<0.05$) downward trends were detected for eight out of twenty three catchments, and for the remaining catchments tendencies for downward trends were noted. For particulate P (PP), the testing revealed significant downward trends for only two catchments. This indicates that mitigation measures have been more successful in reducing DRP losses. It is also important to keep in mind that other factors such as weather conditions, soil type etc. also have a profound effect on P losses, which can mask the effects of BMPs. We still believe that even small losses can be reduced substantially through development and implementation of proper BMPs.

Keywords：*P use efficiency, soil P pools, diffuse losses, monitoring*

O50-4

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

25 Years of Research on Biological Nitrification Inhibition (BNI) by Grass and Trees from the Rhizosphere to Landscape in Savannas of West Africa: New Insights for Enhanced NUE and Soil Fertility

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Nitrification process, being involved in plant N nutrition and N losses through leaching and denitrification of nitrate, plays a key-role in ecosystem functioning and particularly in N-limited ones like wet tropical savannas. Regulating nitrification is thus central to any plant strategy for improving NUE. Biological Nitrification Inhibition (BNI) is an active plant-mediated natural function, where nitrification inhibitors released from roots suppress soil-nitrifying activity, thereby forcing N into other pathways.

We observed such processes in African savannas where grasses but also trees control nitrification. This is of great importance because: i) savannas and tropical grasslands represent 25% of terrestrial biomes and are second only to tropical forests for their contribution to terrestrial primary production; ii) more than half the surface of African continent is covered by savannas and savanna-forest associations; iii) African savannas are associated with the regions showing the strongest growth of human population, and are therefore particularly sensitive to changes in land use and climate; finally iv), most of savanna grasses are also of major economic interest, especially for grazing, and have been introduced in South America and Australia, where they have become invasive in some areas.

25-years studies in West African savannas showed that savannas exhibit two different types of N cycle, with high- and low-nitrification sites. Some dominant perennial grasses, such as some from Hyparrhenia or Andropogon genera, are mainly responsible for this duality. We showed that they express BNI differently between species, but also at subpopulation level, with widespread ecotypes being able to inhibit nitrification causing the general low nitrification status of savannas. Other less common ecotypes exist, unable to reduce nitrification and leading to the existence of nitrifying zones. At rhizosphere scale, we demonstrated high sensitivity negative or positive relationships depending on ecotypes between root densities and nitrification. At plant scale, the different nitrification rates led to huge differences in NUE that can explain differences in primary production that is 2-times higher for nitrification inhibiting subpopulation. These differences are at least partly explained by different plant intrinsic growth characteristics. Finally, at landscape scale, all grass species mainly expressed an inhibiting effect but inversely, all tree species expressed a very high stimulation impact, with nitrification up to 377-fold greater near trees.

All these inhibition/stimulation effects of biotic landscape elements seem site-dependant, linked to the overall baseline nitrification level of the two systems. They shape the global conservation of the nitrogen nutrients at ecosystem level, e.g. reducing the N losses through denitrification by 10-fold when BNI is expressed by the dominant grasses. These results are crucial to understand i) how to improve both NUE and soil fertility of tropical fallows and pastures and ii) if BNI processes can explain the invasiveness of African perennial grasses when introduced for pasture. Experimentations are currently undertaken to decipher how BNI impact indirectly soil functioning through modifications of total microbial diversity, but also the diversity of nitrifying and denitrifying organisms, and through the level of cattle or wild herbivores pressure.

Keywords：*BNI; tropical African savannas; tropical pastures; control of soil N fertility; NUE; grasses; trees*

O50-5

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Mechanisms of Fast Above-belowground Coupling of C Cycle: Pressure Concentration Waves Vs. Direct Assimilate Transport

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Plants have recently been recognized as drivers of rhizomicrobial respiration. However, the mechanisms involved in this above-belowground regulation are still uncertain. Particularly, it is not clear if the respired C originates from the direct translocation of recent assimilates from leaves to belowground with the mass flow, or from much faster mechanism based on phloem pressure concentration waves. The mechanism involved will determine the quickness of the response of the sinks: roots and rhizosphere microorganisms to changes in photosynthetic activity. The faster response is expected for indirect transition of information and is generally described as a propagation of pressure concentration waves after the loading of assimilated into the phloem with a contemporary expulsion of soluted organics from the opposed end of the phloem tube – from the roots. However, no empirical evidences yet exist to confirm the possibility of the indirect aboveground influence on the sink activity through the pressure waves' propagation.
The main objective of our study was identification of the mechanisms behind above-belowground assimilate transfer and turnover. In particular we attempted to induce pressure concentration waves propagation and evaluate its efficiency and quickness in soluted organics delivery to belowground in confront to direct molecule transport.
Corn grown in nutrient solution was dual labeled one month after the germination (plants height approx. 80 cm). 13C labeled glucose and 14C labeled carbonate was added at night to the soil solution. Subsequent treatments included simulation of various length of light and dark phases during the next 8 hours. Such experimental set-up was focused on sharp increase in photosynthesis rate for phloem loading. Consequently, soluble organics already present in the roots is expected to be pushed out into the solution by the pressure wave propagation. Dilution of the 13C and 14C label in the nutrient solution with unlabeled exudates was measured. If the dilution is very fast, it will serve as a confirmation of the propagation of the pressure/concentration waves throughout the phloem tubes. To account for the time of the translocation of the assimilates with the direct phloem flow to the roots, separate set of plants grown in solution and in soil was placed for 30 min in the atmosphere enriched with 14CO2. The kinetics of the 14C release from the solution and soil to CO2 was monitored during 3 days after the labeling.

We did not find any evidences of pressure propagation waves on root and rhizodeposition activity. Switching between light and dark phases did not induce any particular changes in total and organic C content as well as in 14C/C ratio of the nutrient solution compared to plants kept constantly in the dark. However, significant increase of root and rhizomicrobial respiration was measured within two hours after switching on the light, whereas CO2 evolved from pots with darken plants was not affected. In contrast, direct translocation of assimilates by phloem and their respiration to CO2 reached maximum almost 12 hours after the labeling of plants grown in nutrient solution. For plants grown in soil however, this delay was much shorter – four hours. We explain this by faster utilization of exudates by rhizosphere microorganisms compared to those living in nutrient solution.
We conclude that combination of labeling with timing of light/dark phases clearly shows that the phloem pressure-concentration waves are not affecting rhizosphere functioning. Therefore, the direct assimilate transport is the only significant mechanism linking the aboveground assimilation with C turnover in the rhizosphere and with CO2 fluxes from soil.

Keywords：*Rhizomicrobial respiration, Photosynthesis, Phloem transport , Pressure propagation, Labeling*

O51-1

[C3.6-2] Salinity Management when Irrigating with Marginal Quality Waters

Acacia Species for the Rehabilitation and Utilization of Salt-affected Lands and Waters

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Salt affected soils have higher concentration of soluble salts or exchangeable sodium affecting normal growth of most of the crops. Salt-affected soils may be saline, sodic or saline- sodic in nature. Availability of water is very crucial for the fulfilling the needs of present and future generations and its scarcity are increasing day by day due to climatic changes. Reclamation the salt affected soils have been done using different techniques like chemical treatments, tillage operations, crop based interventions, water-related methods, and electrical currents. However, in recent times, the most effective and low cost reclamation approach is the phytoremediation. The response of various plants for phytoremediation of sodic and saline-sodic soils varies with species. Many acacia species can survive at higher levels of salinity and sodicity, so they may be helpful for the reclamation of the salt affected soils. This project has been conducted to evaluate the comparative physiological, biochemical and phytoremedial performance of two acacia species of different origin for salt affected soils. The species used include Acacia ampliceps and Acacia nilotica. A number of different studies were done to achieve the specific objectives. In the first experiment, three weeks old seedlings of both species were transplanted in half strength Hoagland nutrient solution having five treatments (control, 100, 200, 300 and 400 mM NaCl). After eight weeks, the plants were harvested and the data were recorded. The data regarding growth and ionic composition (Na+, K+ and Cl-) showd that A. ampliceps was more tolerant to salinity than A. nilotica. The seedlings of A. nilotica could not survive at 400 mM NaCl due to ion toxicity.

In another solution culture experiment, the plants of both species were exposed to 100 and 200 mM NaCl concentration. After four weeks of salinity development plants were harvested and physical growth data were noted. Membrane stability index (MSI) and activities of antioxidants enzymes like superoxide dismutase (SOD), peroxidases (POD) and catlase (CAT) were determined using their standard methods. Root exudates were collected for the analysis of organic acids i.e citric acid, malic acid and tartaric acid. Shoot and root ash alkalinity was also measured. The results indicated that more rhizosphere acidification and higher activities of antioxidants enabled A. ampliceps to produce more shoot and root biomass and better respond to salinity. Both the species were further studied under the combination of salinity and water stress in the pots. The salinity levels (control, 10, 20 and 30 dS m-1) were developed in the respective treatment pots by adding calculated amount of NaCl. After the establishment of the plants water stress was applied during the period of the experiment. The results demonstrated that A. ampliceps proved to be better tolerant to salinity whereas A. nilotica performed better when salinity was combined with water stress. Postharvest soil analysis showed non-significant changes in the soil properties.

In the final study these species were grown in the salt affected field and their growth and ionic data was recorded after specific time intervals for two years. The changes in the soil chemical and physical properties were also determined at different intervals. The comparison of both species indicated that A. ampliceps produce more biomass and caused more reduction in the soil chemical properties like pHs, ECe and SAR as compared to A. nilotica, due to more addition of organic matter and rhizospher acidification. On the other hand the physical properties like bulk density and infiltration rate were also improved more in case A. ampliceps than A. nilotica.

On the basis of results of the presented studies, it can be concluded that salinity caused a significant reduction in growth of both the species however A. ampliceps showed more tolerance than A. nilotica due to its better physiological and biochemical mechanisms of salt tolerance. On the other hand, A. nilotica performed better when salinity was combined with water stress due to its xerophyte nature. A. ampliceps caused more phytoremediation of the saline sodic soil so it could be grown on such lands as a good source of fuel wood and forge for livestock at the same time rehabilitating barren lands.

Keywords：*Acacia, salt-affected land, saline water, salinity, sodicity, plant*

O51-2

[C3.6-2] Salinity Management when Irrigating with Marginal Quality Waters

Understanding Clay Mineralogy and Net Negative Charge in Relation to Soil Specific Threshold Electrolyte Concentrations

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There is competing pressure placed on good quality water resources, which limits the availability for irrigated food and fibre production. Marginal quality saline-sodic (MQSS) water presents a possible resource that could alleviate this pressure, but there are concerns for maintenance of soil permeability. While previous work has demonstrated that soil permeability can be maintained under high sodicity conditions with sufficient electrolyte, the threshold electrolyte concentration (TEC) at which this occurs has been shown to be highly site specific. Numerous research has suggested the individuality of TEC to be primarily governed by organic matter, clay content and clay type, whilst emerging evidence suggests that the net negative charge of clays is responsible for such an individual response. The work reported in this paper uses a large range of soils on which to demonstrate TEC individuality and understand the role of clay mineralogy and net negative charge on these. Clay mineralogy is determined through X-Ray Diffraction and the net negative charge of clays by use of zeta potential. Calculation of TEC curves from the south-eastern Queensland, Australia, soils illustrated that TEC relationships are soil specific within and between major soil orders. Through correlation based analysis, the relationships between TEC response, clay mineralogy, clay net negative charge, clay content and organic matter were determined.

Keywords：*marginal quality water, salinity, sodicity, threshold electrolyte concentration*

O51-3

[C3.6-2] Salinity Management when Irrigating with Marginal Quality Waters

Theory Put into Practice: Amending Water High in Alkalinity and Sodium within the Soil Profile

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Due to the increasing volumes of marginal quality waters and the strain on fresh water resources worldwide, there is an environmental responsibility to seek potential applications to use marginal water beneficially. However, irrigation of waters high in alkalinity and Na and low in Ca has the potential to cause environmental harm. In particular the high Na can cause dispersion and physical degradation of the soil. Traditional reverse osmosis desalination treatment of marginal waters is energy and capital intensive and generates concentrated saline wastes. Similarly, chemical amendment of marginal water by dosing with sulfuric acid and micronized gypsum at a dedicated water treatment facility also involves significant capital, energy, and operational (chemical) costs.

Theoretically, the chemical interaction between the alkalinity and Na in water and soil amended with gypsum and sulfur can result in appropriate amendment of irrigation water by neutralizing alkalinity and improving soil solution SAR. The oxidation of elemental S within the soil produces H2SO4, to neutralise the alkalinity from the irrigated water. Similarly, the addition of excess gypsum can not only decrease the SAR (by increasing the soluble Ca) but also remove alkalinity through the precipitation of CaCO3.

A repacked soil column experiment investigated the chemical amendment of alkaline sodic water within the surface soil profile as an alternative to the use of dedicated chemical amendment water treatment facilities.

Three soils of differing texture were investigated; a Red Ultisol, a Red-Brown Ultisol and a Brown Vertisol. Soil was collected from sites not previously irrigated. Soils were collected to a depth of 200 mm and repacked into PVC columns 150 mm in diameter and 700 mm high. Soils were amended with either gypsum alone (20 t/ha or 40 t/ha) or with both gypsum (5 t/ha) plus elemental S (3 t/ha). Amendments were applied either as a surface treatment or incorporated to a depth of 200 mm. Two grades of gypsum (mined gypsum and phosphogypsum) and S (powdered S and pelletized S) were investigated. Two control treatments were included in the study; (i) unamended soil irrigated with untreated water, and (ii) unamended soil irrigated with chemically-amended water. Water was irrigated at an equivalent rate totalling 36 ML/ha. Soil solution was collected periodically via polyacrylonitrile hollow-fibre samplers.

Results showed that the chemistry of water high in alkalinity and Na concentration can be successfully amended within the soil by land amendment (rather than through the use of dedicated amendment water treatment facilities). For all three soils, surface-application of amendments was more effective than when the amendments were incorporated to 200 mm depth. Although phosphogypsum is more readily soluble, no differences in soil solution surface SAR values were observed. Pelleted S provided a moderate rate of acid generation and is preferred over powdered S.

Using this preferred method for land amendment (i.e. surface-application of appropriate amendments), soil solution SAR values for the Red Ultisol and Brown Vertisol were similar when amendments were surface-applied (i.e. approximately 10-25), and in some cases lower, for amended soil treatments than in control treatments (SAR 15-35) which were irrigated with chemically-amended water. Thus, soil structural stability in those two soils can likely be maintained by land amendment. In comparison, soil solution SAR values for the Red-Brown Ultisol were higher. The SAR reached approximately 10-40 at the surface of columns for surface applied amendments, however this was still lower than for the corresponding unamended control treatment (SAR of 50-70). The reduced effectiveness of land amendment in the Red-Brown Ultisol likely resulted from (i) a slower release of acidity from elemental S under experimental conditions, resulting in the precipitation of soluble Ca which increased the SAR, and (ii) a low inherent soil buffering capacity (CEC of 2.3 cmolc/kg), which resulted in larger changes in soil chemical properties when treatments were imposed.

Overall, land amendment requiring minimal capital investment can be environmentally effective in treating water high in alkalinity and Na. However, prominent differences were observed between soils, demonstrating that some soils would require more frequent monitoring and flexible adaptive field management than required for standard chemical amendment facility water treatment systems.

Keywords：*salinity, alkalinity, irrigation, amendment*

O51-4

[C3.6-2] Salinity Management When Irrigating with Marginal Quality Waters

Impact Study on the Application of Vinasse to Cambisol and Vertic Luvisol in Ethiopia

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To study an impact on the application of vinasse to Cambisol and vertic Luvisol in Ethiopia, we used HP1 an hydrogeochemical models to assess the medium-term risks of the use of that agricultural practice by a Sugar Factory. The three water input scenarios tested play a major role in soil function and simulated soil changes after a vinasse input. There is always drainage in all three types of soil; it varies from slight (50 mm/yr) to fairly substantial (1000 mm/yr). However, the latter value is related to a scenario (i) that does not take rainfall into account in irrigation management and (ii) that ignores losses of water before it reaches the soil. Overall the conditions seem optimal, strictly from the water supply standpoint, for limiting the risk of salinization. Under the initial conditions, the irrigation water used was not heavily loaded with salts (ca. 4.5 mS/cm) and the soil exchange complex was 80% saturated with calcium because of the calcareous origin of the parent rock. The behaviour of the three soils is fairly similar overall. The input of vinasse, at a dose equivalent to 340 kg/ha of potassium, causes a significant increase in the concentrations of chemical elements in the soil solution but also greater leaching of these chemical elements out of the soil profile. Over time, the distribution of cations in the CEC does not change very much and appears to settle on noncritical values. Sodium, then potassium, partially replaces magnesium and calcium in the CEC, but ultimately the change is slight. The percentage of calcium in the CEC never falls below 75%. Saturation indices determine whether the physico-chemical conditions are such that minerals (halite, calcite, gypsum, etc.) will precipitate out and cause salinization. Our simulations show that when vinasse inputs are done at a normal dose (equivalent to 340 kg/ha of potassium), the risk of precipitation of minerals is nil, especially when water inputs are properly calculated (low drainage). However, when the inputs are doubled (equivalent to 580 kg/ha of potassium), several minerals are near supersaturation and therefore liable to precipitate out. The volumes of water supplied are also immaterial, since when drainage is slight, anhydrite and gypsum are the substances liable to precipitate out, and when it is greater, K-jarosite will. Therefore, whatever the water input scenario tested, we recommend against vinasse inputs at a dose equivalent to 580 kg/ha of potassium. On the other hand, for all three types of soil, vinasse inputs at a dose equivalent to 340 kg/ha of potassium present no medium-term risk of soil salinization. Moreover, at these same doses, no parameter (chemical composition, breakdown of elements in the CEC, SI, etc.) tends toward a critical threshold.

Keywords：*vinasse, spreading , HP1 , hydrogeochemical models*

O52-1

[C2.1-1] Quantifying Evaporative Fluxes from Terrestrial Surfaces

A Heat Pulse Probe Array for Subsurface Soil Evaporation Estimates

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Soil-water evaporation is a crucial component of both the surface energy balance and the hydrologic cycle, coupling heat and water transfer between land and atmosphere. Bare-soil evaporation and plant-soil-atmospheric interactions are important components of the water balance, especially in semiarid and arid regions. The rate of evaporation is affected by atmospheric variables and processes such as temperature, humidity, thermal and hydraulic conductivities, vapor diffusivity, and wind induced convection. Our research initially aims to determine subsurface water evaporation in a soil column exposed to constant atmospheric conditions with a heat balance method. In a second step, the sensible heat balance method will be applied under field conditions to assess the diurnal cycling of energy inputs. In-situ soil water evaporation dynamics are measured using a heat pulse probe designed to determine soil temperature and thermal properties. The probe consists of a heater needle and five or six thermistor needles. A small heat input is applied to a resistance wire in the heater needle, while the remaining thermistor needles measure the temperature response at fixed distances of 6.5mm from the heater. The heat pulse probe is rotated 27.3° from a vertical orientation yielding temperature measurements every 3mm within the soil profile. In order to get finer thermistor spacing near the soil surface, a sixth thermistor is added in between the top two array needles. Measurements of soil temperature and thermal properties (thermal conductivity and thermal diffusivity) obtained with the heat pulse probe array allow calculation of the sensible heat balance below the soil surface. The heat pulse probe array provides an effective means to determine subsurface soil-water evaporation rates and can be coupled with surface evaporation estimates using remotely sensed measurement techniques to allow separation of evaporation from evapotranspiration measurements.

Keywords：*Subsurface Evaporation, Heat Pulse Sensor, Soil Thermal Properties*

O52-2

[C2.1-1] Quantifying Evaporative Fluxes from Terrestrial Surfaces

Quantifying Evaporation from a Bare Soil Surface using an Open Top Chamber

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Planning for newly formed landscapes including revegetation like in rehabilitation of mine sites requires a good understanding of quantities of water available for plant growth. Particularly in semi-arid environments where a plant cover is often less than 50%, evaporation contributes markedly to the overall water flux towards the atmosphere. An accurate quantification of evaporation (E) often requires high technological effort, like the installation of (weighable) lysimeters. A relatively simple method is the use of open top chambers, which are widely used to determine the evapotranspiration of plants. This same approach was used to measure evaporation, only, from bare ground. The diurnal and daily E was measured at a site at initially dry soil conditions, but following a simulated rainfall event. The measurements showed that E decreased with increasing time after initial watering. However, a temporal pattern for daily E was observed, which was strongly linked to the atmospheric water demand represented by the vapour pressure deficit. A morning vs. afternoon relationship could be distinguished where E was higher at the same vapour pressure deficits in the morning compared to the afternoon. Loss of water at and close to the surface during the day led to more negative water potentials and hence lower unsaturated hydraulic conductivities, which reduced E. Based on the measured data, a hydrological model was employed to predict E based on soil physical properties. The model was able to predict the diurnal changes. This relationship was then used to determine at which soil moisture conditions E will be substantially affected during the course of the day by the change of soil physical conditions.

Keywords：*evaporation, open top chamber, modelling*

O52-3

[C2.1-1] Quantifying Evaporative Fluxes from Terrestrial Surfaces

Estimation of Soil Evaporation by Aerodynamic-profile Method used with Various α and β Formulations

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The evaporation from soil is a function of soil and atmospheric physical variables; hence evaporation from bare soil can be estimated from known meteorological variables while at the same time, The aerodynamic equation can be used to estimate evaporation when the surface soil is non-saturated by either employing the relative humidity at the soil surface, the so- called α-method, or by implicitly incorporating, via the β-method, However, none of the α and β equations, when incorporated into the aerodynamic method, were able to properly reproduce variations of evaporation from bare soil, neither under wet or under dry conditions. However, the β equations proposed by Deardoff (1978), Noilhan (1989) and Mahfouf (1991) performed relatively well when estimating the evaporation from bare soil when the moisture content was around field capacity.

Keywords：*soil evaporation, aerodynamic, α-method, β-method*

O52-4

[C2.1-1] Quantifying Evaporative Fluxes from Terrestrial Surfaces

Predicting Water Retention Curve from Two Point Measurement

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The soil water characteristic (SWC) is a fundamental property which controls soil water storage and movement. Various analytical functions are often used to describe SWC because they are convenient in the solution of numerical flow equations as well as the implementation of closed form methods of predicting unsaturated hydraulic conductivity. These applications will only be successful provided the analytical functions adequately describe the measured SWC data. Two large datasets from New Zealand and United Kingdom was used to evaluate analytical functions on the basis of how well they describe the measured data. Among the various analytical functions, simpler power law equation described measured SWC well and was only reported. Most of the errors with the power-law functions occurred at water contents near saturation. This may be from physically unrealistic equation discontinuity around the air entry potential. The good performance of the power-law form of equation enabled development of a method to predict SWC data from only two measured SWC points and a knowledge of soil bulk density. The power law equation was used in association with parabolic smoothing to obtain the parameters using just two measured SWC points. A very good prediction was obtained within the range of 0 to -150 m matric potential. The prediction based on two point measurement significantly reduced the cost of obtaining SWC data and provided an opportunity to overcome the constraint of widespread application of soil water simulation models based on Richard's equation.

Keywords：*soil water retention, parametric functions, Campbell equation, unsaturated hydraulic conductivity*

O52-5

[C2.1-1] Quantifying Evaporative Fluxes from Terrestrial Surfaces

Partitioning of Evaporation and Transpiration in Arid Shrublands

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Evapotranspiration (ET) fluxes often approach 100% of rainfall in arid climates. Consequently, understanding desert shrub water use has the potential to explain a significant proportion of the water balance and its variability. Plant cover, soil properties, and water budget represent closely coupled systems in water-limited environments. These relationships are influenced by the scale at which the phenomena are studied, due to the heterogeneity of soil, plant and atmospheric characteristics. The partitioning of ET into evaporation and transpiration has drawn increasing attention, particularly with respect to quantifying the control of shrub cover on water budget studies. The main objective of this study is to examine the effects of shrub coverage spatial patterns on simulated water partitioning into transpiration and evaporation in relation to the simulation cell sizes. Correlation lengths of spatially distributed shrub cover in fine resolution grid cells are used to distinguish spatial patterns (i.e., patchiness of arid environment landscape) of shrub distributions. We then aggregate the fine resolution grid cells into large cells of various hierarchies, calculate the potential transpiration of each large cell as a proportion of total potential ET with varying percent shrub cover in the large cell, and simulate the partitioning of actual total ET. The effect of simulation cell size and spatial patterns of shrub distributions on the water partitioning in a heterogeneous field is examined. Results illustrate that simulated transpiration increases with cell size, while evaporation rate and total evaporation do not change significantly. The spatial distribution of shrub pattern influences the partitioning of ET into transpiration and evaporation. Transpiration portion increases with decreasing correlation length of shrub spatial coverage. Significant differences in transpiration and evaporation partitioning are linked to the different correlation lengths, due to the highly non-linear relationship between potential transpiration and percent shrub cover, which indirectly take into account subsurface lateral flows in the root zone.

Keywords：*Evapotranspiration; partitioning; shrub spatial pattern; modeling.*

O53-1

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Supply and Demand: What Australian Soil Science Students Get and What Australian Employers of Soil Scientists Want

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As indicated in a companion paper, there is a growing need for graduates with soil science knowledge that is applicable to a diverse range of end-users and employers. In Australia, at present, graduates with soil science knowledge may be employed in the agricultural, environmental, engineering and government sectors, and may find themselves working as researchers, consultants, technicians, regulators, policy makers or communicators. With such an array of potential career paths, the ways in which soil science knowledge could be used are many, and the type of soil science knowledge required by particular jobs could be quite different. To investigate how well matched are graduates' soil science knowledge and the soil science knowledge demanded by employers and stakeholders, we carried out a Delphi study of soil science learning outcomes at eight Australian universities and a narrative survey of soil science topics focused on by several relevant governmental and industry stakeholders. For the Delphi study, the soil science learning outcomes were grouped into seven teaching applications, namely, (i) soil genesis, classification and morphology, (ii) soil chemistry and mineralogy, (iii) soil fertility and nutrient management, (iv) soil biology, microbiology and ecology, (v) soil physical properties, (vi) land use management, and (vii) soil information systems. For the narrative survey, the annual reports over the period 2007-2012 of the Australian Centre for International Agricultural Research (ACIAR), the Australian Government's Department of Agriculture, Fisheries and Forestry (DAFF), the Australian Government's Department of Environment (DE), Dairy Australia (DA), the Grains Research and Development Corporation (GRDC) and Meat and Livestock Australia (MLA), were analysed for references to soil issues and functions, and these references aligned to the seven teaching applications listed above. Results from the study of university soil science teaching and learning showed a slight emphasis on (v) soil physical properties, but with the exception of (iv) soil biology, microbiology and ecology, and (vii) soil information systems, all of the other teaching applications were fairly widely represented across the eight universities. The two exceptions (iv, vii) were notably under-represented across the universities surveyed. The results of the narrative survey of stakeholders showed considerable variation in soil science topic emphasis between the different government departments and industry bodies, and also (in some cases) considerable variation from year-to-year. Not surprisingly, the production-focused stakeholders including ACIAR, DA and MLA made most references to (iii) soil fertility and nutrient management. In contrast, the production-focused GRDC, although having a slight bias towards (iii) in each year, made reference to all of the teaching applications across all years, indicating a very broad interest in the discipline of soil science. References to soil in DAFF reports were dominated by (vi) land use management, while in DE reports references to soil were generally dominated by teaching applications (ii) and (iii). Only in the 2007/2008 report of MLA was (v) soil physical properties, the dominant soil theme reported. On the whole, for the universities surveyed and the stakeholder reports analysed, there is a moderate matching of soil knowledge 'supplied' to graduates and soil knowledge 'demanded' by stakeholders. To strengthen the certainty of this conclusion, however, further survey work of other university providers of soil science teaching needs to be done, along with further analysis of the demands of other groups of stakeholders and employers. The soil science knowledge requirements of agricultural and environmental consultants, for example, may differ markedly to those of large government departments and industry peak bodies.

O53-2

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Soil and Soil Science Education in the Compulsory and Vocational Education through Korean Textbooks

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Public education on soil and soil science in Korea was reviewed through textbooks written in Korean Language which were taught in compulsory and vocational courses in primary, middle and high schools. Numbers of words 흙(Heuk), Korean native word, and 토양(To-yang), Chinese originated one, of which meaning was both soil, were counted and compared with the old textbooks published in 1950's and 1990's. Contents in the science and practical courses in primary and middle school, and vocational courses for agriculture and technology in high school were reviewed focused on soil education.

Compulsory public education through Korean Language textbook was begun in 1950 under the Law of Education proclaimed in 1949 after independence from Japanese occupation. The Korean native word “Heuk” was used 18 and 25 times in the 1955 and 1996 version of the Korean reading textbook of the primary school, but was done 13 times in the 2012 version. The first appearance in the 1955 version was in the 3rd grade book, but was in the 1st grade books in 1996 and 2012. In this recent version, the primary school student met this word at first on the poet “Toad, Toad build a house”. In the science course book of the 4th grade, the precious resource, Heuk, was introduced, and observation experiment was guided as the chapter, “Changing of ground surface”. However, the scientific word, To-yang, was used only twice together with environment. In middle science course, soil was simply introduced as a part of geosphere. In the high school science course of general schools, role of soil in the environmental system was described as the plant growth medium, the water reservoir, environmental purifying tank, preserving cultural heritage, and the base of construction site. In the vocational courses of the technical high schools, details on soil characteristics and role of soil science were described in the textbook, Production Material” written by senior author and his colleagues. Soil information system, “Heuk-To-Ram”, was introduced in this book, and practical application was involved as well.

Authors recommended more valuable soil information should be provided to the compulsory , and vocational education courses to expand understanding on the 'precious soil' for public.

Keywords：*soil, Heuk, public education, compulsory education, Heuk-To-Ram, soil information system*

O53-3

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Expanding the Horizons of Soil Science to the Public

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Soils are critical to all life on the planet yet most individuals treat soil like dirt. As soil scientist we have long recognized this and have struggled to find ways to communicate the importance of soils to the public. The goal is not purely altruistic as we recognize that society funds or research and provides the workforce in soils that we need to continue to gain knowledge and expertise in soil science. In 2006 the Soil Science Society of America took a bold move and created its K12 Committee in part to compliment the Dig It! The Secrets of Soil exhibit that opened in July 2008 at the Smithsonian's Institution's Nation Museum of Natural History (of which SSS was a founding sponsor). The committee's work began quickly with a website designed to provide resources for K12 teachers (primary and school teachers). The first accomplishments included reviewing and posting links to web based information already available to teachers. These links were sorted by subject and grade level to make it easier for teachers to navigate the web and find what they needed quickly. Several presentations and lessons designed for K12 teachers were also posted at this time. Concurrent with this effort a subcommittee review and organized the national teaching standards to show where soils could fit into the overall K12 curriculum. As the website was being developed another subcommittee developed a soils book (Soil! Get the Inside Scoop, 2008) to further compliment the Dig It! exhibit. This was a new endeavor for SSSA having never worked with the non-academic audience in developing a book. Peer-reviews of this book included not only scientist but also students in order to make sure the book was attractive to them. Once the book was published and the website developed it became clear more outreach was needed. SSSA K12 Committee has attended both the National Science Teachers Association (since 2008) the USA Science and Engineering Festival (since 2010) with exhibits and workshops. It has cooperated and contributed to the American Geologic Institutes' Earth Science Week materials with brochures and lesson plans and with National Association of Conservation Districts by providing peer-review and distribution of materials. The most recent developments from the committee include a web redesign that is more student and teacher friendly, the development of a peer-review system to publish K12 Lesson Plans, and finally the publication of a new soils book (Know Soils, Know Life, 2012) for the 8-12th grade audience. It is hoped that Know Soils, Know Life will be used by the Cannon Envirothon and environmental science students and teachers. Future activities planned include a state soils book, teacher's guide for Know Soils, Know Life and development of a searchable digital photo/video library. Overall this committee has been exceedingly productive in its brief 8 year history.

Most recently and in part based on the success of the K12 Committee's success, SSSA created an Identity Committee with the goal of not only reaching our members and other related scientist but also to better engage the public and the media. The efforts of this committee have been to redesign our web site to make it more accessible to the general public. The opening page has interest of a general nature and links that some who knows nothing (or very little) about soils can navigate to find out more. Prominent on this home page are links to soil questions posed by the public and answered by soil scientists. There is also a soil related blog as well as a resource for soil photos. In order to encourage secondary school students to consider a career involving soils there are profiles of individuals who are researchers, consultants, teachers and artists as well as soil scientists. The hope is that all this information will inspire a new generation of soil scientist as well as help the general public understand that soil is not just dirt.

Keywords：*Education, outreach, wesite, blog, Secondary and primary education*

O53-4

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Monitoring Soil Science Program for Schools

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The Monitoring Soil Science Program introduces soil science into school science curricula, providing opportunities for students to learn about soil science and to develop their own research projects. The program is relevant to students at all high school levels, as well as to primary school students. The Monitoring Soil Science Program has direct links to the Australian Curriculum through Biological Sciences, Chemical Sciences, Earth Sciences, including Science Inquiry and Science as a Human Endeavour.

The resources for the Monitoring Soil Science Program were developed by the SPICE team at The University of Western Australia (UWA). The SPICE team present Professional Development Workshops for teachers to introduce them to the resources available and to provide practical experience in their use. This program was supported by IUSS in collaboration with UWA in 2010, and since then, additional resources have been developed by SPICE to expand its suitability to students of all ages. The resources are available on a website for teachers to use in their classrooms. The resources include (i) a "Monitoring Soil Science Manual", (ii) "Soil Life" (for Year 9 Biological Science - energy in ecosystems) and (iii) "Introduction to Soil Science" (a primary school resource). "Soil Life" is a learning resource package which addresses Year 9 Biological Sciences outcomes for the Australian Curriculum. It specifically includes concepts such as feeding relationships, food chains, food webs and energy flow through ecosystems in the context of meso-fauna communities within the soil. Opportunities for scientific investigations is also presented within this resource. "Introduction to Soil Science" enables primary students to engage with the world of soil meso-fauna, explore feeding relationships and investigate how changes to variables can affect populations of soil organisms.

The Monitoring Soil Science Program has been implemented at Shenton College which is the leading coeducational school in Western Australia. The Monitoring Soil Science Program is included in this school's Science Curriculum for Year 8 and 9 students (approximate age 13-14 years). It is a very successful program, which engages and excites students. Currently, collaborative programming for teaching and learning is being conducted between Shenton College in Perth (Australia) and the Sichuan University High School (China) in a sister-school relationship.

The Monitoring Soil Science Program has also been used by Shenton College as a science extension program. Cameron Gardner started his soil science project as a Year 10 student in 2012 and continued with additional research in 2013. He conducted a series of research projects using soil collected from The University of Western Australia's farm at Pingelly (UWA Future Farm), which is in a wheat/canola and sheep production region. Cameron's school science project included (i) hypothesis development and experimental design, (ii) analysis of soil fauna in relation to land use at 8 sites on the farm (iii) analysis of mycorhizal fungi in roots of bait pasture plants grown in soil from the 8 sites, and (iv) analysis of bacterial diversity based on molecular analysis of bacterial DNA using the Ion Torrent Personal Genome Machine. He also gained experience in presenting soil science information in posters and in oral presentations. His research took him to Beijing and Singapore for international science initiatives, and he participated in the BioGENEius Challenge conducted by the Western Australian State Government. The activities involved soil collection, glasshouse experiments, soil and root analysis, DNA extractions, soil fauna quantification, assessment of mycorrhizal fungi in roots, data analysis and collaboration with other students in explaining soil information.

The Monitoring Soil Science Program is used regularly at the UWA Future Farm with visiting school students from city and country schools. During these visits, students investigate soil, plant roots and soil fauna extracted from soils with different land use histories. The associated activities introduce school students to below-ground life in soil using individual microscopes or projected on screens to the whole class. Digital microscopes and basic equipment for extracting soil fauna were provided to country schools near the UWA Future Farm as part of the "UWA Gives Back" initiative in 2013.

Our experience with the Monitoring Soil Science Program over several years has demonstrated it has direct links to many aspects of school curricula. The program provides a framework for teachers to easily include aspects of soil science in their teaching schedules.

Keywords: *schools, teachers, science investigation, teacher resources*

O53-5

[C4.4-1] Education and Social Awareness for Soil Science in General Public

A Global Soil Monolith Collection for Education and Advocacy on Soils of the World

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The World Soil Museum in Wageningen, The Netherlands, has a collection of over 1100 soil profiles from more than 70 countries. These profiles are vertical sections of the soil that show the composition, layering and structure of the soil in manner very close as to how the soil may be viewed in the soil pit in the field. Most profiles have been sampled up to a depth of 1.50 m and are conserved through impregnation with diluted lacquer. The thickness is about 6 cm's. Such preserved soil profiles are called soil monoliths. The collection is unique in the world and specimens representative for the units of the legend of the Soil Map of the World, or it successor, the Harmonised World Soil Database.

The soil profiles on display represent the 32 major soil groups of the World Reference Base for Soil Resources and the variation of soils within those groups. Also soils are presented according to the soil forming factors and in special themes such as land management and soil colour. The Dutch soil collection is important for serving broader visitor groups, as some visitors, such as secondary school classes, are specifically interested in the Dutch landscape and soils. The uniqueness and the value of the collection of soil profiles (soil monoliths) and associated collections, such as soil samples, hand pieces, thin sections, slides, is emphasized by the fact ISRIC is the only World Data Centre for Soils (WDC-Soils) within the World Data System of the International Council of Science (ICSU).

Broadly speaking, the World Soil Museum has five functions: (i) education and courses, (ii) research, (iii) information and edutainment, (iv) social function, and (v) a real museum function (Art). The World Soil Museum is well known in national and international circles soil and the English name has almost 4,000 references on the Internet. The museum is housed in a new building, opened early 2014, on the Wageningen Campus.

In the museum visitors learn about the role of soils in life and ecosystems and get an impression of the enormous variation of soils in the world. A wide range of soils are displayed with their different properties and management requirements. A selection of 80 soil monoliths are on display. Interactive displays support education; a large monitor is placed centrally in the exposition and serves as a portal to global soil information. The map data refer to the monoliths on the walls and vice versa. Around the central map six theme stations communicate current topics that show the relevance of soil in different fields. For the general public it explains the principles of soil formation and it shows the relevance to actual issues like food production,soil management and climate change.

About 1000 people visit the museum each year. Visitors are mainly university and college students from Western Europe. Other visitor groups that have found their way to the museum are students from disciplines broader then soil science, such as geography and rural development. Secondary school classes visit the museum for geography classes. With the new facilities,in a new building on Wageningen Campus opened early 2014, the number of visitors are expected to rise and the user groups broadened.

O54-1

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Characteristics of an Abandoned Peat Mining Area Underlain by a Sulfidic Subsoil

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Black shists are metamorphic rocks commonly rich in sulfidic minerals such as FeS2 and CuFeS2. Mining activities often take place in these areas, and acid drainage, associated with oxidation of sulfidic minerals to sulfuric acid and dissolved heavy metals, is a well-known problem. These rocks are common in Eastern Finland [1]. During the Weicheselian glaciation, ending at 10,000 yrs BP, part of the bedrock was crushed and ground by the continental ice, and quaternary deposits containing sulfidic materials were formed in areas where black schists are common. In humid climate these sulfidic materials have been preserved in soil particularly where peatlands occupy the landscape. Peat mining has exposed the waterlogged deposits to oxidation, due to ditching and complete or partial removal of the peat. Penetration of atmospheric oxygen into the sulfidic subsoil has resulted in acidification of soil and acid drainage waters [2] like in mining areas and in coastal acid sulfate soils.

In Parnansuo mire in Joensuu, eastern Finland, peat was excavated from 1979, and since 2011 the area is in agricultural use. When peat excavation ended, the thickness of peat varied from non-existent to 0.7 m. Yellow colours of jarosite were abundant in the soil, particularly on ditch walls, indicating oxidation of sulfidic materials. Human influence has converted the Typic Cryofibrists, sulfidic materials below the diagnostic depth (<100 cm), to Typic Sulfosaprists or Typic Sulfaquepts. In May 2012, the 30-ha area was sampled in 16 points and soil pH, redox potential, electrical conductivity and sulfur content was measured down to about 100 cm. In a repeated leaching experiment, where the total amount of water equaled to the annual runoff in the area, chemical composition of the leachate was monitored and potential load of acidity that can enter the recipient waters was estimated.

In the topsoil, the pH in the field ranged from 2.8 to 3.7. Groundwater seeping into a 1.1 m soil pit was high in soluble iron (250-500 mg/l). The loamy mineral subsoil contained 0.5% carbon and 0.54% total sulfur and it was acidic already in the field (pH 2.9 - 5.5). During a 6-week incubation the pH dropped further to 2.6 - 3.3, indicating the presence of sulfidic materials. The greatest drop occurred in locations that had the thickest peat cover and lowest redox potential (-50 - 100 mV) in the field. In the leaching experiment, the pH of the leachates averaged at 3.3 and sulfur removal was 1.8 g dm-3 of soil, corresponding to 18,000 kg ha-1 from a 1m layer. Assuming that all leached sulfur originated from oxidizing sulfidic minerals, accompanied with an equivalent amount of acidity, about 50 t ha-1 of CaCO3 would be needed for neutralization. Low soil pH to start with and rapid leveling of the pH in the leaching and incubation experiments indicate that sulfidic materials were already actively oxidizing. Abundant leaching of acidity and metals has probably occurred already during the three decades the area was used for peat excavation.

The closer to the soil surface the sulfidic materials are, the more challenging is their sustainable management. In coastal acid sulfate soils of Finland sulfidic materials most commonly occur at 1-1.5 m from soil surface [3]. In peat mining areas they can extend up to soil surface if all peat is removed, which enhances rapid oxidation and high loads of acidity. In spite of their limited extent, these soils can result to severe acidification of waters. Acid drainage can locally cause substantial ecological damage in the recipient rivers and lakes consisting of soft water with low pH buffering capacity. New methods are needed to control acidification in peat mining areas affected by black shists.

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Keywords：*acid sulfate soils, black schist, peat mining, acid drainage, sulfur*

O54-2

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Formation of Inland Saline Acid Sulfate Soils in the Saloum Region, Senegal

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Acid Sulphate Soils (ASS) are formed in coastal environments (Coastal Acid Sulphate Soils, CASS) as well as in continental environments (Inland Acid Sulphate Soils, IASS). Similar biogeochemical processes develop when reduced medium by prolonged waterlogging becomes an oxidizing medium. Among these processes, the oxidation of pyrite generating sulfuric acid dominates. CASS are related to the presence of a mangrove ecosystem and form a physical and chemical ripening due to changes in the hydrological regime. IASS are associated with ancient deposits of organic matter buried in continental deposits and undergoing prolonged oxidation. They are much less common and were mainly described in Australia.

In West Africa, the CASS are widely represented as the mangrove was formerly installed in Holocene fluvial deposits from the estuaries of major rivers: Senegal, Sine Saloum, Casamance rivers in Senegal, Gambia river in Gambia, Geba and Cacheu rivers in Guinea Bissau, Great Scarcies rivers in Sierra Leone. Their natural formation was accelerated in the 1970s due to the drastic drop in precipitation. They are often affected by salinization processes related to seawater intrusion in surface and underground. IASS occur in more continental environment and are generally near coastal rivers.

In Senegal, CASS in the lower valley of the Senegal river are associated with vertisols in the middle valley. However, CASS in the valley of Casamance river are connected to red soils (ferralsols) distributed atop the surrounding plateaus by a system of soil transformation where the iron removal processes along the slopes dominate. The objective of the study is to characterize, in a pedological and mineralogical point of view, the ASS in the valley of Saloum River Valley which lies in an intermediate climate context between that of the Senegal river in the north and that of the Casamance river in the south.

The climate of the Saloum region is sudano-sahelian with an average annual precipitation of 600 mm, a wet season (from June to October), a cold dry season (from October to February), a hot dry season (from February to June) and evapotranspiration potential ranging from 1500 to 2000 mm per year. The study site is located 50 km from the sea, 20 km west of the Kaolack town and near the Saloum river whose salinity is higher than that of seawater. A selected toposequence (14°4'20"N, 16°10'59"W) encompassed three topographic units with different pedoenvironmental conditions: floodplain, low terrace and middle terrace. The elevation was ranging from 20 cm in floodplain to 1.15 m in low terrace and 4.15 m in middle terrace. The methodology used was based on (i) the soil description, according to the World Reference Base, of the toposequence with nine soil profiles, (ii) the physical and chemical characterization of soils (iii) the mineralogical characterization of the solid phase by X-ray diffractometry.

The described soils are distributed along the toposequence as Gleyic Hyposalic Solonchak in floodplain, Haplic Gleysol in low terrace and Endogleyic Arenosol in middle terrace. The middle terrace is characterized by a coarser soil texture (mainly sand) compared to the floodplain and the low terrace. The variations of the groundwater level lead changes in soil colour indicating the presence of redoximorphic features at various depths according to the landscape position. The bulk mineralogy is dominated by quartz. The downstream soils (floodplain and low terrace) highly contain halite. Feldspar was only identified in the floodplain and low terrace profiles. The vicinity to the estuary explains the higher amounts of halite and feldspar, mainly albite ($NaAlSi_3O_8$) in the floodplain soils compared to the low and middle terraces. Pyrite is present in the floodplain while jarosite was detected in the floodplain and low terrace. Hematite is only present in the low terrace, while lepidocrocite occurs in all the profiles. Kaolinite is the dominant clay mineral in the entire toposequence suggesting an eolian origin from regional sources. Smectite is also found in all the soils.

The ASS in the valley of Saloum river are more closely related to IASS than CASS, especially by their more continental geographical position. There is a continuum between the soils of the floodplain and those of the middle terrace. The soils of the middle terrace are formed by aeolian deposits that appear to cover former ASS.

Keywords : Acid sulphate soil, mineralogy, salinity, mangrove, Saloum, Senegal, West Africa

O54-3

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Increasing Rice Production on Soils Developed from Pyritized Coastal Sediments in the Malay Peninsula

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The Last Glacial Maximum was known to take place some 20,000 years ago. When global ice melt the sea level in Southeast Asia rose 15 mm/year, reaching its maximum height of 5 m above the present level 4300 BP. During this time, part of the coastal sediments in the Malay Peninsula was inundated with seawater and subsequently pyritized. When the sea prograded, the present coastal landscape was formed in the peninsula; these are the areas where acid sulfate soils occur. Some of these soils are utilized for rice production, but the yield is below the national average of 3.8 t/ha/season. The low rice yield is attributed to low pH, Al3+ and/or Fe2+ toxicity. The objectives of this paper are: 1) to explain the pyritization process occurring in the Malay Peninsula during the Holocene; and 2) to determine its effect on soil properties and rice production.

This study consisted of four parts: 1) A study on the process of pyritization of the coastal plains in the Malay Peninsula; 2) Laboratory study to test the effects of pH, Al and Fe on rice growth; 3) Glasshouse experiment to determine the efficacy of lime, basalt and organic fertilizer as soil ameliorants; and 4) Field trials. For the laboratory, glasshouse and field studies, rice variety MR 219 was used as the test crop.

Result showed that pyrite (FeS2) was sporadically distributed at the study sites, occurring up to 10 km from the present coastline of the Malay Peninsula. When this area was opened up for development, the pyrite was exposed to the atmospheric condition, and subsequently oxidized, releasing acidity, Al and Fe. The soils were very acidic with pH < 3.5, containing high concentration of Al and Fe.

Water pH in the paddy fields was < 4. At low pH, root cells were severely damaged by the presence of high concentration Al and/or Fe, shown by the negative correlation between root length and Al and/or Fe concentration. Applying ground magnesium limestone (GML) at the rate of 4 t ha-1 increased water pH, but it was still below 5, implying that Al still remained a threat to rice plant.

Rice plants grew quite well when GML or basalt was applied at 4 t ha-1 in combination with organic fertilizer. Water pH was 4.5 and so Al3+ existed at toxic level. How rice was able to defend itself against Al3+ toxicity- Al3+ was attracted to the negatively-charged cell walls of rice roots that released organic acids, which in turn, chelated the Al3+, rendering it inactive. Rice was also able to overcome Fe2+ toxicity. When the soils were submerged, Fe3+ was reduced to Fe2+ ion. Fe3+ hydrolysed in water:

Fe3+.6H2O + H2O → Fe2+OH.5H2O + H3O+ (pKa of Fe is 3)

The pH of water was above 3 due to GML or basalt treatment. Therefore, the reaction of Fe hydrolysis was in the reverse order, resulting in the precipitation of Fe(OH)3 that would appear as brown crust on the roots of rice, preventing further uptake of Fe2+.

The critical pH and Al concentration for rice variety MR 219 were about 6 and 20 μM, respectively. However, water pH of the paddy fields in the vicinity of acid sulfate soils in Malaysia was < 4 and therefore Al concentration was very high. To raise the pH and consequently precipitate Al as inert Al-hydroxides, GML or ground basalt has to be applied at the rate of 4 t ha-1. The best way is to apply GML or basalt in combination with organic fertilizer.

Al concentration in the root of the control treatment was 1.06%. Treating the soil with basalt at the rate of 4 t ha-1 had reduced the Al concentration in the root to 0.86%. The dissolution of basalt had released SiO44-, which was subsequently hydrolyzed to release OH- and monosilicic acid (H4SiO4) that had been taken up by the rice plant. Si was able to improve rice growth and reduced the incident of rice blast disease.

Keywords：*Acid sulfate soils, pyritized coastal sediment, Al tocicity, Fe toxicity, rice production*

O54-4

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Stable Sulfur Isotopes in Acid Sulfate Soils: Baseline Studies for Se Australia

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Acid sulfate soils (ASS) occur in many coastal and inland environments in Australia and around the world. The oxidation of ASS materials causes considerable environmental harm including the production of acid, release of toxic metals, fish kills and degradation of aquatic ecosystems. The use of stable sulfur isotope ratios is a geochemical technique that is sensitive to environmental conditions and can provide valuable information about the formation and oxidation of ASS materials.

The aim of this study was to establish a baseline for the use of stable sulfur isotopes in ASS in eastern Australia. δ34S was determined on the sulfide fraction using the chromium reducible sulfur method, and the water soluble sulfate fraction of selected soil layers. The sites selected were grouped into four categories: coastal clay dominated ASS, coastal peat dominated ASS, coastal monosulfidic black ooze (MBO) samples and inland MBO samples.

The results indicated large and consistent differences in the sulfur isotope signatures of the various categories of ASS materials. In the coastal clay dominated ASS, δ34S in the sulfide fraction ranged from -28.57‰ to -2.13‰. δ34S in the sulfate fraction were also negative and ranged from -17.3‰ to -2.23‰. Isotope signatures in the peat dominated ASS gave both positive and negative values in the sulfide fraction with a δ34S range of -7.34‰ to +10.84‰. The sulfate signatures in the peat ASS were positive with a range of +7.27‰ to 12.98‰.

The samples collected from the inland ASS sites also gave positive and negative values in the sulfide fraction with a range of -13.46‰ to +8.38‰. Sulfates in the inland samples were strongly positive with a δ34S range from +11.07‰ to +29.05‰. The δ34S in the sulfides for the coastal MBO samples fell within the range given for peat ASS. The sulfate range for one MBO was +4.76‰ to +14.44‰, extending the range of the peat sulfate slightly. The other MBO sulfate fell within the range given for inland sulfates.

The variations in the sulfide fractions can be attributed to the formation environment and the effect it has on sulfate supply and sulfate reduction rates. Strongly negative δ34S in the sulfide fraction are representative of environments in which sulfate is supplied more rapidly than it can be reduced. Such environments are referred to as being ‘open’ with respect to sulfate replenishment and can be linked to the deposition and formation of clay dominated ASS.

Closed system conditions exist where the sulfate supply is finite or when sulfate reduction exceeds supply. Such conditions would have dominated during the formation of peat ASS where a drop in sea level resulted in back swamp areas becoming fresh water dominated with limited sulfate availability. In addition the accumulation of organic matter would have increased the sulfate reduction rate. These conditions give δ34S values in the sulfide fractions that are slightly negative to positive.

The isotope signatures for the inland sites suggested another very different environment for the formation of ASS. The δ34S signature for sulfides were similar to those recorded at the peat sites, however the δ34S sulfate signatures were considerably higher. In these environments, sulfate supply is limited and possibly derived from the weathering of parent rocks or from anthropogenic sources.

In many ASS environments, the dominate source of sulfate is the oxidation of sulfides, which results in the sulfate having a similar isotope signature to the sulfide. During contemporary sulfide formation at the oxidation boundary or at the surface of ASS, the isotopically negative sulfate may be reduced which produces sulfides that are more enriched in 32S.

The sulfur isotope signature was sensitive to the environment of formation which determined if the sulfate supply was open or restricted during bacterial sulfate reduction and sulfide formation. The results suggest that sulfur isotopes could be used to identify the environment of formation, trace the source of sulfate in contemporary and relic sulfide accumulations and possibly quantify the amount of sulfate in waterways that is derived from the oxidation of ASS materials during hydrological events.

Keywords：*geochemistry, clay, peat, inland, monosulfidic black ooze*

O54-5

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Subsurface Chemigation of Acid Sulfate Soils - a New Approach to Mitigate Acid and Metal Leaching

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In this paper we present a new method for in situ treatment of farmland acid sulfate soils.
By utilizing the subsurface drainage system, oxidation-inhibiting chemicals mixed with irrigation water are injected into the environmentally critical subsoil. Laboratory and field tests have been performed in the four-year project PRECIKEM (Chemical precision treatment of acid sulfate soils to prevent the formation of acid). The project has completed its third year, and promising results are emerging.

As sulfide-rich sediments are drained, atmospheric oxygen gains access to the sulfides through macropores in the soil material. This initiates a combined chemical/microbiological process that eventually produces an acid sulfate soil. In order to inhibit further microbially mediated sulfide oxidation along the hydrologically active macropores, the soil is treated by passing a suspension of fine-grained (d50 = 2.5 μm) calcium carbonate or calcium hydroxide through these macropores. Fine-grained materials are necessary in order to avoid sedimentation and possible clogging of the drainage system, as well as to facilitate both dissolution and dispersion of chemicals in the soil.

In the laboratory, column leaching experiments have been performed by passing suspensions under hydrostatic pressure through cylindrical soil samples. In our experiments, pH, EC, ORP, as well as sulfate and chloride, and occasionally Al, Fe, Zn, Mn, Ni and Co, have been measured in the outflowing solution. Depending on an inherent variation in the size and abundance of macropores, the flow through the different soil columns varied greatly. Nevertheless, reproducible effects have been obtained.

Corresponding large-scale field experiments have been performed during two consecutive years at the Risöfladan experimental field. This field consists of nine hydrologically separated 1-hectare subfields. Each subfield has its own drainage system, consisting of subsurface drainage pipes, a collector pipe and a control well. Suspensions have been created with water from the nearby Toby River. Treatments have been performed in late summer when groundwater levels are below drainage depth, and have consisted of injections of calcium carbonate suspensions (4 and 8 g L−1), calcium hydroxide suspensions (2 and 4 g L−1), and river water. Solutions/suspensions are pumped via the control well into the drainage system for about 10 hours, with a flow rate of about 3 litres per second. The system of macropores allows the suspensions to spread in the field at drainage depth. Treatment effects are monitored by sampling drainage and groundwaters (Österholm et al. this volume).

The sediment in the Risöfladan area is representative of the region, with a clay content of 40%, an organic carbon content of 1.6%, and a total sulfur content of 0.9% (Nordmyr et al. 2006). Also, typical for the region is significant oxidation and leaching in the uppermost 1.5-meter soil layer. This results in significantly lower S concentrations in this oxidation zone and an enrichment of secondary sulfides in the narrow transition zone just above the parent sediment. The microbial community in the Risöfladan soil material has also been studied (Wu et al. 2013). Several known acidophilic microorganisms have been identified, as well as gene sequences previously found in cold environments. These results indicate that the metal and acid release from the Risöfladan soil material is catalyzed by indigenous microorganisms adapted to low pH.

The PRECIKEM project is funded by the European Agricultural Fund for Rural Development via the Rural Development Programme for Mainland Finland 2007-2013. This programme is administrated by the Centre for Economic Development, Transport and the Environment in Ostrobothnia, Finland. Co-funding is provided by the Field Drainage Association, Maa- ja vesitekniikan tuki, Central Union of Agricultural Producers and Forest Owners, and Österbottens Svenska Producentförbund. The investments needed in drainage system, field equipment, etc., are funded by the Oiva Kuusisto Säätiö, Aktiastiftelsen in Vasa, Gustaf Svanljungs Donationsfond and K.H. Renlunds stiftelse. Support in constructing the field and material for experiments have been provided by companies KWH Pipe and Nordkalk.

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Keywords：*chemical treatment, oxidation inhibition, sustainable agriculture*

O55-1

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Hot Issues in Cryosol Research

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Cryosols are one of the 'youngest' major soil groups of the world. It was separated at the highest taxonomic level first in Canada, then in Soil Taxonomy (as the order of Gelisols) and in the WRB system. Cryosols occupy more than 18 M sq. km and are found in both circumpolar regions, as well as in many high-mountain regions, including the tropics. Being assembled together from different previously distinguished soil orders, they represent the most diverse group of world soils. Together with arbitrary diagnostic criteria of Cryosols, this creates certain problems in their classification.

Soil temperature criteria are of key importance in the definition of Cryosols. However, existing soil temperature classes are insufficient to describe the real diversity of temperature regimes of Cryosols. Some soils with similar temperature regimes and cryogenic processes 'fall out' of the Cryosols. Relationships between the climatic parameters and the temperature and water regimes of Cryosols, being mediated by local factors, are intricate. We need data on the current thermal state of Cryosols and on the trends of its changes under the impact of global climate change. The maps of changes in the thermal state of Cryosols and related processes have to be developed. The properties of two major temperature buffers in Cryosols - the surface litter/moss/high-humus horizons and the transient layer underlying the soil profile have to be examined more carefully and mapped. Little is known about Cryosols in the frozen state, though this is the longest period in their development.

Most of the Cryosols are highly dynamic soils subjected to cryoturbation. Cryoturbation actually includes different sets of processes affecting soil morphology. These processes are controlled by different factors, and it would be reasonable to differentiate them. An interesting problem concerning cryoturbation is its frequency. Arecryoturbation features relict or modern- How often does this phenomenon occur- For some soils, the answer is simple; for other soils, it requires additional research.

Cryosols store up to 50% of the global soil carbon pool. However, we still do not know exactly the fate of this carbon under changing climate. Several theoretical models (enhanced emission, enhanced sequestration owing to active vegetation development, or balanced state) are considered in the short-time and long-time ranges. It's a challenge to develop corresponding maps and to quantify the overall effect of these processes.

Cryosols are generally young soils. Most of them have developed under conditions of the existing permafrost. Upon syngenetic pedogenesis (in parallel with sediment accumulation), thick permafrost layers containing the remains of former soils have formed. Their age may be up to 2-8 Ma. These objects represent the museum of paleosols in the frozen state and present valuable information on the paleoenviornment. Application of new genetic methods of studying biotic remains, including the study of their metagenomes, should give us insight into the rates of life evolution and, probably, disclose genetic mechanism of biota tolerance toward temperature extremes.

Some Cryosols are developed from pre-permafrost parent materials and soils. The problem of inheritance of their features in the profiles of Cryosols remains poorly investigated. In particular, this concerns Antarctic Cryosols. At the same time, relict features of former Cryosols are typical of many soils in periglacial regions. Their role in the modern soil functioning is to be examined. Many processes typical of Cryosols are also developed in other soils. Little is known about the pedogenetic specificity of Cryosols. Application of advanced methods of soil studies might help in solving this problem.

Cryosols on the world soil maps remain 'poorly colored' regions. Much has to be learned about their geography. Though Cryosols are marginal (though locally important) soils in terms of agriculture, they are

Keywords：*Cryosols, soil temperature, transient layer, soil classification, cryoturbation, carbon budget*

O55-2

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Characterization, Classification and Distribution of Soils from the South Shetlands Archipelago, Antarctica

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During the last decade, several studies have increased the knowledge about the characteristics and distribution of soils in ice-free areas of the South Shetlands Archipelago. Although several recent publications highlight interesting and novel aspects of soil genesis in this part of Antarctica there has not been a regional approach to describe soils characteristics, formation processes and distribution. In the present work we describe soils occurring in some of the main ice-free areas of the South Shetlands Archipelago. Chemical and physical attributes are presented for the different soil classes along with soil maps of selected areas. Soils in this region are much different from those reported for other parts of Antarctica. Frequent freeze-and-thaw cycles result in intense physical fragmentation of parent materials whilst higher water availability and biological activity increase biochemical weathering, with neoformation of clay minerals. Biological activity in terrestrial ecosystems results in large vegetated areas. Unique oases of biodiversity occur associated to bird colonies, especially penguins. There, higher primary production by the vegetation results in soils with very high organic carbon content for Antarctic standards. Soils, both past and present-day, affected by breeding colonies of sea birds are subjected to phosphatization as a result of the reaction between P-rich solutions that percolate the soils with the underlying, physically weathered mineral substrate. The general model of soil distribution in the South Shetlands describes large areas of mineral, ahumic soils occupying the highest parts of the landscape, frequently exhibiting cryoturbation features and permafrost starting within 2 meters of the surface, being classified as Gelisols according to the U.S Soil Taxonomy (which correspond to the Cryosols of the WRB system); smaller areas of soils with higher organic carbon (Histosols and Histels) occur on stable landforms at lower altitudes. Inceptsols and Entisols are common at altitudes < 30 m.a.s.l., where permafrost is considered sporadic or absent. At specific areas affected by bird activity, soils present the ornithic character, with unique chemical and mineralogical attributes such as very high P, N and organic C levels, and a dominance of crystalline and poorly crystalline secondary phosphates. Although these maritime Antarctic soils have the deepest active layer (often reaching 1 meter depth) and the most developed pedogenic horizons in Antarctica, they are still very young soils with chemical, mineralogical and physical attributes markedly influenced by the nature of the parent material. These range from basaltic-andesitic rocks in King George Island, to recently deposited pyroclastic materials in Deception Island and marine sedimentary rocks in Byers Peninsula (Livingstone Island). Soil maps are presented for the following ice-free areas: King George Island - Low Head, western shore of Admiralty Bay, Keller, Barton, Potter and Fildes Peninsulas (King George Island) as well as the western coast of Admiralty Bay); Livingstone Island (Byers Peninsula) and Deception Island, representing the major pedological variations found in this part of Antarctica.

Keywords：*Active layer, Soil mapping, Gelisol, Cryosol*

O55-3

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Some Results of the Soil Cover Research in the Permafrost Area (West Siberia)

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The research in Ural Federal University is supported by grant of Government of Russian Federation, the agreement № 11.G34.31.0064

Data on properties of permafrost area soils are useful for long-term forecasting of their status in connection with the global climate changes.
The soil cover research was carried on in the western edge of West Siberia. Key sites of 1 km2 were selected in accordance with four main types of forest-tundra zone vegetation on the left Bank of the Ob River in Labytnangi area: tundra, peat bog, forest and floodplain. Then the experimental squares 10×10 m were done in mostly spread soil-vegetation units in these sites. Active layer depth was measured at chosen sites with a step of 1 m in more than 700 points. The main soil types were defined, described and sampling, after which temperature and moisture sensors were installed in one wall of each vertical soil section.
Soil temperature vertical gradients were calculated in order to compare heat conductivity of different soils. The average temperature vertical gradients for profile as a whole in the different texture soils, forming under various vegetation communities groups of forest-tundra vary by order of magnitude (from 0.29˚C/10 cm in Albic Podzols to 2.61˚C/10 cm in Histic Cryosols). It leads to the differences in warming of these soils and, as a consequence, in the depth of seasonal thawing table. The best insulating ability was got for the upper 10 cm of organic peat horizons: their temperature gradient is 9.69–15.00˚C/10 cm in the beginning of August. The relationship of the active layer depth and the organic horizon thickness of different soils were shown.
On the base of the active layer thickness and soil temperature vertical gradients the following main soil groups, which are different in their thermal properties were identified:
1. Forest sandy loam and sand soils with active layer depth more than 2–3 m.
2. Tundra sandy loam soils with permafrost table from 1 to 1.5 m from the surface.
3. Tundra loam soils, which active layer thickness is very rare more than 1m.
4. Oligotrophic bog silt soils. Permafrost table usually is just under peat layer at the depth of 35–45 cm.
Comparison of the active layer depth in early August of 2012 and 2013 revealed a significant effect of precipitation on the permafrost thawing. The active layer thickness decreased with decreasing of precipitation in sandy, loamy and silt soils by 25, 5 and 2 cm, respectively.

The physical-chemistry properties are rather close in soils under investigation. The reaction of all forest-tundra soils is acid (pHKCl is less than 4.4). The volumes of hydrolytic acid reached 13–25 mmol/kg of the soil in the organic horizons. The content of exchangeable cautions is not high (less than 24 mmol/kg of the soil), especially in podzols.
The maximum content of organic carbon (more than 9%) was found in the surface horizons, the minimum – in the lower part of the soil profile, where it amounts to 0.05–0.20%. Carbon stocks were calculated, using bulk density, in the upper 20 cm of studying soils. They vary under different vegetation communities. Minimum values occur in Podzols (10–21 tones per m2), maximum – in Histic Cryosols (88–120 t/m2). Turbic Cryosol is characterized by the volume of 44 t/m2. Accoding to Orlov (1990) these carbon stock corresponds to the very low level in Podzols, middle level in Turbic Cryosol and high and very high level in Histic Cryosols.
A significant share in the humus content is on the aggressive fraction of fulvic acids, their amount in humus composition in some cases is near 50%. Mobile fractions of humus acids (brown humic acids and related with them fulvic acids) are dominated in the composition of humus. Therefore, despite of the differ level of carbon stocks in forest-tundra soils, half of them exist in mobile humus forms, which are less stable and can cause the rapid increasing of soil CO2 emissions in the case of global climate warming.
The obtained data on soil thermal properties and stocks of carbon for permafrost territory soils can be used for forecasting of seasonal thawing layer and carbon status in connection with the global climate changes.

Keywords：*thermal properties, permafrost, humus compound, carbon stock, soils, forest-tundra*

O55-4

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

A Mechanism for Polygon Evolution on Hill Slopes in Taylor Valley, Antarctica; Evidence from Osl Dating and Micromorphology of a Typic Haploturbel

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Patterned ground landscapes in Taylor Valley consist of polygons comprising soils with ice-cemented permafrost. Polygons are defined by linear troughs (tension cracks) in the underlying ice-cement. Sletten et al. (2003, Journal of Geophysical Research) proposed a mechanism for the development of patterned ground on flat surfaces in these landscapes, based on cryoturbation involving a rotating motion ("convection cell") driven by thermal ice expansion during summer. This returns some surface material to the polygon troughs, by forcing the sand away from the cracks towards the polygon centre. Recent work by R. Delisle et al (pers. comm.) using 10Be cosmogenic dating in polygons in the McMurdo Dry Valleys, demonstrated that 10Be-rich sediments infiltrate polygon cracks with the annual contractions, but that this sediment does not appear to be pushed to the centre of the polygon as suggested by Sletten's model.

We aimed to test the general applicability of Sletten's mechanism to hillslopes (which dominate the landscape) and to examine the influence of cryoturbation on soil transport and properties, desert pavement dynamics and hence the effect on the surface and sub-surface ages of patterned ground.

Along a surveyed transect aligned downslope on a Typic Haploturbel, developed on Ross Sea Drift (LGM but underlain by Taylor III drift; 208-335 ky) we logged the exposed stratigraphy, sampled for chemical analysis and micromorphology. Five samples were collected for luminescence dating along the transect at 4, 6, 7, 9 and 10.5 m from the upslope trough. The OSL dating (University of Washington), used the single-grain K-Feldspar technique, corrected for anomalous fading. Single grain luminescence dating would also help to identify if individual sand grains had been mixed by post-depositional cryoturbation.

The stratigraphy showed that sand, emerging from the ice cement near the uphill trough of the polygon, moves downslope, in en echelon layers, rather than a polygon-centre ward movement of sand at depth. These layers outcrop at the soil surface at different points along the transect, producing a crusted soil surface and concentrations of overturned clasts and also carries a raft of gravelly desert pavement. The microstructure of the fabric is single grain and displayed extensive calcic pendants in the surface horizons. The OSL dates of these sediments are reported as: 2.68±0.28 ka (4 m from upslope trough, 35 cm depth), 4.69±0.29ka (6m, 25cm), 7.48±0.37ka (7m, 18 cm). The radial graphs of age distribution of the samples at 4 and 7 m show some mixing or partial bleaching suggesting post-depositional cryoturbation.

En echelon layers of sand appear at depth (extruded from the ice cemented permafrost) in the downslope section of the polygon. Silt caps and localised bridging/ grain coatings in the fabric we interpret as the influence of melt water in the mobilisation and subsequent deposition of fine textured particles. The granostriated b-fabric of the clay matrix – where present in this fabric unit, suggests compression, most likely from seasonal expansion of the ice cement. The OSL ages for these sediments are reported as 29.7±1.60 ka (9m, 22cm) and 29.5±1.81ka (10.5m, 18cm). The radial graphs of age distribution for the sample at 10.5m suggests a single-aged sample, with no post-depositional mixing and no partial bleaching.

We conclude that different mechanisms maintain patterned ground on hillslopes compared to flat land. The stratigraphy of the sediments, the micromorphology of the fabric and the OSL dates have all demonstrated the difference in the sediments between the younger, recycled sand extruded from the upslope trough, compared to down slope area of the polygon. Here, the sand extruded at depth is most likely to originate from the underlying Ross Sea Drift.

This work also further considers the implications on the use of surface exposure dating for chronostratigraphic interpretation in this landscape. If stones and boulders can be rotated and exhumed then there are important implications for the cosmogenic dating of surface clasts and soil at depth.

Keywords：*Cryosols, Antarctica, McMurdo Dry Valleys, Patterned ground, stratigraphy, Luminescence dating, micr*

O55-5

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Effects of Nitrogen Addition on Soil Carbon Dynamics in the Active Layer of an Arctic Tundra Soil during Repeated Freeze-thaw Cycles

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Anthropogenic nitrogen (N) deposition can affect soil carbon storage and its dynamics in the Arctic permafrost-affected soils, but little is known about the soil carbon storage and dynamics responses to N deposition in the Arctic region compared to forest and agricultural soils. Therefore, we were motivated to investigate the effect of N deposition on the changes in the storage and dynamics of carbon of Arctic tundra soils under repeated freeze-thaw cycles. To do so, we conducted a laboratory batch incubation of the mineral soils of the active layer with or without litter (less decomposed plant residue) layer after application of 15N-enriched urea [(15NH2)2CO] at a rate of 10 g N m-2. The freeze-thaw cycle consisted of freezing at -11±1 °C for 3 weeks, transition at 0±1 °C for 1 week and thawing at 8.3±1 °C for 2 weeks, and was repeated. Soil C storage was not affected by additional N in the active layer. However, addition of N increased CO2 emission substantially during thawing span regardless of litter treatment and the amount of dissolved organic carbon (DOC) in both mineral soils and litter layers. Much more CO2 and DOC were produced in mineral soils without litter layer than with it. We therefore suggested that N deposition would stimulate transformation of soil C compounds to more labile forms in the active layer and organic C in mineral soils without litter layer was more susceptible to decomposition than with it. In litter treatment, almost added 15N was recovered in the litter layer and the 15N recovery gradually increased in mineral soil layers during the entire experiment. This result showed that vertical transport of small and dissolved compounds (DOC and inorganic N) was limited in the active layer. Repeated freeze-thaw cycles did not considerably affect soil C dynamics in the active layer. Therefore, we suggested a possibility that increased N deposition in the Arctic tundra soil would accelerate soil organic C decomposition, once organic litter layer was removed from the surface as a result of thermokarst.

Keywords：*active layer, carbon, freeze-thaw, 15N-isotope dilution, nitrogen*

O57-1

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Mapping Soil Microbial Diversity: a First Approximation

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Below-ground ecology has been linked with plant biodiversidity (Van der Heijden et al. 1998). There are associations between plant genera and mycorrhizal fungi (e.g. Allsop & Stock 1993; Van der Heijden et al. 1998; Lambers et al. 2008), and plants and decomposers (e.g. Ayres et al. 2009). Here I link above- and below-ground biodiversity to map soil microbial communities over Australia. First I review the literature to populate a look-up table relating plant to soil microbial communities. Then I use the National Vegetation Information System (DEWR 2007) to make a first estimate at a map of below-ground biodiversity in Australia. This map should be useful to guide sampling efforts for further studies of microbial functional genetic diversity.

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O57-2

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Central-european Digital Soil Database - The e-SOTER Methodology

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Digital soil mapping has become a very efficient tool in soil science, and several applications have been published. Many of these applications use environmental covariates like remotely sensed images and digital elevation models, which are raster based data sources with block support. Raster format is favored by the many users as well. The majority of soil data users requires data in raster format with values of certain properties, like pH, clay content or soil organic matter content. Qualitative data can be later classified and used as categorical data. The most typical categorical soil data is the soil type/classification category, like WRB or the national classification systems. This kind of data is difficult to be used and understood due to its complex information behind the category names.

The presentation and validation of the raster based, categorical soil data is not well developed. The e-SOTER project developed a novel approach to present categorical information on block support. The resulting dataset has several layers of occurrence probabilities of WRB diagnostic horizons/features/properties and an additional layer of the reference soil group (RSG) of the WRB system. This paper describes this novel approach for the development of digital soil datasets containing soil classification information. This approach disaggregate the class information for soil properties (WRB diagnostics) and map the occurrence likelihood using digital soil mapping, remote sensing and digital elevation modeling tools.

Keywords：*e-SOTER, globals soil mapping, digital soil mapping categorical data, WRB*

O57-3

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Comparing Different Approaches - Data Mining, Geostatistic, and Deterministic Pedology - to Assess the Frequency of WRB Reference Soil Groups in the Italian Soil Regions

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The assessment of class frequency in soil map legends is affected by uncertainty, especially at small scales, where generalization is larger. The aim of this study was to test the hypothesis that data mining or geostatistic techniques provide better estimation of class frequency than traditional deterministic pedology in a national soil map.
In the map of Italian soil regions compiled at 1:5,000,000 reference scale, soil classes were the WRB Reference Soil Groups (RSGs). Different data mining techniques, namely neural networks, random forests, boosted tree, classification and regression tree, supported vector machine (SVM), were tested and the last one gave the best RSGs predictions, using selected auxiliary variables and 22,015 classified soil profiles. Given the categorical target variable, the multi-collocated indicator cokriging was the algorithm chosen for the geostatistic approach. The first five more frequent RSGs resulting from the three methods were compared. The outcomes were validated with a Bayesian approach on a subset of 10% of geographically representative profiles, kept out before the elaborations.
The most frequent classes were uniformly predicted by the three methods, which instead differentiated notably for the classes with a lower occurrence. The Bayesian validation indicated that the SVM method was as reliable as the multi-collocated indicator cokriging, and both more than the deterministic pedological approach. An advantage of the SVM was the possibility to use numeric and categorical variable in the same elaboration, without any previous transformation, which notably reduced the processing time.

Keywords：*learning machine, non-linear kriging, soil type classification, Italy*

O57-4

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Towards a New International Typological Data Base - Data Integration and Validation

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A recent research exercise (eSOTER) has developed a new approach to soil mapping in small scales. In a data dense setting in central Europe (Germany and Czech Republic), a new land form map was combined with re-interpreted geological maps, to form so-called terrain units. Thousands of soil profiles and high-resolution soil maps were then used to stratify these terrain units into soil typological units. In a parallel exercise, a digital soil map has been produced using radiometric data sets and other covariates, similar to SOTER.

The new land form map, and both kinds of soil predictions were then validated against high-resolution soil map and soil profile data sets including field work. The hypothesis has been tested whether soil predictions for unmapped territory (digital soil mapping and eSOTER) can be integrated together with conventional reconnaissance maps into a homogenous and consistent soil typological data base – to form the new global soil polygon data set. The results of this validation study will be presented, and a concept towards a new global soil map developed.

Keywords：*soil typological data bases, SOTER, Digital Soil Mapping, validation*

O57-5

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Spatial Variability of Electrical Conductivity of Salt-Affected Soils in Northeast Thailand

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The problem of soil salinity represents a major challenge to agriculture and environment in Northeast Thailand. Careful assessment of the status and spatial variation of salt-affected soils is required to implement appropriate control measures and to secure sustainable land uses. Currently, mapping classes of these soils is based on the percentage of salt crusts formed on the soil surface. Scant information is available on the spatial correlation and, in turn, the spatial variability of the electrical conductivity (EC). The objective of this study was to describe the spatial variability of soil electrical conductivity of the saturation extract (EC_e) in areas of different degrees (classes) of salt-affected soils using geostatistics which is an essential tool for this purpose. Attention was on areas of very severely salt-affected soils (class 1), severely salt-affected soils (class 2), and moderately salt-affected soils (class 3). For each class, two study sites were chosen, totally six sites were taken into consideration. Soil samples were collected according to the stratified systematic unaligned sampling method in the dry season of 2012. In each site, a representative area of 50x50 m^2 was selected. This area was divided into 100 equivalent grids of 5x5 m^2. Within each grid, one sample were randomly collected at 0-30 cm depth. Thus, a total of 600 soil samples (100 samples x 6 sites) were analyzed for the EC_e. For the dataset obtained from each study site, geostatistics was applied to elucidate the spatial correlation of EC_e. The semivariogram was created for this purpose. The Ordinary Least Square (OLS) method was applied to fit the semivariogram model. The best-fit model (i.e., spherical or exponential) was determined based on the coefficient of determination (R^2). Corresponding parameters including nugget, range, and sill values obtained from this model were used to describe the spatial correlation. To generate the relevant spatial variability map, these three parameters were employed in the kriging interpolation.The results showed that the salinity levels as indicated by the EC_e values were very strongly saline (EC_e 56.70- 433 dS m^{-1}), normal to very strongly saline (EC_e 0.16- 49.00 dS m^{-1}), and normal to slightly saline (EC_e 0.11- 5.26 dS m^{-1}) for areas of very severely salt-affected soils (class 1), severely salt-affected soils (class 2), and moderately salt-affected soils (class 3), respectively. For every study site, the semivariogram model fitted well with the semivariogram samples (R^2 0.73-0.98). When using the semivariograms to describe the spatial correlation of the EC_e, it was found that the variation was generally high. It varied between classes and within the same class. The range values were 190 and 8 m, 34 and 61, and 170 and 16 m. for both study sites of classes 1, 2, and 3, respectively. The shorter the range, the higher the variation. The nugget effect varied between study sites indicating the uncertainty of the occurrence of the spatial sources of variation. Based on the salinity maps generated using the kriging interpolation, the areas of class 1 were entirely very strongly saline soils (EC > 16 $dS.m^{-1}$). For the areas of class 2, very high variation in salinity levels was found ranging from normal (EC < 2 $dS.m^{-1}$) to very strongly saline soils. In the areas of class 3, the soils varied slightly from normal to very slightly saline (EC > 2-4 $dS.m^{-1}$). The information on spatial variation of EC_e is very important for soil management especially in the areas of class 2, because these areas includes a large variety of salinity levels, ranging from normal to very strongly saline. In areas of classes 1 and 3, this information is less important because in the class 1 areas the soils, even though highly varied, were entirely very strongly saline. No arable crops can be grown on these areas. On the other hand, in the areas of class 3, the soils were generally normal to very slightly saline. There is very slightly effect on crop growth especially in the growing (rainy) season.

Keywords: *geostatistics, electrical conductivity, salt-affected soils, semivariogram, spatial variability*

O57-6

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Hydrophysical Database for Brazilian Soils: Challenges and Perspectives

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Access to soil hydrological data is vital for hydrologic projects and for supporting decision-making in issues related to the availability of food and water, as well as natural disasters.

Brazil, a country of continental dimensions, has accumulated a significant body of soil information, and holds a prominent position in the studies of tropical soils. In this study, hydrophysical database derived from Brazilian scientific publications is discussed. We developed a metadata describing the methods of determining some soil hydrophysical attributes and also presenting the characteristics of the site where these soil properties were estimated. Statistical analyses were performed to characterize the dataset based on the metadata-based data structure.

Total of 8,725 samples (without considering replicates) had soil moisture retention information associated with physical or chemical properties, such as organic matter content, granulometric fractions, bulk density, particle density and penetration resistance. Total of 63% of the publications present data of moisture retention related to determinations of organic matter (or organic carbon), granulometry and bulk density. The distribution of the samples with water retention information across the Brazilian territory showed that some regions were better represented than others, especially the Southeast and Midwest, where 2,245 and 2,321 samples were obtained, respectively. The North region lacks adequate representation, considering its social and environmental importance to the country. All Brazilian soils classes were represented. Two dominant soil types were Latossolos (FAO Ferrasols) and Argissolos (Acrisols, Lixisols or Alisols, according to FAO). This amount of soil water retention measurements also represented both topsoil and subsoil very well. All texture classes, except those with high silt content, were well characterized.

Total of 1,253 samples with saturated hydraulic conductivity measurements associated with water retention measurements were also found. The study showed that these data could not represent all Brazilian soil classes satisfactorily, neither the Brazilian states, in particular the ones in North and Northeast regions. Surprisingly, little appears to be known about the unsaturated hydraulic conductivity, as only 30 samples were analyzed.

The results analysis suggest that it is possible to develop a hydrophysical database on Brazilian soils that is all-encompassing, representative, with substantial volume of available data, homogeneous with respect to the methods of measuring soil properties and relatively diverse with respect to the physico-chemical properties. Some information on data quality needs to be collected.

The challenge in the development of the Brazilian soil hydrophysical database is to refine a data model that can encompass the wide range of available information and that meets the different kinds of queries of interest to different users in soil sciences. A preliminary structure of the database is in development. Considering the size of the Brazilian territory it would be of interest that the database development should become a joint effort of government agencies, universities and commercial enterprises.

Keywords: *water retention, hydraulic conductivity, tropical soil*

O58-1

[WG2] WRB - Lessons Learned from the Development of the Third Edition 2014

Presenting the 3rd Edition of WRB

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The third edition of the international soil classification system "World Reference Base for Soil Resources" (WRB) will be presented during der 20th World Congress of Soil Science. The second edition was published in 2006 and the first in 1998, which, in turn, was based on the Legends of the FAO Soil Map of the World. Now, after eight years of experience with the second edition, time was due for a revision.

The way to the third edition was long. Numerous soil scientists all over the world worked with the second edition. It was tested in the field during several international correlation tours. A large number of observations and suggestions was submitted to the chair of the WRB Working Group. Several international meetings in 2013 were held to finalize the decisions on the third edition. The major changes are:

1. The second edition had two different qualifier sequences for naming soils (IUSS Working Group WRB, 2006, update 2007) and for creating map legends (Guidelines for creating small-scale map legends using the WRB; IUSS Working Group WRB, 2010). The third edition has one sequence for both. The qualifiers for every Reference Soil Group are subdivided into a small number of main qualifiers that are ranked and a larger number of additional qualifiers that are not ranked and given in an alphabetical order. The name of a pedon must comprise all applying qualifiers. The name of a map unit comprises a specified small number of main qualifiers, depending on scale, whereas all other qualifiers are optional.
2. For some soils, problems have been reported. Albeluvisols are difficult to detect in the field and cover only small surfaces. They have been replaced by a Reference Soil Group with a broader definition that is easier to identify in the field.
3. The use of some diagnostics was difficult. Examples are: The argic horizon had too low limit values, so we had much more soils with argic horizons than justified. The definitions of the cambic horizon and the gleyic and stagnic properties were not precise enough. Organic material, mollic and umbric horizons had an unnecessary complicated definition.
4. Some changes in the key to the Reference Soil Groups seemed to be justified. Fluvisols were moved further down, Durisols and Gypsisols switched their position, also Arenosols and Cambisols. The soils with an argic horizon were brought into a new sequence.
5. The umbrella function of WRB aims to allow the allocation of soil classes existing in a national classification system within the WRB. Characteristics that in a national system are regarded to be important must be considered in WRB - not necessarily at the highest level, but at least somewhere. The third edition of WRB allows a better accommodation of soil types, e.g., of the Australian and the Brazilian system.
6. Some environments or even ecoregions had not been well represented in WRB up till now. The third edition allows a better accommodation of soils of ultra-continental permafrost regions, acid-sulphate soils and Technosols.
7. How to explain complicated sets of characteristics? For the third edition, efforts were made to give better structured definitions that can be more easily grasped.

The editors of the third edition are convinced that the new WRB allows a more precise classification of soils including both, a better naming of pedons and a better elaboration of soil map legends. In addition, we hope that the document is easier to read, to understand and to apply.

Keywords：*WRB, 3rd edition, soil names, map legends*

O58-2

[WG2] WRB - Lessons Learned from the Development of the Third Edition 2014

The Application of Wrb by the European Commission: Experiences and Future Perspectives

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The European Commission as been consistently promoting the use of WRB at European and global scales through a number of initiatives: The most important application has been the use of WRB for the development of the European Soil Information System (EUSIS), especially for the 1:1,000,000 scale Soil Geographical Database of Europe but also for the 1:250,000 Georeferenced Soil Database of Europe. Besides the operational use of WRB within its soil information systems, the EC has been actively promoting the use of WRB for its series of Soil Atlases: Starting with the Soil Atlas of Europe in 2005 it has developed various reference publications based on WRB covering the Northern Circumpolar Region (Soil Atlas of the Northern Circumpolar Region, 2010), Africa (Soil Atlas of Africa, 2013) and Latin America (Soil Atlas of Latin America, 2014). In the future the European Commission intends to continue its commitment towards the consistent application of WRB at European and Global scale by further developing its series of soil atlases covering as well Asia, Oceania and the Antarctic. In Europe the planned development of the 1:250,000 scale Georeferenced Soil Database will continue on the basis of WRB in selected pilot areas. In addition the EC is planning to further develop its awareness raising and training initiatives, like the European Summer School on Soil Survey, the series of demonstration soil profiles and other educational and awareness raising materials, all based on WRB as a standard.

O58-3

[WG2] WRB - Lessons Learned from the Development of the Third Edition 2014

WRB and the Australian Soils Experience

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The World Reference Base has not been widely adopted in Australia, as it is perceived to be complex and there are some difficulties in correlation with the Australian Soil Classification. Hosting the 19th World Congress of Soil Science in 2010 enhanced our exposure to the WRB, and this was followed up by an official WRB Tour to Australia in 2012. Resulting from this, several modifications incorporated in the third edition of the WRB have been adopted specifically to better accommodate the suite of Australian soils. This paper reports on those adjustments and briefly summarises some issues that remain.

Keywords：*Australian soils, correlation*

O58-4

[WG2] WRB - Lessons Learned from the Development of the Third Edition 2014

A New Diagnostic Horizon in WRB for Anthropic Topsoils in Amazonian Dark Earths (South America)

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The Amazonian Dark Earths (ADE), also called “Terra Preta de Indio”, are classified according to WRB as Anthrosols(IUSS Working Group WRB, 2006), and different studies attribute to them the hortic, plaggic or terric horizon according to base saturation, extractable P content, amount of artefacts, and other soil diagnostic criteria. But they do not fit the central concept of any of them: deep cultivation, intensive fertilization and/or long-continued application of human and animal wastes and other organic residues (hortic horizon); addition of sods (topsoil layers together with vegetation) and animal manure (plaggic horizon); addition of earthy manures, compost, beach sands or mud (terric horizon).

The ADEs are associated to pre-Columbian Amerindian settlements and have been reported mainly in the Amazon region. They are variable in terms of depth of the diagnostic horizon, physical and chemical properties, but mostly have dark colors, high stocks of organic carbon, extractable and total phosphorus, calcium, magnesium, micronutrients (mainly zinc and manganese) and other metals as strontium and barium. Contrasting with natural soils in the surrounding area,the surface horizons influenced by human activities have extraordinarily high CEC and nutrient availability. Artefactsof ceramic, stones and bones and pieces of charcoal are frequently found mixed into the soil. Clear evidences of past human occupation in the landscape (constructions, gardens), shell mounds (“sambaquis”), earthworks (geoglyphs) are identifiable. The ADEs may not show the evidences of animal activity required for the hortic horizons, and they were not influenced by manuring,as required for the hortic horizons, since this activity was not part of the pre-Columbian Amerindian culture.Additionally, the surface anthropic horizons typical for the ADE show a high base saturation; the basecations were added from bones (Ca), ashes, and many other organic materials (i. e. kitchen middens, palm leaves, human feces). It is still a matter of discussion, whether these fertile horizons have been created intentionally. The presence of buried ADE horizons in naturally fertile GleysolsandFluvisols near the Amazon and Solimoes rivers suggests that there was no intention to create them.

Thus, a new diagnostic horizon was proposed during the revision of WRB, identified as pretic (from Portuguese preto, black), and its diagnostic criteria will be presented in this report.

Keywords：*Terra Preta de Indio; Anthrosols; Soil classification*

O58-5

[WG2] WRB - Lessons Learned from the Development of the Third Edition 2014

Classification of Technogenic Soils in WRB in the Light of Polish Experiences

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The first national soil classification that included unit for technogenic soils was the one for England and Wales in 1980. In next decades many other national soil classification systems were supplemented with such units, e.g. The Czech Taxonomic Soil Classification System, German Soil Classification System, and Russian Soil Classification System. As a culmination of this process could be considered the introduction of the Technosols to the international soil classification system WRB in 2006. Classification is a major requirement of all science and must be revised periodically as knowledge increases. In case of technogenic soils it is particularly important since the history of their classification is much shorter than natural ones.

Technosols are relatively young soil group in the WRB soil system, and there is still a lot of to do to better understand processes taking place in these soils and to classify them in a proper way. After introduction of Technosols in the WRB, this reference soil group (RSG) have been evaluated by Polish researches and between 2006 and 2013 numerous proposals of modification was given. Technogenic soils are extremely heterogeneous. The list of qualifiers for Technosols is one of the longest one of all RSGs defined in 2006 edition of WRB. In author's opinion it is still insufficient and do not allow for precise classification of pedons, which underwent transformations related to construction, industry, transportation, mining and military human activities.

The objectives of this study were to (1) evaluate Technosol and 'technogenic' qualifiers for other Reference Soil Groups, and (2) propose new solutions which would improve the classification of technogenic soils in WRB.

New qualifiers - Edific (for soils developing spontaneously from technic hard rock on the buildings), Nekric (for cementery soils), Misceric (for soils disturbed and mixed by activity connected with construction), Artefactic (to highlight substantial amounts of artefacts, but not reaching criteria for Technosol), Radioactivic (radioactivity exceeding the geochemical background) and new Technic specifier (to emphasize technogenic origin of certain soil properties) are proposed to be added to keys to Technosols. Moreover, Salic and Sodic qualifiers should be also available for Technosols. Furthermore, the supplementation of definitions of thionic horizon andsulphidic material with reference to Technosols is also suggested.

Keywords：*Soil classification, Word Reference Base for Soil Resources, Technosols, Technogenic soils*

O58-6

[WG2] WRB - Lessons Learned from the Development of the Third Edition 2014

Conceptual Development of WRB 2014 and Its Impact on the Third Soils Cartography Series in Mexico

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Changes in the World Reference Base for Soil Resources (WRB) not only show the progress in their conceptual development but also imply changes in the diagnosis of fertility or soil conservation within a country. For 46 years the Instituto Nacional de Estadistica y Geografia (INEGI) has compiled field information about 54,620 soil profiles that were used in the generation of two sets of cartographic series in Mexico (1968-1998, 1998-2010). This study describes the comparative analysis of the diagnostic criteria of the three official versions of WRB, as well as assessing the impact of the new conceptual base in the redistribution of soil groups for the third series of Mexico, now in process (2014-2016). We believe that the WRB 2014 criteria are clear, more precise and attached to soil genetics than the previous versions of WRB (1998 and 2006). This major accuracy is reflected in the better spatial delineation of anthropogenic activity (e.g. anthric qualifier), stoniness effect (e.g. chernic horizon, akroskeletic qualifier) and geomorphological changes, especially those related to fluvial and colluvial processes. WRB 2014 clarifies complex soil cases (e.g. soils with mollic surface horizons that overlie dystric horizons) and the criteria substantially improve the certainty of the field diagnosis for soils with cementation, induration or those that show gleyic and stagnic properties. The World Reference Base 2014 includes an annex of 258 qualifiers that best describe the diversity of soils, including less developed soils that are most prevalent in Mexico (e.g. Leptosols, Regosols). However, WRB 2014 requires further fieldwork for rock description or lithic discontinuities, as well as for the study of limnic, subaquatic soils and soils with argic horizons more than one meter deep. In order to be truly functional it has established changes and additions in laboratory processes especially related to the quantification of base saturation, iron and aluminum for the fine fraction. For Mexico, we anticipate a reduction in the surface of sodic soils, soils with clay illuviation and soils that have been modified by anthropogenic activities. In contrast, we expect an increase in the surface of vertic, mollic and andic soils. This is due to various changes in the clay increase requirements, relocation in the order of groups, elimination of organic carbon content requirements, changes in the minimum thickness of the mollic horizon and other criteria related to artefacts distribution. A substantial variation of the national surface for soils with gleyic properties, and a slight increase in surface of plinthic and pisoplinthic soils and is expected. Some additional criteria in WRB 2014 might introduce the Cryosols group in Mexico for the first time at the typical national scale (1:250,000).

O58-7

[WG2] WRB - Lessons Learned from the Development of the Third Edition 2014

Software Tool for Deriving WRB Soil Names from National Soil Data - Potential for Further Development of WRB

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In Germany, a large amount of soil data is stored in various soil information systems. Our aim was to simplify the use of the soil data in international contexts by deriving soil names according to WRB (2006, update 2007, map legend addendum 2010 and 2014) by reducing the processing effort for data holders. The initial idea of applying WRB to existing soil data enabled important feedback to WRB development.

The criteria of all WRB diagnostics, the key to the Reference Soil Groups (RSG) and the qualifiers (incl. specifiers) were formalized as graphical schemas and implemented in Visual Basic code as a bilingual (English and German) MS Access application. The software tool was tested using data of more than 250 soil profiles representing the common soils of the German federal state Brandenburg. The data were of various detail regarding field profile description and analytical effort.

The formalization process discovered shortcomings in WRB 2006 definitions and criteria which helped to improve WRB 2014, e.g. gleyic and stagnic colour pattern, some criteria of the argic horizon, etc. Almost all descriptive parameters already recorded regularly in Germany are used in processing, which means that WRB covers most soil properties and processes attached importance to by German soil systematics.

The results of the automated classification are reliable. The software tool makes it possible to classify much larger sets of profile data as could be done manually and in a much shorter time. The match between field classification and automated classification is satisfying. Most differences are due to slight differences between the profile analyzed and the – sometimes several years - later field-classified profile. Some challenges originate from soil genetical concepts that are covered by WRB, but much less by German systematics and – therefore – soil description, e.g. albeluvic tonguing/glossae of WRB is hardly correct to determine from German soil data.

The formalization process not only gave reason to rethink and possibly adjust the national soil description rules, but also clearly showed that WRB is – with the amendments towards WRB 2014 – able to address central European soils properly. Doing the same for other climatic regions will be a powerful means to check WRB's applicability to soils worldwide.

Keywords：*WRB, Data Evaluation, Quality assurance*

O59-1

[C2.3-2] B: Life in Soils - Distribution and Function of Soil Microorganisms in a Changing Environment

The Survival Strategy of the Soil Microbial Biomass

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The soil microbial biomass (biomass) is defined as the sum of the masses of all soil microorganisms > 5000 μm3 (e.g. fungi, bacteria, protozoa, yeasts, actinomycetes and algae). Research into the biomass has therefore been likened to studying the forest rather than the individual trees. Typically comprising about 1 to 3 % of total soil organic matter (SOM), the biomass might be though to live in a highly substrate rich environment. The SOM is, normally, only exceedingly slowly available to the biomass. Despite this, the biomass can survive for months or even years on this meager energy source. Not surprisingly, therefore, the biomass exhibits many features typical of a dormant or resting population. These include a very low rate of basal and specific respiration, a slow rate of cell division (about once every six months on average) and slow turnover rate. These are clearly adaptations to existing in an environment where substrate availability is very low. Yet, paradoxically, the biomass, in soils worldwide, has an adenosine triphosphate (ATP) concentration (around 10 to 12 μmol ATP g-1 biomass C), and an Adenylate Energy Charge (AEC = [(ATP) + (0.5 ADP)]/[(ATP)+(ADP) + (AMP)]) which are typical of microorganisms growing exponentially in a chemostat. This sets us several questions. Firstly, under the condition of extremely limited substrate availability in soil, why does the biomass not mainly exist as spores, becoming active, by increasing both its ATP concentration and AEC, when substrate (plant and animal residues) becomes available? We surmise that a spore strategy may put organisms at a competitive disadvantage, compared to others which are prepared to invest energy, maintaining high ATP and ATP, to take advantage of a 'food event' as soon as it becomes available. Secondly, since SOM is available (although only very slowly) to the biomass, why have some groups not evolved the ability to mineralize it faster, obtain more energy, and so gain a competitive advantage? We believe that the reason why organisms do not use this strategy is, simply, that they cannot. In fact we believe that the mineralization of SOM is independent of the size, community structure and activity of the biomass. Thus Kemmitt et al., (2008 Soil Biol. Biochem. 40, 61-73) showed, as known previously, that CHCl3 fumigation killed about 90 % of the biomass in both an arable and grassland UK soil. Yet, after 4 days, when the fumigant-killed biomass was mineralized, the rates of mineralization of humified soil organic matter were the same in both soils. However the sizes of the biomass in the fumigated soils were only about 10 % of those in the non fumigated soils and the community structures in the two soils, determined by Phospholipid Fatty Acid Analysis, were very different. Thus, the populations in the CHCl3 fumigated soils had lower proportions of G+ve, about the same G-ve bacteria and less fungi than in the nonfumigated soils. The two populations were therefore greatly different in terms of size, community structure and activity, yet both mineralized humified SOM at the same rates. Why could the large intact population not mineralize SOM much faster than the populations in the fumigated soils? This is the paradox of soil organic matter mineralization, which has remained unanswered since the pioneering work of Jenkinson (1966 J. Soil Sci. 17, 280-302) and Jenkinson and Powlson (1976 Soil Biol. Biochem. 8, 167-177). Our explanation is that the rate of mineralization of humified SOM is not, as usually believed, regulated by microbial activity but by abiotic processes which are outside of the control of the biomass. We do not yet know what these processes are. They could involve diffusion from soil aggregates, oxidation processes, free radical reactions, other mechanisms, or none of these. We will present experimental evidence in support of our hypothesis - termed "The Regulatory Gate Hypothesis". If correct this hypothesis will have serious implication for our understanding of soil organic matter dynamics, C02 evolution from soil and climate change.

Keywords：*Soil organic matter mineralization, Regulatory Gate, abiotic C release*

O59-2

[C2.3-2] B: Life in Soils - Distribution and Function of Soil Microorganisms in a Changing Environment

Niche Specialisation and Differentiation of Archaeal and Bacterial Ammonia-oxidisers across Agricultural Soils in Southern Hemisphere

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Archaeal and bacterial ammonia-oxidisers (AOA and AOB) play a major role in soil nitrification, however, the factors regulating their diversity, distributions and abundance remain unresolved. This study sought to identify the key factors driving the nitrification pathway in 200 agricultural soils under different management practises across Australian agricultural soils. The relative abundance of the ammonia-oxidizing archaea (AOA) and bacteria (AOB) for all samples were quantified by targeting the amoA gene using quantitative PCR. The archaeal and bacterial communities in the soil samples were assessed by both PCR amplified 16S rRNA or metagenomic analyses using the Ion Torrent PGM platform. Soil pH had a profound impact on the distribution of AOB and AOA populations, resulting in two distinct ecological niches across Australian soils. Ammonia oxidisers exhibited a unimodel pattern of abundance along a soil pH gradient. Additionally, particle-size distribution (PSD) was identified as another possible mechanism supporting the coexistence of AOA and AOB populations. A better understanding niche specialization of ammonia oxidisers in soils will help develop best management practices for improving the N retention in agricultural soils and plant uptake whilst limiting N losses via nitrous oxide emissions and leaching.

Keywords：*Archaeal and bacterial ammonia-oxidisers, microbial ecology, soil pH, Ion-tag sequencing*

O59-3

[C2.3-2] B: Life in Soils - Distribution and Function of Soil Microorganisms in a Changing Environment

Exoenzyme Activities across the Soil Micro-landscape: Spatial Distribution, Stoichiometry and Ecosystem Function

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The spatial ecology of soil microbial communities and their functioning is a neglected aspect of soil microbial ecology. Much of our understanding of the spatial organisation of microbial communities has been obtained at scales that are inappropriate for identifying relationships between spatial patterns and ecosystem function. In order to gain insight into the spatial strategies of soil microorganisms, we measured the microscale spatial distribution of 7 exoenzyme activities (EEA) and related them to the catalytic potential of three different soils. The relationship between EEA profiles and microbial community attributes was also measured in 2mm aggregates. The extent of spatial dispersion varied significantly among EEA associated with the carbon, nitrogen and phosphorus cycles, suggesting that microbial communities employ different foraging strategies for acquiring these elements. Alkaline phosphatase was the most dispersed EEA, suggesting that microorganisms invest more heavily in the acquisition of P, probably because P is a less readily available nutrient. The EEA associated with the C cycle were significantly affected by soil management practices, whilst the EEA associated with the N and P cycles were not. This apparent sensitivity to changes in management practices suggests that spatial analyses may be useful for the development of a soil quality index. Finally, a significant positive relationship between the extent of dispersion of EEA and the overall intensity of the EEA was identified, indicating that the microscale spatial ecology of microbial activity can have a significant impact on ecosystem function.

Keywords：*Exoenzyme activity*

O59-4

[C2.3-2] B: Life in Soils - Distribution and Function of Soil Microorganisms in a Changing Environment

Water Flow Drives Small Scale Biogeography of Substrates and Soil Microorganisms-a Microcosm Study using 2,4-D as a Model Compound

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Biodegradation of organic compounds in soil is a key process that has major implications for chemical fertility and plant nutrition, physical properties, carbon storage, control of pathogens and also dynamics of pollutants. The fate of organic compounds in soil is controlled by processes occurring at the micro-scale. Measurements and modeling performed on a macroscopic scale do not take into account the microscopic specificities of the soil and in particular the important heterogeneity at this scale. If microorganisms and substrates are not co-localized, transfer processes controlling the accessibility of the microbial substrate will be a key factor. Active motility of bacteria is generally reduced in soil. Therefore, bacterial degradation is strongly regulated by diffusive/convective transport of substrates to these microorganisms.
The objectives of this work were to better understand how transport conditions drive spatial distribution of 2,4-D and its bacterial degraders at a millimetric scale. We built soil columns (diameter 5 cm, height 3 cm) combining natural and sterilized soil aggregates in which we localized soil microorganisms and the pesticide 2,4-D (2,4-Dichlorophenoxyacetic acid), with the following spatial distributions: (i) homogeneous distribution of microorganisms and 2,4-D in all the soil cores, (ii) co-localized distribution of microorganisms and 2,4-D in a mm^3 spot and iii) a disjoint localization of microorganisms and 2,4-D in 2 mm^3 soil spots. Controls with only 2,4-D or only microorganisms were also carried out. Two sets of experiments were performed: one with ^{14}C-2,4-D to study the fate of 2,4-D and one with ^{12}C-2,4-D to follow the growth of degraders, total bacteria and fungi. Microcosms were incubated at 20°C and at a matrix potential of -320 cm (pF 2.5). Three irrigation events corresponding to 2 pore volumes were carried out every 3 days after starting the incubation.
At the core scale we followed total and 2,4-D mineralization (CO_2 and $^{14}CO_2$) with time and measured ^{14}C in leachates. After 24 days of incubation, soil cores were cut out in slices of 6 mm thickness. Each slice was then further separated into soil cubes (6 mm edge length). The individual soil cubes were analyzed for extractable and non-extractable ^{14}C-residues and for microorganisms (qPCR of tfdA genes, 16S and 18S rRNA genes). Knowing the initial position of soil cubes allowed us to establish 3D maps of ^{14}C residues and microorganisms in soil.
Results showed that whatever the spatial distribution of 2,4-D and microorganisms, the loss of ^{14}C in leachates represented more than 50% of added ^{14}C and was not significantly different between treatments. The 2,4-D mineralization rates were faster when 2,4-D and microorganisms were homogeneously distributed in the entire soil core. When substrate and microorganisms were co-localized at the top of the core, 2,4-D mineralization rates were slower but the final mineralization was close to the homogenous distribution after 24 days (28.7 and 32.7% of added ^{14}C respectively). When 2,4-D was localized at the top and microorganisms at the bottom of the soil core, 2,4-D mineralization represented only 11.4% of added ^{14}C at the end of the incubation. The disappearance of ^{14}C in the extractable fraction and the production of non-extractable ^{14}C residues were stronger when mineralization increased.
For the homogeneous distribution of 2,4-D and microorganisms, we detected degraders, bacteria and fungi in the entire core. When 2,4-D and microorganisms were not co-localized, microorganisms were concentrated at the bottom of the soil cores while 2,4-D was distributed by diffusion and convection everywhere in the core. When 2,4-D and microorganisms were co-localized at the top of the soil core, 2,4-D spread in the entire soil core, whereas microorganisms grew or were transferred mainly vertically in the central part of the core. Non-extractable residues were mainly produced in zones colonised by microorganisms. Bacterial degraders of 2,4-D played a predominant role in the formation and localization of biogenic non-extractable residues in soil.
These results emphasize the importance of considering microscale processes to better understand the fate of organic substrates in soil.

Keywords：*biodegradation, mm scale, biogenic non extractable residues, convection/diffusion transport*

O59-5

[C2.3-2] B: Life in Soils - Distribution and Function of Soil Microorganisms in a Changing Environment

Are Microbial Habitat Conditions or Microbial Communities the Main Drivers of Soil Organic Matter Decomposition ?

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Soil microbial communities live in the soil complex three-dimensional framework, which causes a variety of niches, corresponding to the microbial habitat. For our knowledge, no study analyses and assesses the relative importance of microbial habitat conditions versus this of microbial communities in the soil organic matter decomposition.

Some studies showed that the main factors structuring and driving community abundance and diversity are soil physico-chemical characteristics, such as texture, pH, and organic matter status (quantity and quality), but include also soil management and plant cover. In order to work with different soil microbial communities, we choose six contrasted soils from a same region (Ile-de-France, France), so with the same climatic conditions. These soils vary in texture, pH, organic matter status, so we have different microbial habitat conditions, and we verified the existence of different microbial communities (their structures and activities).

In order to uncouple effects linked to microbial habitat conditions from ones linked to microbial communities we sterilized soils by gamma radiations and proceeded to crossing inoculations. Each soil microbial community was extracted from its native soil by a saline solution, and inoculated in each on the six different sterilized soils. During the incubation, carbon mineralisation was measured, and the microbial degradation capacities as well as the microbial communities structures were analysed. The cumulative respiration curves were fitted with two-compartments first-order model, and parameters were extracted. Microbial habitat appeared to be the dominant determinant of soil organic carbon decomposition, and of microbial community structure. Nevertheless, the mineralisation rate of the native pool (β parameter), as well as the metabolic capacities were affected by the microbial community effect.

Keywords：*soil, microorganism, microbial community structure, habitat, soil organic matter,*

O60-1

[C2.2-2] B: Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

A Soil-glomalin Map of France: Are Levels of Soil Protein Related to Land Use or Soil Properties?

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Glomalin, the operationally defined soil protein reputed to be produced by Glomus fungi, is thought to confer physical stability to soil and contribute to stable stocks of carbon and nitrogen. We randomly selected 200 topsoils from the collection sampled in the framework of the French soil monitoring network. This network is based on a systematic grid (16-to-16 km) covering the whole territory by about 2200 sites. Detailed composition of the soils and the corresponding land-use is known for all the samples. We have assayed easily extractable (EE) and total (T) Bradford reactive soil protein (BRSP). These fractions are obtained by autoclaving once for 30 minutes in 20 mM sodium citrate solution at pH 7 (EE) or twice for 1 hour in 50 mM sodium citrate solution at pH 8 (T).Our study is the first large scale screening of soil protein carried out to date. The protein contents have been compared to land-use and soil composition. Total BRSP was in the range 1-5 g kg-1, with a median of about 2 g kg-1, and easily extractable BRSP was about 2 to 5-fold less, with most values in the range 0.5-1 g kg-1. Easily extractable and total protein contents were correlated suggesting that both fractions are probes of soil protein content and that the fractions do not necessarily reflect differences in protein age. BRSP followed a similar trend to soil organic carbon content (SOC). No strong correlations between BRSP and other soil properties, including pH, clay content, cation exchange capacity, C/N ratio, were observed. The proportion of SOC that could be attributed to BRSP decreased with increasing clay content and with increasing SOC. Data mining using the Cubist algorithm gave an excellent agreement between predicted and observed values of BRSPT (r2=0.94) . The most important parameters were found to be total nitrogen, non-complexed organic carbon followed by organic carbon content, with other measured parameters (including complexed organic matter) having much lower importance and land occupation ranking very low, less than 5%. The agreement between predicted and observed BRSPEE was not as good (r2=0.73) with predictions overestimated at low protein content and overestimated at higher values. The order of importance of soil and land use parameters differed from BRSPT : non-complexed organic carbon was most important, exchangeable aluminium and organic carbon ranked much lower (40-50 %) and total nitrogen had only an importance of about 20%. The small importance of land-use, identified by this approach, in contrast to simple linear correlations, indicates that the land-use effect is largely accounted for in carbon content and degree of complexation. A much larger number of parameters were important in predicting the ratio BRSPEE /BRSPT , starting with pH and including texture (sand and clay content) but all measurements of organic matter (organic carbon, complexed and non-complexed organic carbon had low importance (20%).
These observations do not support the hypotheses that glomalin is stabilized by association with clay minerals, although extractability may be related to texture. When organic matter content is high, a large proportion of organic matter will be in the form of fresh, non-stabilized organic matter. Protein contents were lower in agricultural cereal soils than in pasture and forest soils, in line with the lower organic matter content of the former. Interestingly the proportion of organic carbon attributable to protein was much greater in cereal soils. This suggests that protein is stabilized in soils depleted in organic matter. However the mycorrhizal fungal activity in these soils that are usually highly fertilized would be expected to be low, illustrating that the net protein content results from a complex balance between production of protein and breakdown and that not all protein may be of fungal origin.

Keywords：*soil organic carbon; soil protein; glomalin*

O60-2

[C2.2-2] B: Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

How Do Microbial Metabolism and New Microbial Legacy Mediate Soil Carbon and Nitrogen Cycling?

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Abstract: We know well that the turnover and dynamics of soil organic matter (SOM) is mainly driven by microorganisms, but we know little about how and to what extent the microbial processes of exogenous substrate transformation mediate carbon (C) and nitrogen (N) cycling in soil system. The mediation of exogenous substrates on soil microbial processes cannot be well deduced from microbial biomass measurements or microbial community evaluation alone due to its vulnerability to environmental regime change, but microbial metabolism feature and legacy (residue) such as amino acids and amino sugars can provide an integrated view of microbial roles and functions linked to soil C and N transformation and dynamics. However, a big challenge or a pivotal knowledge gap for the understanding of the underlying mechanisms is how to interpret the microbial metabolisms of both added substrate and soil native C and N, and moreover, a crucial technical limitation is how to differentiate the newly microbial-derived legacy (residue) from the soil native portions with the same components. In this context, we established a set of isotope-based gas/liquid chromatograph-mass spectrometry techniques, and applied the novel techniques to investigate the biochemical processes of C and N transformation and dynamics in soil systems as affected by substrate input. The key approach is differentiating between the newly microbial-derived amino sugar and amino acid legacies (residues) and the same soil intrinsic components (molecules). Our hypothesis is that microbial metabolism and new microbial legacy would mediate soil C and N cycling. Our results showed that extraneous organic C (13C labeled) and inorganic N (15N labeled) were rapidly immobilized by microorganisms and a large portion was incorporated into soil amino acids and amino sugars fractions as metabolic constituents. The both 13C and 15N enrichments in the target compounds increased significantly with increasing C:N ratios from 51 to 30:1 of substrates, although significant decomposition of the endogenous microbial-derived components was found along with the synthesis processes. The finding indicates that higher C availability stimulated microbial proliferation and in turn enhanced the microbial assimilation of exogenous C and N. However, a significant net decomposition of both the new microbial legacy and soil native organic C occurred at the C:N ratio of 5:1 and interestingly the decomposition rate and magnitude of the latter was found in a much larger extent as priming effect suggesting that soil native organic C is apt to be decomposed for compensating C and N supply when available C is in deficiency. On the contrary, the higher availability of C (C/N=30) resulted in more rapid renewal of both microbial derived components and soil intrinsic organic C and consequently, the net accumulation of soil organic matter (SOM) was possible. Given the important transitional function of microbial-derived legacy we suggest that the endogenous microbial components can be further stabilized in the SOM as recalcitrant forms and this processes were controlled by available C, i.e. the substrate availability controls the turnover and dynamics of microbial legacy and soil native organic components. Therefore, we conclude that the cycling of SOC and N is dominantly mediated by microbial metabolism and new microbial legacy, which may play an important transitional role in adjusting and balancing the processes of microbial synthesis and decomposition of C and N, but the strategies of microbial proliferation and the contribution of microbial metabolisms to SOM accumulation is dependent on the stoichiometry of labile C and N.

Keywords：*microbial process, microbial legacy (residue), metabolism, soil organic carbon and nitrogen, substra*

O60-3

[C2.2-2] B: Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Uncertainty in Modelling of Soil Organic Carbon Dynamics Caused by Model Calibration Against Variable Observational Data

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Soil organic matter (SOM) models are widely used to assess potential changes and sequestration of soil organic carbon (SOC) in various terrestrial ecosystems. In fact, model–based approaches are recommended for national inventories of SOC and greenhouse gas emissions. It is common that SOM models, after calibration and/or validation against data collected at point (field or paddock) scales, are extrapolated to estimate SOC changes at larger spatial and longer time scales. In addition, model calibration and evaluation are usually conducted against the average value of measured SOC, and rarely quantitatively consider the variability of SOC measurements and its impact. Hence, uncertainty in simulated SOC caused by the variability in measurements is not assessed. In this study, the Agriculture Production Systems sIMulator (APSIM) was used to assess the potential uncertainty in predicted SOC stock induced by model calibration against SOC observations. Experimental data collected from a 25-year field trial at Wagga Wagga of Australia were used. The cropping system was a continuous wheat system with two treatments of N fertilizer applications (i.e., control with no N fertilizer and one treatment with 100 kg urea ha–1 yr–1). The SOC in the 0–10 and 10–20 cm soil layers were measured 21 times during the 25-year experiment period, each time with six replicates for each measurement. The APSIM model was calibrated against the observed SOC dynamics with consideration of the variability among the six replicates, by assuming a normal distribution for the replicates of each measurement and sampling the distribution to construct 100 sets of 'observational' data containing 21 points for each dataset. For each set of the sampled 'observational' data, the relevant model parameters of APSIM were optimised to get the best agreement between simulated and 'observational' SOC. The model was run for 100 years after the end of experiments using the 100 sets of model parameters under different carbon input and fertilizer application scenarios. The uncertainty in predicted SOC change was quantified by calculating the 95% confidence interval of the 100 simulations for each treatment.

Two parameters of the APSIM were targeted for the model calibration and SOC simulations: decomposition rate of humic organic matter in bulk soil (rd_hum), and the fraction of inert (i.e., inactive) SOM (finert) in humic organic matter. These two parameters are the two most important parameters directly influencing SOC dynamics. Three optimisation strategies were used to calibrate APSIM: (1) optimise rd_hum only, (2) optimise finert only, and (3) optimise rd_hum and finert simultaneously. The calibration results indicated that SOC stock was overestimated in the 0–10 cm soil layer and underestimated in the 10–20 cm soil layer if rd_hum was optimised only. This resulted from the fact that humus shared the same rd_hum regardless of its location in the soil. If finert was optimised only, however, finert can unrealistically reach to 1. These results suggested that other factors such as oxygen level and compaction may limit the decomposition of SOC in deeper soil layers and should be considered in future modelling studies. Optimising rd_hum and finert simultaneously resulted in better simulations under both N fertilizer application treatments. Using the optimised 100 sets of parameter(s) to run APSIM generated a wide range of simulated SOC change ranging from loss to gain even under the same carbon input and the same rate of fertilizer application. The calibration strategy itself also had significant effect on the uncertainty of simulated SOC even for the same cropping system under the same management. The findings of this study demonstrated the importance to consider measurement variability/uncertainty in future model calibration and in the assessment of the uncertainty in predicted SOC.

Keywords：*APSIM, Optimisation, Projection, Uncertainty, Measurement error*

O60-4

[C2.2-2] B: Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Investigation of the Degradation of ^{13}C-Labeled Fungal Biomass in Soil - Fate of Carbon in a Soil Bioreactor System

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Nutrient balances and degradation processes in boreal forests are mainly influenced by interactions of plant roots and ectomycorrhizal fungi. Plants benefit from nitrogen compounds provided by their symbiotic interaction partner. In return ectomycorrhiza are provided by large amounts of carbon from the plants which is used for the synthesis of hyphal networks in soil and for metabolic activity for nutrient uptake.

Therefore ectomycorrhizal fungi play a major role in ecosystems of boreal forests and are consequently an important sink for carbon by building large amount of mycelia.

Recently, it has been shown that microbial biomass residues contribute significantly to soil organic matter formation. This suggests that also residues of ectomycorrhizal fungi may be an important source for soil organic matter formation in forest soils where these fungi are abundant. However, the fate of ectomycorrhizal biomass residues in soils is unknown.

We therefore investigated the fate of ectomycorrhizal biomass in soil in a soil bioreactor system to quantify the contribution of this material to soil organic matter formation. As a model organism, we selected *Laccaria bicolor*, which was labelled by growing the fungus on ^{13}C glucose. The stable isotope-labeled biomass was then homogenized and incubated in a podzol from a typical forest site in Central Germany. The fate of the labeled biomass was traced by analyzing the amount of ^{13}C mineralized and the amount remaining in the soil. The fungal biomass carbon was mineralized rather rapidly during the first 25 days. Then the mineralization rate slowed down, but mineralization continued until the end of the experiment, when approximately 40% of the ^{13}C was mineralized and 60% remained in soil.

In addition, we analyzed biomolecules such as fatty acids and amino acids to trace the incorporation of the *L. bicolor*-derived biomass carbon into other microorganisms and to identify potential primary consumers of fungal biomass. By these analyses, we found a significant incorporation of *L. bicolor*-derived carbon into a wide variety of different bacterial taxa, indicating the relevance of fungal biomass residues for soil bacteria as a carbon source.

In a later phase of the experiment, we will also trace the fate of soil organic carbon into the fungal biomass and the plant partner (*Picea abies*). These results will provide a comprehensive view of the role of ectomycorrhizal fungi and their residues on soil carbon cycling.

Keywords: *Soil Organic Carbon , Ectomycorrhiza*

O60-5

[C2.2-2] B: Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Modern Approaches to the Isolation and Characterisation of Soil Humin

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It is estimated that there are approximately 2344Gt of organic carbon (OC) in the top 3m of the world's soils, which is more than four times the living pool of OC on the earth's surface. Soil organic matter (SOM) can be separated into unaltered organic materials that include fresh and recent debris and transformed products, or humus that bears no morphological resemblance to the structures from which derived. The transformed products can be divided into amorphous, brown coloured humic substances (HSs), and into compounds belonging to recognisable classes such as saccharides, peptides, nucleic acids, altered lignin, etc. The humified products are commonly divided into fulvic acids (FAs), humic acids (HAs) and humin on the basis of their solubility (or lack thereof in the case of humin) in acidic and basic media.

Humin is the least understood of these fractions yet it is known to comprise 50% or more of the OC in mineral soils and more than 70% of that in lithified sediments. Thus it can be assumed that humin is the most abundant operationally definable class of organic substances in the environment, and the major contributor to the sequestration of OC. Despite the obvious importance of humin it has not been studied to the same extent as HAs, mainly because of its low solubility in the extractants commonly used to extract humic substances. At the same time, it has been assumed by many workers to be similar in composition and structure to the less soluble HAs. This is a view that we will challenge.

The emergence of new isolation and fractionation procedures, and above all else the availability of advanced analytical instrumentation has enabled us to focus in more detail on the compositions of the fractions of humified organic matter in the isolates from soil. Recent research suggests that the compositions of the SOM fractions that can be designated as humin are chemically different from humic and fulvic acids such that humins are not in fact HSs. Thus it is time to critically evaluate our concepts of the nature of humic components, and of humin in particular.

Significant advances have been made in studying the composition of humin by exhaustively extracting the base-soluble SOM, and then treating the residual soil or soil clays with HF or HCl/HF mixtures. The residual organic matter when subjected to dialysis and recovered by freeze drying was shown by NMR to be composed largely of aliphatic hydrocarbon materials.

The approach used has been to exhaustively extract the soil in a basic medium (0.1 M NaOH), followed by further exhaustive extraction in 0.1 M NaOH + 6 M urea. The residue is repeatedly extracted in dimethyl sulphoxide (DMSO) + 6% concentrated H2SO4 and the humin precipitated by the addition of H2O. The residual clay material is subjected to the HCl/HF treatment and the remaining associated organic matter that was not recovered in the DMSO-acid system is recovered following dialysis and freeze drying.

The use of two-dimensional (2D) NMR has allowed observations of molecules that are masked in the traditional 1D NMR experiments because of overlapping of signals, and our NMR data have helped resolve awareness of the molecular structures that become part of the long term C sink in soils. The recalcitrant organic C in the humin is mainly composed of aliphatic hydrocarbon materials that are resistant to, or are protected from degradation by microbial activity. Peptides and carbohydrates are also shown to be important contributors and are selectively preserved in the organic C sink. Lignin residues form only a small part of the humin. Detailed studies showed that the DMSO-acid treatment did not chemically alter the compositions of the isolates.

The highly ordered aliphatic hydrocarbon components in humin, (sometimes referred to as ‘crystalline’ methylene structures) resist swelling in DMSO, and represent the most rigid materials in humin. These highly aliphatic ‘polymethylene’ structures have strong association with the mineral colloids, and have a high resistance to microbial transformations. These aliphatic materials can have a significant role in the binding of hydrophobic contaminants. Most importantly, due to their inherent chemical and biological stability, they can play a major role in carbon sequestration and greenhouse gas mitigation.

Keywords：*Humin,Soil organic matter, characterisation, refractory C, carbon sequestration*

O61-1

[C3.5-3] Management and Reclamation of Mining Site Soils

Capacity of Tamarix Africana Poiret to Colonize Contaminated Estuarine Sediments by Former Steel Industry Activities. Microcosm Assays

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Former Portuguese steel industry disposed its wastes on the left bank of the Coina River, an affluent of the Tagus River near its estuary, creating a landfill, which is connected to the river itself, forming a lagoon. This landfill is subject to tidal influence, representing a potential risk of contamination of water, sediments and biota in Tagus estuary. Phytostabilization may be a promising technique reducing the dispersion of the contaminants. This study aims to evaluate the capacity of Tamarix africana Poiret to be used for phytostabilization of estuarine contaminated sediments. A sample of representative sediments and two samples of river water were collected during ebb tide. Thirty specimens of T. africana, resulting from propagation by cuttings of plants harvested in uncontaminated site and planted in peat, were used in the assay.
A pot experiment was conducted in a greenhouse during 97 days, in a total of eight pots filled with 16 kg of sediment each. In four pots were planted a total of 20 plants and the other pots (control) remained without plants. All the pots containing sediment were watered daily using the collected river water in order to simulate the sediment-water field conditions.
The sediment was characterized for: pH, electric conductivity (EC), TOC, extractable P and K, mineral N, iron oxides (crystalline and non-crystalline), manganese oxides, and multi-elemental analysis by ICP/INAA. Both pore water and river water were analysed for pH, EC, HCO3– and SO42–, Cl–, and multi-elemental analysis by ICP-MS. Plants were harvested at the end of the assay, divided in shoots and roots weighted and analysed for multi-elemental content by ICP-MS. Plant shoots were washed with 0.1 % HNO3 aqueous solution for two minutes in order to dissolve the salts exuded by plants during growing. These solutions were analysed by ICP-MS.
Sediment had pH=7.2, EC=18.5 dS/m, TOC=147.8 mg/kg, high to very high concentrations of extractable P (62.8 mg/kg), K (1.24 g/kg) and mineral N (11.3 mg/kg). Concentration of Fe in iron oxides was very high (169.4 g/kg) being 99 % ascribed to the non-crystalline phases.
Sediment is considered contaminated as the concentrations of several hazardous elements (in g/kg: Zn=2.9; Pb=0.91; Cr=0.59; Cu=0.16, and in mg/kg: As=65.5; Cd=5.4; Hg=1) are above Canadian ISQG values for marine sediments. Iron (190 g/kg) and Al (49.1 g/kg) also presented high concentrations. The available fraction of the chemical elements, evaluated by their concentration in the sediment pore water, was lower than 1 % of their total concentration.
River water used for irrigation showed values for pH (8.2-8.4), EC (28.6-44.7 dS/m), sulfates (885-1234 mg/L) and Cl- (230.5-251.7 mg/L) above the maximum allowed values for irrigation waters according to the Portuguese legislation. Cadmium (0.017 mg/L) and Mn (1.28 mg/L) concentrations were above Canadian Water Quality Guidelines.
Shoots from plants growing on sediment showed concentrations of trace elements within the range considered normal for plants in general. Translocation coefficients (shoots/roots) are < 1 for the majority of the elements, except for the micro- and macro-nutrients. This species is not accumulator of the analyzed elements, except for Na (transfer coefficient soil/shoots = 1.27).
The concentrations of Al, As, Cd, Cr, Cu, Fe and Pb in the pore water (after plants growing) presented a decrease between 14 and 42 % when compared to the control samples. However, Zn and Mn showed an increased of 67 and 13 %, respectively.
Salts exudated by leaves contained high concentrations (referred to plant dry weight) of: Al (29.01 mg/kg), Cd (0.16 mg/kg), Fe (35.85 mg/kg), K (1.69 g/kg), Mn (13.28 mg/kg), Na (2.96 g/kg), Pb (1.72 mg/kg), and Zn (18.51 mg/kg). Concentrations of some elements are similar (e.g. Cd) or even higher (Al, K and Pb) than their concentrations in shoots. Tamarix africana seems to be adapted to the sediment and water characteristics showing the ability to release chemical elements by the leaves as an adjustment to the salty estuarine environment as well as to some hazardous elements, avoiding symptoms of toxicity. Chemical elements are mostly retained in the roots, which indicate that this species has potential for phytostabilization of contaminated estuarine environments.

Keywords：*Halophyte species , Phytostabilization, Tagus estuary , Trace elements*

O61-2

[C3.5-3] Management and Reclamation of Mining Site Soils

Long-term Effects of Compost Additionsl to Metal Contaminated Soils: Soil Chemical Parameters, Function of Microbes, and Avoidance Response of Earthworms

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Phytostabilization has been used extensively as one method for remediation of Pb/Zn contaminated waste materials. This generally involves the application of large quantities of organic matter in order to improve physical, chemical, and biological characteristics, which enhances biogeochemical nutrient cycles, and that may provide adequate nutrients and organic C to establish a sustainable vegetative cover. Unfortunately, many phytostabilization efforts fail within 5 years and one cause may be linked with inadequate organic matter additions when the area is first remediated. In this study, beef manure compost was applied at two different rates with and without lime and bentonite. A 269 Mg/ha application of composted beef manure is compared to the standard 45 Mg/ha application that has been shown to be ineffective at maintaining an acceptable long-term vegetative cover on this mine waste. Switchgrass (Panicum virgatum) was seeded into plots to establish a vegetative cover. Enzyme activities and microbial biomass measurements were used to monitor nutrient cycles upon amendment addition. Avoidance response of earthworms was used as a screening tool to evaluate the effect of amendment addition on ecotoxicity. Compost additions significantly increased C, N, P, and K contents along with pH values. Experimental results indicated that over a period of 5 years the high compost treatment had significantly higher microbial biomass and enzyme activities than the control while in general all low compost treatments did not differ from the control. Avoidance response of Eisenia fetida indicated that there was no mortality of earthworms after 48 hr exposure period of any of these materials, although the control showed habitat limitation (< 20% earthworms were found in the control). Avoidance was clear in the contaminated control and in the low compost treatments. Results suggest that a high application of beef manure compost improved the soils chemical and biological status over the contaminated control, in particular restoring soil microbiological properties and/or their function to a higher level. Results also suggest that a high manure application reduces ecotoxicity. The application of 45 Mg/ha of compost did result in significant improvement over the control, for most measured parameters, and it was significantly different from the high compost treatments. However, a decrease in plant biomass and enzyme activities seen in the high compost treatments after 5 years suggests that long-term sustainability of these efforts may require repeated addition of soil amendments every 4 to 5 years. This is a long-term effort so the purpose of this report is to provide the most recent data on the study to address the question of sustainability of the reductions in metal bioavailability and enhancements of microbial activity and vegetative cover induced by the high compost additions.

Keywords：*heavy metals, phytostabilization, enzyme activity, microbes, earthworms*

O61-3

[C3.5-3] Management and Reclamation of Mining Site Soils

Punakaiki Coastal Restoration Project: a Case Study for a Consultative and Multidisciplinary Approach in Selecting Indicators of Restoration Success for a Sands Mining Closure Site, West Coast, New Zealand

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This case study outlines how a consultative approach to mine closure can deliver shared benefits and create new endeavours that advance conservation, knowledge of biodiversity and a broader understanding of the role of multi-sector partnerships. It also illustrates how an interdisciplinary research project, high level closure policy implementation and the value of partnerships can work in a collaborative approach to bring about sustainable post mining land use.

In 2000, Rio Tinto acquired 114 hectares of coastal land at Punakaiki on New Zealand's South Island that had been the focus of a proposed mineral sands development, culminating in pilot-scale mining and processing by Westland Ilmenite Limited (WIL, part of North Ltd), in the early 1990s. The site had been in care and maintenance from 1994. Rio Tinto instigated a process to ensure its approach to post closure was developed and managed to meet its goal of contributing to sustainable development. Though much of the land has been cleared for pasture, the area is of high conservation value. The WIL land is adjacent to Nikau Scenic Reserve, located between the Paparoa National Park and the coastal dunes; contains remnant coastal forest and wetlands. The Paparoa National Park contains the only known breeding colonies of the vulnerable Westland Black Petrel.

The Punakaiki Coastal Restoration Project (PCRP) was established in 2009 to enhance the revegetation of the sand plain forest on land adjacent to the Nikau Scenic Reserve that had been previously mined and farmed. Over 120,000 trees have been planted to date.

To develop and test indicators of restoration success, we performed interdisciplinary research:

1) Floral and faunal inventories and monitoring to determine characteristics of forest and disturbed environments at the species and community level, with a focus on the transition of these characteristics during restoration.

2) Pedology and soil chemical analysis was completed to identify potential variables that may influence the restoration of floral and faunal communities at the site.

3) A literature review was prepared comprising historical studies of the Nikau Scenic Reserve, New Zealand sand-plain ecology and geomorphology, the utilization of indicators in monitoring ecological restoration and the potential for the research to support biodiversity offsetting in New Zealand.

Three monitoring plots were established across the site: mature forest, unplanted and restored. Several significant ecological indicators were identified across these three monitoring plots. Terrestrial ecological indicators included dung beetles, weta, spiders, moths, leaf litter invertebrates, endemic and exotic earthworms, native and exotic bird species, mice and rats. Blue penguins were observed and photographed within the PCRP area for the first time. Aquatic invertebrates and native fish were identified. The future trajectory of restoration success will be determined by canopy closure and subsequent colonisation and recruitment of additional species, with epiphytes and plant associations being particularly critical.
Four different soil series were described across the site; Karoro, Kamaka, Kamaka (shallow variant) and Waiwero. The description of soil chemistry at the site was confounded by the overlay of the four different soil series and by the complex and historic usage of the plots. Multivariate analysis allowed separation of the 3 treatments and important chemical variables included C/N ratios, Zn, K, S, Mn and Mg. A soil chemical response is apparent after the first five years of restoration.

This monitoring and interdisciplinary research programme has informed the restoration process on its trajectory from post-mining to farmed pasture to mature forest, beyond the initial establishment of 120,000 trees over 5 years. A multi-dimensional approach linking changing soil, vegetation and faunal communities, beyond a baseline survey and onward monitoring, provides an example of best practice in restoration ecology.
The legacy of this work is the development, protection and management of a unique biodiversity asset through the collaborative partnership and collective vision of Rio Tinto, CVNZ, DoC and Lincoln University. Future management of this site presents an opportunity to further this legacy by developing ecological, educational, and recreational values and potentially benefit the local community through tourism.
This research signals a paradigm shift in creative conservation through integrative restoration ecology that includes the floristic, faunal, geological and pedological components. This approach is readily transferable and could constitute a new standard for the next generation of restoration projects.

Keywords：*Collaborative partnerships Restoration ecology, Soil chemistry, Pedology, Ecological indicators, New*

O61-4

[C3.5-3] Management and Reclamation of Mining Site Soils

Spatial Distribution and Bioaccessibility of Lead in Soil in the Urban Area of Broken Hill, New South Wales, Australia as Affected by Dust Deposition and Remedial Works with Cracker Dust

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Mining activity in Broken Hill, New South Wales, Australia has been conducted for more than a century due to the presence of a rich lead-zinc-silver deposit there. Not surprisingly, lead (Pb) in soil in the Broken Hill urban area is ubiquitous due to the natural weathering of local Pb-rich rocks and the deposition of Pb-rich dust generated from the mineralised zone. The local dry and windy weather, with occasional stormwater flow, has allowed these two processes to gradually shape the distribution and concentration of Pb in soil around the city over the long term. Young children are particularly at risk of exposure to soil Pb due to their frequent hand-to-mouth activity. The monitoring of blood Pb levels in Broken Hill's young children in 1991 showed that 86% had blood Pb levels above 10 μg/dL, which is the current 'level of concern' for blood Pb. In order to address the high soil Pb issue, the Broken Hill City Council undertook a Public Land Remediation Programme during the period 1994 to 2004. One part of this remediation programme was the capping of footpaths and vacant blocks with a locally-sourced, Pb-poor, igneous rock crushed to a fine gravel. Known locally as 'cracker dust', the high percentage of coarse fraction material allows it to stably settle down on the top of Pb-rich soil as a Pb-free capping layer. In Broken Hill it has usually been applied as a layer least 5 cm in thickness. The aims of our study are; (1) to evaluate the effectiveness of remedial works with cracker dust, (2) to investigate the impacts of dust deposition on soil Pb distribution after the remediation, and (3) to measure the bioaccessibility of soil Pb and identify its major influencing factors. The urban area of Broken Hill is unequally split into two by the SW-NE trending Line of Lode, with the northern part of Broken Hill (NBH) being approximately three to four times larger than the area of the southern part of Broken Hill (SBH). In early 2013, we took topsoil (10 cm deep) and subsoil (30-50 cm deep) samples from 53 locations covering both NBH and SBH and measured total Pb concentrations by using a portable X-ray fluorescence (pXRF) analyser. Pb concentrations were determined on the bulk (<2 mm) topsoil and subsoil samples, and on the "dust-sized" (<100 μm) fraction of the topsoils. The results of bulk subsoil total Pb concentrations showed a clear negative correlation with distance from the Line of Lode, indicating the weathering of Pb-rich parent material, especially in SBH. The results of bulk topsoil total Pb concentrations showed a somewhat different distribution pattern; although, in general, topsoil Pb concentrations were highest near the Line of Lode, significant areas near the Line of Lode (especially in SBH) yielded low total Pb concentrations (<600 ppm). These areas correspond to cracker dust-remediated sites, indicating that the cracker dust remediation has been generally effective. However, there were several Pb hot spots identified close to the Line of Lode in NBH and on both the western and eastern edges of SBH that need remediation or continued remediation. Previous dust deposition and total dust Pb deposition monitoring data obtained within the mining leases, or close to them, showed significantly high total Pb concentrations in dust around this area. In comparison to bulk topsoil total Pb concentrations, total Pb concentrations in the <100 μm fraction of topsoil samples were generally found to be twice as high, indicating a potential Pb-rich dust loading in the soil. However, due to both the low dust deposition rate and total dust Pb deposition rate, the elevated Pb concentrations in soil caused by Pb-rich dust deposition were not expected to be observed in a short period. In the future, we will measure the bioaccessibility of topsoil total Pb because only a fraction of total Pb in soil can be digested and absorbed by the human gastrointestinal system and enter the blood circulatory system. The identification of major factors influencing soil Pb bioaccessibility can contribute to the development of future remediation strategies.

Keywords：*lead, urban soil, mining site, dust deposition, remediation, cracker dust, bioaccessibility*

O61-5

[C3.5-3] Management and Reclamation of Mining Site Soils

Evaluation of Electrical Resistivity Tomography Method for Estimating Physicochemical Properties of Mining Wastes

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The aim of this study was to evaluate the Electrical Resistivity Tomography (ERT) method as a sustainable tool for estimating physicochemical properties of mining waste. For achieving this objective, three locations (G1, G2 and G3) were selected according with their physicochemical characteristics in a tailing pond from Murcia (Spain). In each location an ERT profile and three ERT measures were carried out, also 36 soil samples (12 for each location), at 0-30 cm, 30-60 cm and 60-90 cm depth were collected and analyzed for physicochemical properties and heavy metals. In addition, 9 control samples were taken for equations validation. Finally, in order to identify which soil properties could be estimated by ERT measures the results from both surveys were statistically analyzed using regression analysis.

ERT measures revealed that in location G1, nearly the whole profile had low resistivity values (3-4 Ωm), except between 30 and 60 cm where some areas had higher resistivity values (12 Ωm). Location G2 is more heterogeneous than previous one, in this case three areas were identified: a lower resistivity area in an edge of the profile; other one located along first 50 cm of depth with highest resistivity values, and a third area with values from 25 to 90 Ωm in the rest of the profile. For location G3, the highest resistivity area is located at the first 30 cm of depth with values over 90 Ωm; the rest of profile had lower resistivity values ranged from 60 to 90 Ωm.

Geochemical characterization showed that this tailing pond has alkaline pH; high salinity; low nitrogen and organic matter contents; it is slightly calcareous; and it has a predominance of coarse fraction compared with clay and silt fractions. Total metal content is higher in location G1 than G2 and G3, but in all cases their concentrations exceed the reference levels established for international legislation.

In order to evaluate the correlation between ERT measurements and geochemical properties Pearson and Spearman correlation coefficients were applied. Spearman correlation coefficients are generally higher than Pearson correlation coefficients, indicating that a stronger non-lineal relation between ERT measurements and some geochemical properties exist. Results showed that moisture, salinity, sand and clay particles affect strongly resistivity values, although other parameters such as nitrogen, silt, inorganic carbon contents and total zinc, lead, copper, cadmium concentrations also affect the resistivity values. Using Spearman coefficients ≥ 0.45 ($p<0.001$) a regression analysis was carried out and the equations calculated. Exponential relationship was found for moisture, salinity and clay, and logarithmic relationship was found for sand, silt, total zinc, lead and copper. Finally, control samples were used for the validation analysis, which indicated that the accuracy was of 25%. Therefore, it can be concluded that equations from regression analysis could be used to estimate moisture, salinity, clay, silt, sand, zinc, lead and copper in similar mining ponds without geochemical analysis only using ERT measures with an accuracy of 25%.

Keywords：*electrical resistivity tomography, mining waste, metals, physicochemical properties*

O61-6

[C3.5-3] Management and Reclamation of Mining Site Soils

To the Issue of Metallization of the Mining Site Soils and the Biosphere in Whole

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Metallization of the biosphere (Vernadsky, 1994) refers to the number of effects of human activities already engulfed the whole world. In the recent decades, the concentrations of metals have increased in such media as the atmosphere, the hydrosphere, the pedosphere. The greatest geochemical changes have occurred in soils, which are the deposing medium where the high concentrations of metals are saved for decades after their direct human use. Therefore concentrations of metals in soils and their changes can be considered as a key indicator of anthropogenic pollution (including metallization) of the biosphere. Chemical elements gradually pass from the soil to the atmosphere, hydrosphere and living matter; during this migration metals in high concentrations can be directly transferred to the human body from the environment and also through the contaminated food (Motuzova, Karpova, 2013). This is the reason for the detailed consideration of the soils metallization process, especially in the mining areas.

The process of metallization of the biosphere, and soil in particular, could be schematically shown in the following way:

a. Migration of metals to the upper parts of the biosphere from the extremely small areas of mineral deposits in the lithosphere with high concentrations of elements (sometimes up to tens of thousands times higher than the average abundance in the lithosphere).

b. Arrival of metals to the environment during the ores transportation, their enrichment and preparation of concentrates. It usually causes the contamination of soils and plants in areas of existing enrichment plants.

c. Arrival of metals to the environment and their accumulation in soils as a result of smelting of concentrates.

d. Accumulation of metals in the soil as a result of manufacture and the subsequent wear and tear, and disposal of the mechanisms, materials, and other substances.

There have been numerous investigations devoted to the contamination of the mining sites soils in the former Soviet Union, and we will review some of the most significant.

a-b. Metallization of the surface parts of the biosphere could only occur through the primary metal extraction, i.e. during the development of mineral deposits. As an example, let us consider the geochemical changes of soil that have taken place during extraction and enrichment of Pb-Zn ore deposit, and remediated settler of the concentrating factory inactivated over 50 years ago, which we have studied at Tekeli, Kazakhstan. The settler material was covered by the exterior soils.

The highest average concentrations in the upper soil horizons are confined to the different parts of the mine (approximately 1 sq. km) and greatly higher than the average concentrations in the soils of the Earth: Pb (225 times), Zn (30.6), Ba (15.5), Cu (7.4). In the soils over the settler average concentrations of base ores metals although less than in soils at the mine, but significantly higher than the Earth's soil abundances: Pb (225 times), Zn (13.6), Ba (3.1). Furthermore, in high concentrations appeared Mo (3.2 times) and Sr (1.7), which are likely related to the process of ore enrichment.

c. The considerable soil metallization is associated with the metals obtaining from the concentrates. Thus, according to M.S. Panin, in soils of Ust-Kamenogorsk (Pb-Zn factory), the average concentration of Cu is 76, Cd – 9, Bi – 2, Ag – 0.5, Mo – 4, Pb – 254, Zn – 890 (all data in mg/kg).

In the area of operation of a large copper-nickel plant "Severonikel" in Monchegorsk, concentrations of Ni at the distance of more than 11 km from the combine are higher than the average in the Earth's soil, and Cu – at the distance 15-30 km (Golubeva et al., 2006). At the distance of five kilometres the average concentrations of Cu in soils are 25 times higher than average in the Earth's soil, and Ni – 6 times higher.

Conclusions:

I. The metallization of soils has covered almost the entire biosphere. Mining sites and ore beneficiation zones are the areas of the highest concentrations of metals in the soils.

II. The largest areas and the most dangerous for the human health metal concentrations in the soils are associated with the extraction of metals.

III. The dominant contemporary way of remediation of the ore beneficiation areas does not prevent the spread of metals through the decades.

Keywords: *biosphere metallization, soil pollution, soil remediation, Pb-Zn mining, stable contamination, mining sites soils*

O61-7

[C3.5-3] Management and Reclamation of Mining Site Soils

Effects of Coarse Woody Debris Extract on Nitrogen Transformation Rates of Reclaimed Oil Sands Soils in Alberta, Canada

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The Athabasca oil sands region has the third largest recoverable oil deposit in the world, and open pit mining is a common practice to extract oil in this region. As of 2013 approximately 715 km2 of boreal forests in northern Alberta have been disturbed which requires reclamation to an equivalent land capability. Peat mineral soil mix (PMM) and LFH mineral soil mix (LFH) are most common sources of organic amendments for reclamation of open-pit mined areas in the Athabasca oil sands region. Such amendments provide nutrients for plants and assist in restoring soil functions. Coarse woody debris (CWD) can be an additional source of organic matter, but the effect of CWD on nitrogen (N) cycling in reclaimed oil sands sites is not well understood. CWD can provide nutrients through decomposition, and can affect soil water content and temperature, potentially changing soil organic matter mineralization rates. However, CWD may increase nutrient immobilization in the initial stage of decomposition mainly due to its high C/N ratio and lignin content.

A laboratory incubation experiment was conducted to study the effect of CWD extract on net and gross N transformation rates using the 15N isotopic pool dilution method. This experiment was conducted with a 2 (PMM vs. LFH) × 2 (CWD extract vs. rainwater) factorial design with three replicates each. PMM and LFH samples were collected from a site reclaimed 5 years ago from the Southeast Dump of the Suncor lease in Fort McMurray, Alberta. Aspen CWD samples were collected from the Suncor lease and ground, passed through a 0.84 mm sieve and extracted with rainwater collected from Fort McMurray. Soil samples were incubated for 4 days at 25 °C after addition of CWD extract or rainwater. Samples were destructively collected every day and the concentrations and isotope ratios of NH4+-N and NO3--N were determined after extraction with 2 mol L-1 KCl.

Gross N mineralization rates increased with CWD extract compared to rainwater; rates were 5.7 and 1.6 times greater in CWD extract than in rainwater addition treatments for PMM and LFH, respectively, in the first day of incubation. CWD extract decreased gross N mineralization rates in the last three days of the incubation, in which rates were 8.0 and 2.1 times greater with rainwater than with CWD extract for PMM and LFH, respectively. CWD extract increased N immobilization rates in PMM and LFH resulting in negative net N mineralization rates. Net N mineralization rates were greater (or less negative) in samples amended with rainwater than those with CWD extract during the four days of incubation, being -6.2 and -0.5 mg N kg-1 day-1 in CWD extract and in rainwater, respectively, in PMM, and -5.3 and 1.3 mg N kg-1 day-1, respectively, in LFH. Gross N nitrification rates decreased with CWD extract compared to rainwater in PMM and LFH during the four days of incubation; the rates were 2.1 and 3.8 mg N kg-1 day-1 in CWD extract and in rainwater, respectively, in PMM, and 2.7 and 7.0 mg N kg-1 day-1, respectively, in LFH. This indicates that CWD application can cause nutrient deficiency by increasing nutrient immobilization and by decreasing nitrification rates if CWD extract input is high. However, applying CWD will change physical conditions and microbial activities. Thus, the field experiment will help us to obtain the full effect of CWD on land reclamation.

Keywords：*oil sands, reclamation, LFH, peat mineral soil mix, coarse woody debris, nitrogen cycling*

O62-1

[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Dirt Dialogues: an Integrated Art Exhibition, Film Program, and Emerging Dialogue at the 20th WCSS

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In an age of accelerated global soil degradation, creative approaches to protecting the soil are needed now more than ever. Raising awareness about soil stewardship means finding new forms of communication. Artists not only visualize critical issues regarding the use and cultural relevance of the soil, they tap into people's aesthetic abilities and emotional states, navigating between different social settings and target audiences. In a variety of ways, artists may be seen as powerful partners in soil protection and public outreach efforts.

As co-chairs of the German Soil Science Society's (DBG) Commission VIII Soils in Society and Education, and founders of the Technical University's soilarts.org initiative, the authors are hosting two special events at the 20th World Congress of Soil Science in collaboration with 20WCSS staff: a soil film screening series and a soil art exhibition. By integrating the arts into of one of the largest and most prominent scientific conferences on soils, different areas of expertise will be brought together to inspire new opportunities for interdisciplinary collaboration, and to widen the horizons of soil protection, communication, and education. This presentation gives a comprehensive overview of the Integrated Soil Art and Film Program within the context of the Commission 4.4 Soil Education and Public Awareness.

Film

A selection of films will be shown at the ICC JEJU during the week of the 20th WCSS. The films are organized into four approximately four-hour programs for each day of the conference with main feature films reserved for lunch breaks. The daily programs each concentrate on a particular topic, such as agriculture, energy, desertification and "being in the field." The films are thematically relevant to the soil science community as well as visually and emotionally appealing to a broader public. They serve to inspire not only a wider discussion on soil stewardship and challenges facing diverse regions of the world, but also to motivate sustainable action and engaged forms of communication.

Art

The format of the art exhibition is a series of poster-sized digital prints that will be interspersed within the overall scientific poster exhibition. The collection of works features a selection of "best practice" art projects that use soil materially or symbolically to

address, for example, issues of food security, soil degradation and land use management. Artistic contributions will be featured in corresponding scientific poster sessions, for example Ayumi Matsuzaka's artwork with Terra Preta in the session on “Biochar Soil Amendments,” or Urbaniahoeve’s 1:1 root diagrams of Alfalfa in the session on “Advanced Technology on Soil Remediation.' In this way intellectual barriers between art and science are challenged by juxtaposing artistic approaches with state-of-the-art scientific research.
Rows of potted rice saplings and white space for comments are the only visual cues besides the poster designs to give the exhibition a framework beyond the moveable walls of the scientific poster session. Over the course of the conference, two guided tours of the exhibition will be offered as well as an oral presentation in one the scientific sessions of Commission IV.

Dialogue

Many artists and filmmakers expressed an interest in “being present” in some way beyond the film or poster contribution and framework of the conference. Some artists also inquired about the fate of the posters after the conference. In response, we will hold a series of virtual round table discussions via Skype to exchange different perspectives on soil protection and communication in the general public, to encourage future interdisciplinary collaborations, and to “harvest” materials for upcoming exhibitions and conferences taking place around the world on the occasion of the UN Year of Soils in 2015.

A symbolic space will be created at the 20th WCSS to conduct conversations with participating artists and filmmakers, session conveners, and interested conference guests in what we call “dirt dialogues.” It is our goal to not only facilitate a productive exchange of ideas, but to gather and record those unique exchanges to inspire further dialogue. A selection of art posters and corresponding scientific posters, together with audio recordings and films is to be “exported” from the conference setting of the 20th WCSS to other settings of critical engagement and public space in the “year of soils” in 2015.

Keywords：*art, film, raising soil awareness, interdisciplinary collaboration, year of soils*

O62-2

[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Soil Science Society of America: Advancing Soil Science across Disciplines

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Whereas the Soil Science Society of America (SSSA) initial scope of research was almost strictly agronomic, it has evolved towards broader applications of soils. Most recently, soil science has been gaining prominence in the context of many societal challenges, such as climate and land-use change, environmental protection of natural resources, ecosystem services, food security and energy production. However, during this same period, many have expressed concerns over decreasing numbers of soil science programs and a weakening of the soil science profession. Some would argue that this is caused by the traditional agriculturally-based focus of soil science, as perceived by those from outside the soil science discipline. This is occurring in parallel with the increasing recognition of the relevance of soils by the broader scientific community and the public. In response, the SSSA membership has expanded its core activities beyond agriculture and food systems, and is actively engaging with sister professional societies, the public and with K-12 students nationwide to fill this gap. Even so, to ensure that soil processes are represented as essential elements in many environmental issues facing society today, soil scientists must increasingly be more involved and become effective partners with other professionals and organizations, to represent the relevance of soils across a wide array of functions and critical services.

In 2010, a SSSA Task Force was charged to evaluate the then current organizational structure towards improving the viability and visiblity of the SSSA. Their report was extensive and insightful with many of the report's recommendations being quickly adopted. These include restructuring the SSSA into broad groupings that foster interdisciplinary activities, while maintaining close association with the other two sister societies of ASA and CSSA. For example, by organizing relevant divisions in a Soil and Ecosystem Processes Group, the SSSA is demonstrating the society's emerging relevance to other scientific areas. In addition, the Society has developed a process for organizing smaller thematic meetings preferably co-sponsored with other related professional organizations, and has agreed to occasionally hold their annual meeting separately or jointly with other professional societies . All of these initiatives are steps in implementing the goal of the SSSA's strategic plan: the building of a stronger home base, in areas of research, outreach, and education while reaffirming its traditional ties with its sister societies.

These changes pursue the goals of SSSA's strategic plan, to engage more broadly with the scientific community in defining a new role for modern soil science that will be widely recognized in the years to come.

O62-3

[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Teaching Soils and Soil Degradation using a Virtual Globe Approach

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Soils are crucial to sustain our lives and therefor their origin, use and potential vulnerability are important to understand. Any graduate in an education program focusing on the "Earth's Critical Zone" should have a basic understanding of soils. We present here an instruction lecture, which is developed for the bachelor programs Earth Sciences as well Future Planet Studies as taught at the University of Amsterdam. The aim of the instruction lecture is to 1. improve learning efficiency by interactively illustrating concepts of soil formation and soil degradation on the Virtual Globe and 2. recognize their spatial distribution in a Virtual Globe environment in which known point information on soil (profiles) can be studied in their spatial context. When using historic imagery, (change in) landscape and land-use patterns can be studied in relation to soil development.

We developed the instruction lecture within Google Earth and use this in a studio class room where presentations and additional non-digital techniques or experiments can be combined. We selected a case study from SE Spain, where field data are combined with remote sensing imagery and (historic) aerial photography, as well as thematic maps and other background information. This information is stored in .kmz files, which can be opened in Google Earth. Questions and assignments have been included, pinned to specific sites, landscape cross sections or regions of interest. These assignment have to be finished during the session, but can also be interactively be discussed in the classroom with the whole group of students. Such an approach can also be implemented within the preparation

of field classes, which potentially improves learning efficiency. This is also important as field classes are more and more perceived as expensive, resulting in an increased pressure by the educational management to reduce in field classes. Also outcomes of research or field classes can be connected to the system by which a digital knowledgebase is built up, directly coupled to the soils geographical environment.

The big advantages of the approach presented here is that 1. Virtual Globe environments connect more to the modern mind-set of students, 2. Point data can be directly coupled to the 3-dimensional regional setting using image drapes over a Digital Elevation Model rather than only numbers or isolated sketches, 3. Integration of knowledge from different fields, such as geomorphology can be easily achieved, 4. Didactical goals on expanding knowledge to understanding and application can be achieved, 5. A far better understanding of field-sites prior to field classes or field research can be achieved, 6. It allows for building up a knowledgebase if applied in a field research context, and 7. Soils science, but also other disciplines like geomorphology, can be educated in a more modern, appealing and effective way.

Keywords : *soil degradation, land use change, virtual globe, digital learning environment*

O62-4

[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Towards a Concept that Frames Soil Science Knowledge Required by a Diverse Range of End-users

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The growing need for graduates with soil science knowledge that is relevant to a diverse range of end-users is opening up many new employment opportunities. The global challenges being faced by society, including food, water and energy security, mitigating climate change, as well as maintaining biodiversity and ecosystem services, all require soil science knowledge. In addition to the biophysical aspects, solutions to these problems will have to also take into account the economic, social and policy dimensions. Therefore, graduates need to have the ability to identify problems and apply their knowledge, work with other 'non-soil scientists', and design contextual solutions that take into account both the biophysical and social dimensions. Developing learning environments to impart the relevant soil science knowledge that satisfies these needs requires a framework in which to consider our teaching of relevant knowledge. As identified by Churchman there is knowledge that is unique to soil science; the study of horizons, colloids, aggregates and biology, which has to be taught and explored in any course claiming to produce soil science graduates. The increasing influence of professional bodies for soil scientists has led to the development of sets of performance objectives that define the standard of soil science knowledge and 'what is to be known', to practice as a soil science professional. Finally, the value of soil science knowledge provided by graduates is also determined by its relevance and effectiveness when implemented to solve problems identified by end-users. All of these groups have a legitimate claim on soil science knowledge and therefore this framework will consider the academic, as well as the vocational knowledge that will form a soil science core body of knowledge (SSCBoK).

O62-5

[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Teaching Soils and Telling Stories with Digital Maps

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Many of the challenges confronting humanity are global. Climate change, water quality and scarcity, food security, all in the context of a growing global population, have clear links to soils. Studying these challenging topics appeals to many of our students. On the other hand, many students are interested in local issues, such as why the soils in their part of town are different from the rest, or how and why soils differ from one area within a field to another. The local interest is particularly apparent during field trips when there are many questions and opportunities to discuss the relationships between soils, landforms, and land use. We also note that students today love any electronic device that has a screen, and they love good stories!

The Integrating Spatial Educational Experiences project (Isee; "I see") implements a teaching-with-maps approach to teaching soil science using digital maps. First developed to support university-level soil science education in Indiana, USA, the project is now expanding to Wisconsin, Illinois, Kentucky, Ohio, West Virginia, and Texas. In the USA, we have detailed soil maps for most of the country, and all the information is freely available online. In the Isee project we have created thematic maps of soil properties that support the way we teach soils using the soil forming factors: climate, organisms, relief, parent material, and time. These soil property maps are combined with a digital elevation model that shows the relief, resulting in attractive, information-rich maps. All the maps are saved onto Apple iPads for use in both the classroom and the field without an Internet connection.

Students study the maps while they are in the field, and we give them exercises to guide their learning. For example, they may be asked to find the end moraine, determine what soil series occurs at a particular location, or to explain how soil drainage class relates to soil parent materials in a particular area. The maps are engaging since they can be changed quickly and zoomed in and out to see both the overview and the details. The maps fascinate students as they can immediately relate to what they are seeing. The overlay of roads and cities allows students to understand what they are looking at in familiar terms, but beneath that familiarity is a map that depicts their world in a new way. This is the entry point from which we as educators can begin to teach our students about the complex mosaic of soils and landscapes with many different properties that impact people's lives in various ways.

The stories that one can tell about the soils and landscapes differ from place to place. For the area around the Purdue University campus, for example, we tell how glacial processes deposited different soil parent materials and how this impacts soil properties and land use. In southwestern Indiana we tell the story of how surface mining for coal has greatly altered the landscape. In the Wisconsin Central Sand Plains we tell the story of the rapid expansion of high capacity wells and how irrigation changed the soils and landscape.

Teaching with maps promotes active learning, allows students to make connections both spatially and between different soil properties, and makes students aware of the role of soils in the complex systems at the Earth's surface. The expanded Isee web site and mobile app will have legends and explanatory text aimed at different audiences, with one level aimed at individuals with little or no prior knowledge of soil science. This will make the maps more understandable to beginning students and to the general public as well.

Keywords：*teaching with maps, digital maps, soil geography, spatial information systems*

O63-1

[C1.2-1] Pedodiversity and Ecological Services -Bridging Soil Geography and Land Use

A Framework for Assessing and Reporting on Soil Assets, their State and Trend

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A Soil Assets, States and Trend (SAST) framework is proposed for describing, analysing, monitoring and reporting on Australia's soil resource. SAST builds on the Vegetation Assets States and Transitions framework indicators that describe a location's regenerative capacity (VAST2 Thackway 2012 and 2013). VAST2 indicator groups relevant to SAST include soil hydrology, physical, nutritional and biological states.

This paper further develops the soil components as an independent framework (but integrated with VAST2) for assessing land management impacts and changes to the functional characteristics of soil and land resources. SAST is based on relative change to eight key functional characteristics of soils including – soil hydrology (plant available water holding capacity, and local groundwater dynamics); soil physical state (effective rooting depth, bulk density); soil nutrient state (deficiency, toxicity); and soil biological state (biotic activity, organic matter). Together, these characteristics relate to the soil's capacity to provide a range of ecosystem services. State and trend is assessed in terms of change from a natural, undeveloped (or best case on offer) reference state.

SAST is a site-based concept that can be applied at the paddock, whole-farm, regional, national and potentially global levels. Assessments can be qualitative, based on expert opinion or any evidence of soil change or impact from land use and management, or can be quantitative if historic land use and land management practice information is known and can be linked to temporal soil monitoring. Scoring is scalar for each functional characteristic (between 1 for baseline state and 0 for total removal) and additive across the characteristics to provide a set of continuous scores over time describing the state of an area's soil resource, its change and trend.

SAST provides an asset-based framework for assessing the state of Australia's soils. At the highest level all soil is an asset, because it is an essential component of the complex environment through which air, water, nutrient and energy cycles provide ecosystem services upon which all life on Earth depends. Soil, or particular characteristics and functions of it, may however be considered a more valuable asset from one viewpoint (e.g. a wetland Hydrosol for biodiversity conservation) but not another (e.g. the same soil for agricultural production, unless it has been modified through drainage).

Scores generated using SAST can be represented over time as a graph showing a continuous temporal history of change and trend. Specific points on a continuous curve may be demarcated and defined as a baseline state against which past, present and future change and trend is measured. A land manager may also set a future target relative to the baseline or a reference state. Progress towards achieving targets can be assessed by comparing expected and observed soil function associated with particular changes to land management practice/s. The use of functional characteristics is less limiting than identifying specific soil attributes (such as pH or organic carbon) for which limited spatial and temporal data may be available, or which may not adequately represent the soil functions of interest to particular users.

SAST could be used by decision-makers to determine likely rates of historic change to soil resources and to identify areas where threshold levels in soil functions may indicate the need for changes in land management practices to prevent further decline in the provision of essential ecosystem services. Such assessments could be applied at farm management unit level, for considering appropriate management practices within specific farming systems (e.g. adoption of minimal till over conventional ploughing, the use of green cane harvesting, or consideration of nutrient addition regimes). Similarly it could be applied to regional or national assessments, such as State of Environment reporting in Australia. In addition, to historic change and trend, scenario planning could be used to assess possible future trends and consequences of continued or changed land use and management practices. Functional characteristics are less value-laden than specific attribute indicators, allowing them to be more readily used in trade-off analyses involving different viewpoints (e.g. production versus conservation).

Keywords：*soil assets, soil condition, state and trend*

O63-2

[C1.2-1] Pedodiversity and Ecological Services -Bridging Soil Geography and Land Use

Sustaining Ecosystem Services based on an Understanding of Pedodiversity: a Global System based on Cloud Computing, Mobile Apps and Crowdsourcing

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This paper will provide an overview of a new global system that will provide anyone with a data-enabled phone the ability to evaluate land potential to sustainably support different types of production systems. It will leverage and improve efforts to down-scale soil information, including the Global Digital Soil Map and the FAO's Global Agroecological Zoning System, using an integrated suite of mobile phone applications. These include a soil color app that uses a standardized color reference, a simple texture key, and a set up graphics-based questions about current land cover, land use and topography. Geo-tagged user inputs will be automatically transmitted to a cloud-based analytics system. This system will integrate the user data with soil predictions based on existing soil maps, as well as climate information and DEM-based topography predictions. Current estimates of land potential are based on traditional research-based production- and erosion-model predictions. Future versions will integrate local knowledge contributed by users as the system will allow users to document management system successes and failures associated with specific types of land, current soil conditions, and climate. Subject to privacy constraints, it will also connect users with similar land potential and management objectives. Our vision is for a global, open source Land-Potential Knowledge System that is owned, supported and expanded by stakeholders, and both builds on and supports soil mapping initiatives with the objective of sustainably increasing global agricultural production and while maintaining or increasing the provision of other ecosystem services. We do not expect the system to completely replace the need for face-to-face conversations among farmers, other land managers, extension, and consultants. Instead, it will allow these conversations to begin with as much existing knowledge and information as possible, from around the world. The system is being piloted in 2014 in Kenya and Namibia, with an initial focus on drylands where spatially-explicit information is needed for pastoralism and conservation, and where cultivation is being expanded into marginally productive lands with relatively high risk of soil erosion. For current information, please see landpotential.org.

Keywords：*information systems, soil mapping, local knowledge, mobile applications, crowdsourcing, analytics*

O63-3

[C1.2-1] Pedodiversity and Ecological Services -Bridging Soil Geography and Land Use

Coupled Analysis of Pedodiversity and Surface Water Diversity for Case Areas from the Developed East and Less Developed Central China

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Pedodiversity methodology is used to conduct the connective analysis between surface water diversity and pedodiversity.

Five case areas in less developed central (Zhengzhou, Kaifeng and Yuanyang in Henan province) and more developed east (Nanjing and Rugao in Jiangsu province) China were chosen respectively.

Surface water information was obtained first by using remote sensing data in different periods (2000-2001, 2004-2006), then soil family was used as basic soil map unit before the soil constituent diversity index and surface water spatial distribution diversity index were then calculated in 1km×1km grid scale of each case area, and finally the internal relations between them were analyzed for exploring the role of water distribution that plays in the soil formation.

Results show that the pedodiversity methodology may create a new way in the discreteness evaluation of surface water spatial distribution. The soil family type numbers always increased with the growth of the region total area. There was a positive correlation between changes of total surface water area and changes of surface water spatial distribution diversity, 19 subarea data supported this inference. The fractal character and structure were clearly shown in this study.

An interesting finding is that there was a negative correlation between region soil constituent diversity and surface water spatial distribution diversity, that is to say as the discreteness degree of surface water increased, the soil composing was always becoming less complicated, and this trend was most evident in Kaifeng subareas, the regression equation was $y=-0.030x+0.787$, $R^2=0.538$.

This study is supported by the National Natural Science Foundation of China “Impact of land use change on pedodiversity and analysis of its eco-environmental effect (41171177)”.

Keywords：*pedodiversity; surface water; spatial distribution diversity; constituent diversity*

O63-4

[C1.2-1] Pedodiversity and Ecological Services -Bridging Soil Geography and Land Use

Development of Ecological Site Descriptions in Coordination with Soil Survey

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Soil survey data and interpretations are an invaluable aid to planning and implementing land management and conservation practices and systems. For more than 60 years, the National Cooperative Soil Survey (NCSS) program in the U.S.A. has systematically developed soil maps and databases that identify key soil physical and chemical characteristics. Published soil survey information is available in standardized form on the Web Soil Survey for about 95 percent of the approximately 9.1 million km2 of U.S. land area. This important work has focused in the past on defining concepts of soil formation and applying state-factor theory in field investigations to describe the centroid attributes of natural soil components delineated in soil map units designed to fit the landscape at specific spatial scales. This has allowed us to recognize and communicate important and repeatable differences in soils, vegetation, and ecological processes within different parts of the landscape. By repeatable, we mean that landscapes are not an incomprehensible jumble of plants, animals, and soils that respond in unpredictable ways to humans influences

Substantial work remains, however, to refine soil survey and related data to better account for the spatial and temporal variability within the complex dynamics of natural systems. New remote sensing, mathematical, modeling, and digital mapping techniques are rapidly developing to assist the study, characterization, and interpretation of ecosystem dynamics including dynamic soil properties, soil-vegetation relationships, and other attributes that vary with land management actions and natural disturbances.

The concept of “site” has developed during the twentieth century as a tenet of natural resource management. Grouping portions of a landscape based on their climatic, geomorphic, and edaphic similarities to predict dynamics of soil, vegetation, and related resources, especially in response to land management, has provided a universally applicable management technology. The site concept has become increasingly sophisticated especially over the past about 20 years, culminating in the “ecological site” archetype. As more supporting information (soil survey maps, plant community dynamics) becomes available, site descriptions are increasingly effective in communicating effects of management.

An ecological site is a conceptual division of the landscape that is defined as a “distinctive kind of land based on recurring soil, landform, geological, and climate characteristics that differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its ability to respond similarly to management actions and natural disturbances”. An ecological site description (ESD) is a report with associated data that contains the body of information associated with each ecological site. An ESD documents the characteristics of an ecological site (including its climate, soils, state-and-transition model) and interpretations related to use and management. State-and-transition models (STMs) coupled to ecological sites specify indicators of ecological resilience and thresholds. STMs are synthetic descriptions of the dynamics of vegetation and surface soils occurring within specific ecological sites. STMs consist of a diagram and narratives that describe these dynamics and evidence for the causes. STMs are developed using a broad array of evidence including historical information, local and professional knowledge, and monitoring and experimental data from specific ecological sites or similar sites. ESDs, including STMs, are used to develop and apply adaptive management strategies and are highly relevant to implementation of soil health management systems and climate change adaptation.

The systematic development of ecological site descriptions throughout the U.S. done in coordination with the next phase of the work in soil survey is an important goal for the NCSS.

Keywords：*soil survey, ecological sites, ecological site descriptions (ESD), state-and-transition models (STM)*

O63-5

[C1.2-1] Pedodiversity and Ecological Services -Bridging Soil Geography and Land Use

Land-related Resource Efficiency in Europe. Focus on Soil-based Ecosystem Services

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Land take, and in particular soil sealing, has already been identified as one of the major soil degradation processes in the EU Soil Thematic Strategy (COM(2006)231). Through the disruption of cycles, soil sealing contributes to the loss of valuable soil functions, such as biomass production, storing, filtering and transforming water and nutrients, or hosting the carbon and biodiversity pool. As soil sealing, also other soil degradation processes (e.g., erosion, contamination) affect the delivery of soil-based ecosystem services, such as food production. Since the regeneration of soil takes more than a human's lifetime, soil can be considered a non-renewable resource.

In recognition of the problems created by land conversion, the EU has announced its Roadmap to a Resource-efficient Europe (COM(2011) 571), according to which ecosystems and their components (such as land in the sense of space for which different land uses compete) are considered a natural resource.

In line with this EU resource efficiency policy, the European Environment Agency has developed a land-related resource efficiency concept in order to evaluate the efficient use of the land and soil resource in Europe. It is based upon relating potential land use with the actual land use in a given region, and evaluates whether land (expressed through its soil functions) is used according to its (theoretical) potential. Land-multi-functionality can be addressed by considering alternative uses of land, including the multiple soil functions embedded simultaneously. Thus, potential synergies and trade-offs can be considered, and options for land-related resource efficiency can be proposed. In addition to the concept, first results based on the soil biomass production potential will be presented.

Keywords：*Soil functions, ecosystem services, resource efficiency, land use, Europe*

O64-1

[C2.4-3] Minerals as Regulators of Carbon Flow through Soils

The Instability of Stable Organic Matter Mineral Associations

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The term 'organic matter-mineral (OM-mineral) association' refers to a diverse class of materials formed through a wide range of physical and chemical processes including: adsorption of organic molecules to the surfaces, edges, or within the interlayer spacing of mineral particles; co-precipitation of organic molecules with metal ions such as Fe and Al; chelation of individual metals ions by organic functional groups; interactions of complex particulate organic matter with mineral particles; aggregate scale physical protection of organic matter; and more. The importance of these and other types of organic matter mineral associations for regulating the transformations of carbon in soil systems is generally accepted, but many questions remain with regards to the specific mechanisms by which this regulation is exerted. If it is assumed that organic matter mineral associations are not one-way regulators, i.e. organic matter moves into an association and becomes permanently removed from further cycling, then the dynamics of organic matter mineral associations become of critical importance. For example: How do the formation and destruction kinetics of organic matter mineral associations depend on the chemical structure of the organic molecules and mineral surfaces? How do changes in major soil conditions such as moisture, redox, and temperature drive uptake or release of organic matter from association with minerals? How do the changes in soil solution chemistry driven by rhizosphere exudation or changes in DOC composition impact the stability of particular organic matter mineral associations? What types of chemistry can take place between the organic matter and mineral while they are associated? These are all questions that must be addressed in order to accurately and quantitatively predictive the impact of organic matter mineral associations on carbon dynamics under current and future conditions and to develop successful carbon and soil management practices. This presentation will discuss some recent work from our group on these topics while attempting to set the stage for the other symposium contributions to follow.

Keywords：*organic matter mineral*

O64-2

[C2.4-3] Minerals as Regulators of Carbon Flow through Soils

Organo-mineral Interactions in Contrasting Soils under Natural Vegetation

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Organo-mineral interactions are important for the preservation of organic carbon (OC) in soils. To understand the role of soil minerals in carbon cycling, we used a sequential density fractionation procedure to isolate <1.6, 1.6-1.8, 1.8-2.0, 2.0-2.2, 2.2-2.6 and >2.6 g cm-3 density fractions in soils of contrasting mineralogies. We sampled 0-10 cm layer from four major Australian soil types - Chromosol, Ferrosol, Sodosol and Vertosol. Organic matter (OM) was found to be partitioned in four distinct pools: i) particulate organic matter <1.6 g cm-3; ii) phyllosilicate dominant 1.8-2.2 g cm-3; iii) quartz and feldspar dominant >2.6 g cm-3; and iv) Fe oxides dominant >2.0 g cm-3. X-ray photoelectron spectroscopy was used to investigate organic C and N bonding environments associated within the density fractions. The OC composition of all fractions was highly heterogeneous, representing a continuum of organic compounds. The mineral density fractions were enriched in distinct organic functional groups and we suggest that organo-mineral interactions improved the stability of organic carbon in soils. For example, the phyllosilicate dominant fractions were enriched with oxidised OC species (C-O, C=O, O-C=O) that support association of these species through ligand exchange with mineral edges and H-bonding. Protonated amide forms were also enriched in these fractions, especially in the smectite dominant fractions, which are able to adsorb to the mineral phase by direct electrostatic attraction. Phyllosilicate dominant fractions also displayed an increasing trend in δ13C values and decreasing C:N ratios with increasing density. Meanwhile, quartz and feldspar dominated fractions were enriched in aliphatic C, protonated amide forms and low C:N ratios. Relating bonding mechanisms to associated OM was made difficult in quartz and feldspar dominated fractions by inclusions of Fe oxides bearing minerals; however there is evidence to support H-bonding of lipids across surfaces and electrostatic attraction of proteinaceous substances with unsatisfied siloxane bonds, ligand bonding of O-C=O appears to be important when surfaces have Fe coatings. The Fe oxides dominant fractions had a greater proportion of oxidised C-O, C=O, O-C=O groups that suggest the presence of ligand exchange bonds with surface hydroxyl groups of the Fe oxides. The Fe oxides dominant fractions were also found to contain higher proportions of OC relative to the corresponding fractions in the other soils and displayed enrichment in δ13C with increasing fraction density, and decreases in the C:N ratios which were less pronounced. These results demonstrate the potential of mineral surfaces in influencing the chemical composition of OM bound in surfaces reactions and subsequently the stability of OM in organo-mineral associations.

Keywords：*sequential density fractionation, x-ray photoelectron spectroscopy, SOM composition, clay minerals*

O64-3

[C2.4-3] Minerals as Regulators of Carbon Flow through Soils

Aggregation of Humic Acid during Coprecipiation with Ferrihydrite

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The chemical and physic-chemical behaviour of humic acid (HA) in natural soil and water environments is a function of molecular structure, which has important implications for organic matter mobility, aggregation, interaction with clay surfaces and sorption of organic and inorganic compounds. The importance of iron oxides for Organic Matter (OM) stabilization in soil environment has been recently demonstrated to show slower decomposition rates of OM associated with iron poorly ordered crystalline compounds. In specific soils (Andosol, Spodosols, Histosols etc.) the long-term OM stabilization were correlated with HA association with poorly ordered Fe mineral contents. The associations between HA and iron were formed primarily through co-precipitation and/or direct chelation, promoting the preservation of OM in soil and in marine sediments. The extent of Ferrihydrite-Humic Acid interactions was ascribed to a large variety of sizes and molecular organization, depending on solution pH and ionic strength as well as the chemical properties of both HA and iron phases. The purpose of this research was to investigate the microstructure of Ferrihydrite-Humic Acid coprecipitates (in solid state through Transmission electron Microscopy (TEM), Atomic Force Microscopy (AFM), X-ray Diffraction (DRX) and Diffuse Reflectance Spectroscopy (DRS) and their colloidal behavior as a function of pH, in aqueous dispersions through Dynamic Light Scattering (DLS). HA under water solution at pH 6,3, observed with AFM was formed by well ordered rhombic planar particle. The isolate particle showed a well defined ring structure with a hole in centre. Some of the ringlike structures were completely closed and appear segmented. AFM images confirm that HA molecules can form multiple adsorption layers, because of the presence of a hydrophobic solid surface situated in the centre of rhombic shape particle which is favorable for HA molecules to assume a parallel organization on the surface of the mica. With the dispersion in alcohol , HA particle clearly become more compact, showing significantly narrowed-like structures. It is indicative of that alcohol may reduce the smaller nanometer-scale rings assemblies as the hydrophobic domains to form associates with humic substances and cause the assembly to become more compact. Coprecipitation of Ferrihydrite on the HA molecules induced net negative surface potential changing macromolecular conformation. The aggregation was fast in acidic pH for both pure HA and Fe-HA when hydrophilic surfaces were involved and electrostatic repulsion was practically absent. At neutral or alkaline pH negative charges of the Fe-HA macromolecules increased and the surfaces generated an increasing electrostatic barrier against aggregation. At pH below the pKa for the phenolic groups (pH $\leq$ 7), the sharp ζ rise observed for Fe-HA precipitate towards less negative values (in comparison to HA), indicated a more efficient charge neutralization. As negative charge increases, hydrodynamic particle diameter (Dapp) of Fe-HA precipitate raises as well. In correspondence of neutral-alkaline pH, the negative surface charge decreases, thereby enhancing colloidal stability. The favored opening of deprotonated Fe-HA network at alkaline pH would also support the experimental evidence of the more negative charge surface. HA contains both functional groups (carboxylic, phenolic, and carbonyl groups) and hydrophobic moieties. In the precipitation Fe(II) process the HA negative phenolic groups seems mainly involved in electrostatic interaction with the Fe hydroxyl surface groups, whereas the HA insoluble part (hydrophobic moiety) allows the macromolecule to accumulate on the inorganic surface. Modeling of the HA with sphere shape and charge located at the surface is thus unlikely, while a network of linear macromolecules that hold for low to moderate electrostatic potentials and large colloids is more consistent. These results confirm that structural variations of HA and their conformational variation strongly affect the colloidal stability of Ferrihydrite-HA association at pH ranging 5-7 and new negative surfaces were formed. Sterically stabilized oxide Fe/HA produced from coating by low polar and high molecular weight HA like leonardite may increase the mobility of Ferrihydrite in soil, and they may act as a carrier of Fe in the aquatic environment. Thus, coating of Fe nanoparticle with structurally different HAs may have a significant impact in terms of iron mobility implications and carbon stabilization. Since the OM stabilization occurred preferentially when HA macromolecules were aggregated with small micropore (<10 nm) of iron and aluminum oxides nanoparticle, the presence of Ferrihydrite coprecipitated with HA would be expected to play an important role in the stabilization and persistence not only in organic-rich settings, but also in waters containing dissolved OM. Development of sterically stabilized Fe/HA complexes, with low polar, high molecular weight leonardite could be useful for soil and groundwater remediation.

Keywords : *Humic substance; Ferrihydrite, colloidal properties, humic acid aggregation, organic carbon stabiliz*

O64-4

[C2.4-3] Minerals as Regulators of Carbon Flow through Soils

Comparing the Stability and Chemistry of Soil Organic Carbon Protected via Pyrogenesis, Aggregation and Mineral-association

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We investigated the influence of soil texture and mineralogy on soil organic carbon (SOC) stability in two native soils of different texture and mineralogy from the Southern Highlands of NSW, Australia. To do this, a heavy-textured (clayey) soil and coarse-textured (sandy) soil were sampled at various depths to bedrock. The bulk samples were then fractionated into different particle-sizes and SOC content and stability measured using elemental analysis and radiocarbon analysis. Diffuse-reflectance infrared Fourier Transform spectroscopy was applied to infer molecular chemistry and variability in the soils, and investigate to SOC chemical structures associated with shifts in radiocarbon content of the soils. In both soils, the highest SOC content was found in the finest fraction, indicating that particle-size is a dominant control on SOC retention, independent of soil texture. In contrast, the mechanisms of SOC stabilization varied between the two soils, which we attribute to the differences in mineralogy and texture. In the coarse-textured soil, the chemical recalcitrance of charcoal was found to be the dominant stabilization mechanism in most of the soil profile, and the chemical recalcitrance of other aromatic structures may have contributed to SOC stability in subsoils. In the clayey soil, the most important stabilization mechanism throughout the soil profile was aggregation, which was centuries older than the mineral-associated organic matter in the soil. SOC was highly correlated with radiocarbon content and depth in both soils, so that SOC turnover may be limited by substrate availability at depths near bedrock in the soils. Comparing the radiocarbon ages of the two soils, the most stable carbon was (1) C stored in charcoal, followed by (2) C occluded within aggregates consisting of highly-charged clay minerals, (3) C associated with highly-charged clay minerals and Fe/Mn oxides, and (4) C associated with lowly-charged silicates or sandy aggregates. Our results indicate that there is a disconnect between SOC storage and SOC stability. Our findings have implications for SOC sequestration schemes, namely that trade-offs exist between enhancing SOC storage and enhancing SOC stability, and that texture and mineralogy should be considered when tailoring these schemes within an ecosystem.

Keywords：*Soil organic carbon, stability, aggregation, recalcitrance*

O64-5

[C2.4-3] Minerals as Regulators of Carbon Flow through Soils

Assessing Protein-mineral Interactions: Adsorption Versus Fragmentation

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The depolymerization of extracellular SOM by exo-enzymes is a rate-limiting step in any decomposition scenario (Conant et al. 2011). But it is not the enzyme - substrate reaction alone that is potentially rate limiting. A major factor determining the activity of extracellular enzymes is their affinity to mineral surfaces. Any large peptide chain can bear positive as well as negative charge and polar side chains right next to nonpolar side chains. Mechanisms of sorptive phyllosilicate-protein interactions include coulombic (ion exchange, water bridge, ion-dipole) and non-coulombic (Van der Waals bonds, and hydrophobic) mechanisms (Craig and Collins 2002). The enormous versatility of long peptide chains thus predisposes proteins to adhere to the sorbent surfaces that are abundant in soil systems. Coiled chains may further be able to assume entropically favorable and thus highly stable states by unfolding on supporting surfaces (Bergaya et al. 2011).

Perhaps as a consequence of prevailing industrial and technological applications (Gougeon et al. 2003), the scientific community has a long tradition of viewing mineral-protein interactions as an adsorption process involving mainly phyllosilicates as the mineral partner (Gianfreda et al. 2011). But adhesion is not the only possible outcome of protein-mineral associations - when sorbent surfaces act as catalysts, proteins may become altered beyond conformational change to the extent of molecular fragmentation. Numerous publications have established the fundamental ability especially of manganese oxides to oxidize organic compounds (Stone and Morgan 1984a, b, McBride 1987), including the ability to degrade protein-like prions (Russo et al. 2009). Here we report on an experiment where the two proteins -glucosidase (BG, isoelectric point = iep at pH 7.3 and molecular mass 135 kDa) and Bovine Serum Albumin (BSA, iep at pH 4.6 and 66 kDA) were interacted with birnessite at two pH levels (pH 5 and Ph 7). The dried protein-birnessite associations were then subjected to laser desorption at increasing laser energies, using the synchrotron radiation laser desorption post ionization mass spectrometry setup (LDPI-MS) at Beamline 9.0.2 of the Advanced Light Source, LBNL, Berkeley, CA. (manuscript in progress). Three insights were gained from this research: (i) Regardless of their mass, their iep and regardless of system pH, proteins initially adsorb to Birnessite quite firmly, as no desorption was observed unless laser energies were raised above 0.04 microjoule per pulse. (ii) Once energy input rises above this threshold, an exponential release of protein fragmentation products is observed. (iii) The small protein BSA did not desorb at all when the pH of the system was close to the iep of the protein. We conclude that birnessite initially acts as a sorbent, but becomes chemically reactive depending on energy input into the system. Most importantly, our data suggest that it is not possible to predict the fate of a protein simply by knowing that a certain mineral (such as birnessite) is part of the system.

O65-1

[WG1] Soil Monitoring for Mankind and Environment Safety

Digital Mapping of Soil Change

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Digital soil mapping comprises approaches that seek to map soil properties using statistical and mathematical techniques that relate soil observations with its formation and change factors represented as environmental variables. It aims to capture various aspects of the character of soil in a landscape in the form of mathematical models. Digital soil mapping approaches have been successfully used to represent the spatial distribution of soil properties. As a plus, they can also be utilized to map soil change.

There are several approaches that seek to map soil change. A good result can be achieved when we have monitoring sites. In the absence of monitoring sites, legacy soil survey data can be used to infer soil change. Nationwide soil test databases which were collected for soil fertility assessment, can be used to detect decadal spatiotemporal changes in soil carbon and other properties.

Digital maps also can be used to predict likely soil change. It can be done through a mechanistic simulation model or through a partially dynamic empirical model. In the first approach, a map of soil carbon at a given time and the results were fed into a dynamic-mechanistic simulation model. The output can project change, however most soil carbon simulation models do not consider a spatial aspect. The scorpan approach can also be used to infer the likely changes in soil properties over time via partially dynamic soil scenario maps. Finally, we can use pedological knowledge to quantitatively relate soil properties to the environmental drivers that formed soil through quantitative mechanistic modelling of pedogenesis.

O65-2

[WG1] Soil Monitoring for Mankind and Environment Safety

Can We Map Ecosystem Services from Soil at Regional and National Scales?

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Monitoring and reporting for soil and land has largely been focussed on threats such as soil erosion, acidification, salinisation, soil fertility loss, and soil structure decline. This is important but the positive aspects are only implied by the need to protect it from degradation. More recent literature proposing the concept of 'Soil Security' emphasises the link between the negative influences on soil and the positive values it provides and draws on publications concerning the ecosystem goods and services that are provided by soil. These concepts and arguments are important as they raise the profile of soil into an arena where society as a whole should take notice and should care.

However, turning a philosophical appreciation of soil value into a cartographical reality presents a number of challenges. Translating this appreciation into economic value presents a further challenge, but the focus of this paper addresses the challenge to convert these concepts into measurable attributes and maps. Each service needs to be linked to a measurable soil parameter or suite of parameters; there may be other factors such as climate or land management that also affect the delivery of the service so these should be included or at least acknowledged. As service is dynamic, we need indicators that tell us whether the service is being delivered and, in order to report on the service, a data source or data sources are required. This chain of data and information requirements determines the feasibility of mapping. Finally, to produce the map, we need a method.

A review of fourteen ecosystem services from soil, identified in the extant literature, was conducted in order to assess: soil parameters affecting the service, other factors or drivers affecting the service, indicators that the service is being provided, sources of data (for soil parameters, other drivers, and/or indicators), feasibility of mapping (based on the availability of data), and a method. Six of the fourteen appeared to be readily mappable in Victoria:

1. Productive services: support plant growth
2. Hydrological services: store water for plant growth
3. Hydrological services: deliver high quality water to surface and groundwater
4. Atmospheric regulation: sequester carbon in soil
5. Atmospheric regulation: provide clean air (although this is only an interpretation of resisting erosion)
6. Resist erosion

Methods were applied and maps were produced that were useful at a statewide scale to assist in reporting on current condition. Monitoring requires assessments over time and the methods developed will allow repeated reporting, even on an annual basis, wherever plant biomass and fractional ground cover are used as dynamic indicators for service delivery. The underlying base soil information for the initial application of methods was compiled at a uniform but coarse scale (nominally 1:250,000) from existing statewide interpretation of geomorphology attributed with dominant soil types. This scale limits the applicability of the outputs, however application of satellite data as an indicator in conjunction with more recent modelling of soil properties using Digital Soil Mapping is showing promise for finer scale and annual reporting of delivery of some ecosystem services from soil.

O65-3

[WG1] Soil Monitoring for Mankind and Environment Safety

Soil Spectroscopy in the Africa Soil Information Service

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Fourier-transform diffuse reflectance infrared spectroscopy (FT-IR) is the principal soil analytical technique used by the Africa Soil Information Service (AfSIS). A spectral library was established from a probability sample consisting of 19,200 samples from 60 AfSIS sentinel sites located in 23 countries in sub-Saharan Africa. A subset of 960 pairs of topsoil (0-20 cm) and subsoil (20-50 cm) samples was characterized by standard reference methods covering agricultural, environmental and engineering properties. Calibration results are presented using Random Forests regression and data on the prevalence of soil constraints in sub-Saharan Africa summarized.

AfSIS is providing scientific and technical support to a network of 18 spectrometers in 10 African countries through the CGIAR's Soil-Plant Spectral Diagnostics Laboratory at the World Agroforestry Centre (ICRAF). Standard protocols for sample preparation and instrument use were developed to ensure consistency of results across spectral laboratories. An online spectral prediction service has been developed that allows users to upload batches of spectra and obtain predictions with uncertainty estimates for each individual sample, generated using Bayesian Additive Regression Trees. Samples with large prediction error are submitted to the central lab for characterisation using reference methods, and calibrations updated. Calibrations are being provided for visible-near infrared, near infrared (NIR) and mid infrared (MIR) spectrometers.

AfSIS has assisted in the establishment of the Ethiopia Soil Information System under the Ethiopia Agricultural Transformation Agency, who are now running a high-throughput FT-MIR spectrometer and setting up portable FT-MIR spectrometers at regional laboratories. Two private companies are also now using infrared spectroscopy to provide soil testing and advisory services to farmers in Kenya.

Complementary spectroscopy techniques are also being introduced, including total x-ray fluorescence spectroscopy and handheld x-ray fluorescence spectroscopy for total element analysis, benchtop x-ray diffraction for mineralogical profiling, and laser diffraction particle size analysis for soil erodiblity analysis in both wet and dry modes.

The Soil-Plant Spectral Diagnostics Laboratory has demonstrated spectroscopy technique to over 500 people per year for over three years, half of whom have received training on the method. The Lab now runs a biannual hands-on training course on soil spectroscopy for scientists and technicians. We hope that these initiatives will provide institutional capacity for soil monitoring for agriculture and environment in Africa and other regions.

Keywords：*Infrared spectroscopy, Africa Soil Information Service, Soil monitoring, Training*

O65-4

[WG1] Soil Monitoring for Mankind and Environment Safety

Accumulation and Distribution Patterns of Pahs and Trace Metals in Forest Floors

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Forest is considered as an important sink for airborne pollutants, such as trace metals and polycyclic aromatic hydrocarbons (PAHs), due to its rough canopy surface structure which can accelerate pollutants deposition from atmosphere to the forest floor, and its rich organic matter which can accumulate a huge amount of pollutants. Pollutants absorbed by the aboveground parts of plants can subject to secondary deposition to the soil through the litter fall. Thus plant litter can act as an important carrier for pollutants transport within the forest. Study on accumulation and distribution of pollutants in forest floor is essential for further understanding of the fate and side effect of pollutants on nutrient cycling and organic matter sequestration in forest. A survey was conducted to illustrate the levels and distribution patterns of sixteen EPA priority PAHs and trace metals (Cu, Pb and Cd) in coniferous forests as well as evergreen broadleaf forests located at three sites from the Pearl River Delta (PRD) in Southern China. The accumulation effects and burdens of pollutants in the different organic layers (undecomposed litter and partially decomposed litter) and the upper mineral soil layer (0-10 cm) were also evaluated and estimated. Most of 16 PAHs and 3 trace metals could be detected in all samples. Compared to mineral soil layer, higher concentrations of both PAHs and metals in organic layers were detected. The 3 to 4 ring PAHs, including phenanthrene, fluoranthene, pyrene and chrysene, were the dominant compounds in the samples. The concentrations of Cu, Pb and Cd in both litter and soil samples varied in the range of 3 to 48 mg/kg, 42 to 58 mg/kg , and <0.2 to 1.2 mg/kg, respectively. Significant correlations between concentrations of pollutants and organic carbon, total nitrogen and phosphorus were observed. Factors, including air pollution sources, plant types, pollutants properties, were taken into account in influencing the levels and distributions of pollutants. The different ecological effects of PAHs and metals on litter decomposition, nutrient storage and cycling in forest ecosystems were also discussed. The results indicated that plant litter may act as an important pool of pollutants as well as nutrients which can have long-term effects on the forest ecosystems.

Keywords：*forest, litter, soil, metal, PAHs*

O65-5

[WG1] Soil Monitoring for Mankind and Environment Safety

Functional Digital Soil Mapping: Methods from Southern Africa

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During the past two decades digital soil mapping (DSM) have increasingly provided ways to map soils at a high standard, in little time, with various objectives in mind. The bulk of this research has been conducted in Australia, Europe and America. However, due to unique environmental conditions, variable data availability and differences in terrain accessibility, local DSM research is necessary to enable the usage of DSM to provide in spatial soil information needs.

In spite of a lack of infrastructure, development in Africa is gaining momentum. These developments often need soil maps for planning purposes (agriculture based projects) or as part of environmental impact assessments (for other industrial developments, such as mining). Such surveys often cover relatively large areas (10 000 ha and more), with limited accessibility, little or no legacy data and variable ancillary data. Furthermore, being industry driven, they need to comply to a budget, fit a time frame and produce a product easy to understand by a non-soil scientist, for the specific use intended by the client.

This paper discusses a methodology which allows for the above mentioned requirements to be fulfilled. The methodology was developed in Southern Africa during four case studies, each with a unique setting with regards to available ancillary data, terrain accessibility and objective. During each case study the used methodology was improved, based on the experience gained during completion of the previous soil survey.

A baseline methodology was created based on the SCORPAN-SSPFe method of McBratney et al. (2003) during the first case study in the KwaZulu Natal Province of South Africa. A soil class map with six map units covering an area of 6 865 ha achieved a 67% accuracy. During the second case study, an EIA in the Tete province, Mozambique, stratification of the area into smaller homogeneous areas was introduced. This allowed for extrapolation into unsurveyed areas, necessitated by inaccessibility due to a landmine threat in parts of the area to be mapped. Four map units covering 15 000 ha were mapped with a 69% accuracy. Land suitability for forestry production was the aim of the third case study, where 10 000 ha near Namarroi, Mozambique was mapped into 10 mapping units with an 80% accuracy. Pre-determined sampling positions, using the conditioned Latin hypercube sampling method (Minasny and McBratney, 2006) were introduced, which optimized observation usage. In the fourth case study, value was added to the created soil map, when it was used to extrapolate 2D conceptual hydrological response models to a 3D landscape, for a 4 001 ha area within the Kruger National Park, South Africa. Seven map units were mapped with an overall accuracy of 73%.

To optimize each field observation, an expert knowledge approach is being used. This allows for the most knowledge to be extracted from each observation. This expert knowledge is quantified in the SoLIM inference system. A rough estimation predict that for each 1 000 ha increase in size of the area to be surveyed, the expert knowledge approach leads to a 1X gain in time required to complete the project with the conventional method used in Southern Africa. Other benefits of the methodology are that an accuracy assessment accompanies the map, within limits unsurveyed areas can be mapped and map improvements can easily be made once new data become available. However, in our experience, only six soil map units can be mapped per homogeneous area. For functional soil mapping, this is not a problem, as six map units are adequate for management purposes.

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Keywords：*Expert knowledge, land suitability, Management, development*

O65-6

[WG1] Soil Monitoring for Mankind and Environment Safety

Interpretation of Vegetation and Topographic Features Related to Soil Types in Amazon Forest: Comparison of Two Watersheds by the Use of Remote Sensing Data and Gis

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The region of Rio Negro basin extends over an area of about 580,212 km², which represents 11% of the total area of the Brazilian Amazon basin. This region is characterized by a great diversity of soil types, with dominance of Ferralsols and Acrisols associated to an evergreen dense rain forest, covering an area of strongly dissected plateau and residual hills. This region is located at the northwestern part of Brazil and is marked by its warm and humid conditions, a dense rain forest and a constant cloud cover, which makes difficult missions to collect field sample data as well as photogrammetric and remote sensing activities. The RADAMBRASIL project carried out in the Brazilian Amazon had the main propose of mapping vegetation, soils, geomorphology, geology and soil cover. The maps small scales (1:1000.0000) produced by this project were issued from RADAR-SAR remote sensing images and sample filed observations. These products were generated and delivered in the 70s decade. Since then, the only mapping effort at the Amazonian scale was a project carried out by the Brazilian Institute of Geography and Statistics (IBGE), which refined the RADAMBRASIL maps to the scale of 250:000 for the region of the Brazilian Amazon forest. The project developed by IBGE is an actualization of the RADAMBRASIL maps, based on novel remote sensing data but without refinement of the filed sample data set. In such a context, the objective of the present study was to describe and to map the geoenvironmental variables associated with the soil distribution in two watersheds of the Rio Negro basin, intending to compare the results with the ones obtained by RADAMBRASIL and IBGE. For this propose it was considered the lateral variation of the soil cover through the vegetation physiognomies, as well as geomorphological aspects related to the drainage network (Terrain Description Variables - TDV). The interpretation of these variables allowed the identification of general aspects related to the soil types. The studied watersheds are (1) the Bom Intento watershed (1169.88 km²), located at the central coordinates: 64°7'51.307'W, 2°46'39.509'S, in the region of Tefe city and (2) the Baniua watershed (424.49 km²), located at the central coordinates: 65°57'24.417'W, 0°3'29.839'S, in the region of Sao Gabriel da Cachoeira city. To map the topographic variables it was adopted a SRTM (Shutlle Radar Topographic Mission) DEM (Digital Elevation Model) from X band. Some terrain variables have been considered for statistical comparison between the two watersheds by the interpretation of the elevation-relief ratio or coefficient of dissection, steepness or roughness and topographic position index (TPI), as well as, hydrologic variables. The spectral signature of vegetation was analyzed and compared for the two watersheds by the interpretation of atmospherically calibrated Landsat 8 OLI composition and hyperspectral Hyperion (EO-1) scenes. According to RADAMBRASIL and IBGE the region of the Baniua is characterized by the occurrence of Acrisols and Ferralsols in top hills and hillsides, Gleysols in recent depositional areas, and Podzols in depressions and flat zones. Besides, according to these projects, the region of Bom Intento is predominately a flat area with some plateaus dominated by red Acrisols, Planosols and the flat depressions area occupied by Podzols. The results obtained in this study have shown that the IBGE and RADAMBRASIL maps of the Baniua watershed are in agreement with those observed in filed, with a similarity of 90%. Otherwise, the area of the Bom Intento watershed has been misclassified by previous studies (similarity: 40%). The filed truth allowed concluding that the waterlogged depressions area is dominated by Planosols. The topographic feature of the depressed area for the two watersheds are very similar with a widely spaced drainage network and absence of hills, given a flat surface in hillshade models. The aspect that can segment the depressed Podzols from the Planosols is the spectral signature of vegetation obtained in hyperspectral curves. Given this, it was concluded that the sandy areas of Podzols has a less capacity of retain water in surface than clayey areas of Planosols, which can be inferred by the spectral signature of vegetation due the water absorption features related with the flooded areas.
Acknowledgements: This work was funded by grants from Brazilian FAPESP

Keywords：*Amazon Forest, Podzol, Spectral Signature*

O66-1

[WG12] Unique Contributions of Hydropedology to Integrated Soil and Water Sciences

Towards the Unification of Soil Formation and Soil Functions

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A unified framework is proposed to integrate soil formation and soil functions across time and space, where the simultaneous occurrence of fast vs. slow processes, the combination of flux and site factors, and the nonlinear hysteretic function of the soil system's initial state and external gradients are linked. Soil formation deals with long-term time scale of how soils form and evolve, while soil functions refer to shorter-term processes and properties within soil systems that influence their productivity and services. These two are intimately linked, with interactions and feedbacks that are key to the formulation of such a unification needed for whole soils understanding and earth systems modeling. The co-evolution of fast and slow changes in multiphase soil systems is investigated here using different soil orders, where fast and cyclic soil functioning processes involve mostly liquids, gases, and biota (in which circulating water is a key), and slow and irreversible specific pedogenic processes involve predominantly solids. Many soil functioning processes and related cycles are not completely closed, and many input-output fluxes are not necessarily balanced in open, dissipative soil systems. Such non-closed cycles and off-balanced fluxes of soil functioning generate residual solid-phase products in soils that give rise to structured and informative soil profiles over time. Specific pedogenic processes can feedback to alter soil functioning, mostly in a gradual manner, but some could lead to threshold changes in some soil systems. Quantification of these interlinked feedback loops remains challenging.

Keywords：*pedogenesis, soil processes, soil hydrology, ecosystem services, systems soil science*

O66-2

[WG12] Unique Contributions of Hydropedology to Integrated Soil and Water Sciences

A View of Pedogenesis as the Co-evolution and Spatial Organisation of Soils, Landforms, Vegetation, and Hydrology

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Soils are the intermediary for many important environmental processes, and in many cases may be a significant driver of the response of these processes. Moreover the soils themselves are a response (over pedogenic timescales) to these same environmental processes. Soil timescales range from decades (for some fractions of soils carbon, and microbiological processes) through millennia (for vegetation and other fractions of soil carbon) to millions of years (for soil response to landforms). Thus that if we are to model pedogenesis in an attempt to understand the spatial distribution of soils (hillslope, catchment, or landscape scales) and their dynamic response (as, for instance, drivers of sediment load for basin subsidence analysis) we will need to quantify timescale of response and spatial and temporal links of the process dynamics of pedogenesis, landform evolution, vegetation and hydrology. This presentation summarises progress in our group in this coupling of processes across disparate time and space scales. We will show data that we have collected for pedogenesis, soil carbon and landforms that identify timescales for different components of the processes, and computer simulations where we have inferred other timescales from process response. We will also show results of spatial scaling of soil properties derived from our pedogenesis models for residual soils. These time and space scaling relationships arise from the balance and feedbacks between erosive and weathering processes. They explicate the role of climate and geology in pedogenesis. Finally, we will present a framework which we believe will allow us to simplify the complexity of the spatial and temporal coupling by using spatial and temporal scale breaks in the processes.

Keywords : *pedogenesis, scaling, hydrology, vegetation*

O66-3

[WG12] Unique Contributions of Hydropedology to Integrated Soil and Water Sciences

Hydropedological Responses to Vegetation Degradation and Recovery Processes in the Semiarid Region

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Biota has been recognized as an important factor on the genesis and hydrological processes of soils; however, until now there was a lack of studies on coupling pedology and plant–soil–hydrology. This study investigated the specific soil and hydraulic attributes mediating vegetation change for shrub encroachment during grassland degradation, conversion of cropland into grassland and co-evolution of vegetation and soil development during sand-dune stabilization. Results indicated that complex interactions existed between vegetation, soil structure, and soil water dynamics, and that plant-soil architectures coordinate each other to evolve a holistic and self-organized soil-vegetation adaptation system to accumulate water, storage, and efficient use.

Keywords：*Hydropedological responses; shrub encroachment; soil architecture; soil water*

O66-4

[WG12] Unique Contributions of Hydropedology to Integrated Soil and Water Sciences

Water Balance Dynamics in Mixed Crop-livestock Systems of Northern Ghana: Unraveling the Interactions between Farm-level and Landscape Fluxes in the Face of Climate Change

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Water balance dynamics at the farm level were investigated using real-time in-situ data collected with automated data loggers while long-term historical hydrological and climatic data were used with the WaterWorld model to ascertain the impact of climatic change on agro-ecosystems in Northern Ghana. On-farm seasonal water balance estimates within a maize stand revealed that with the 716 mm of rainfall received in the season the ET was the predominant factor accounting for about 78% of the fluxes. Runoff levels were not significant for plots were farmers had conducted soil and water conservation measures and these accounted for 30% less runoff levels compared to the control treatments. From a bioclimatic standpoint, study results in the region indicate a steady increase in temperature and a projected increase in rainfall over the next 40 years to the 2050s. Increment in rainfall amount could be desirable considering the recurrent dry spells in the Northern parts of Ghana. However, the shorter term impacts, particularly changes in the frequency and severity of storm events remains uncertain since increased amounts over short durations may translate into regional extreme events in an area that is already prone to flooding. Managing variability in terms of water storage solutions that complement soil and water conservation measures will help farmers with better coping mechanisms and adaptation to climate change, particularly among the poor resource farmers in these vulnerable landscapes.

Keywords：*Water balance, scale interactions, farmer adaptation, climate change*

O66-5

[WG12] Unique Contributions of Hydropedology to Integrated Soil and Water Sciences

The Relationship between Histosols and River Captures in the Atlantic Plateau Paulista, Southeastern Brazil.

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The Atlantic Plateau Paulista, in Brazil, is dominated by convex shapes, with deep valleys and high drainage density. The layout of the drainage network depends on several factors, including the geotectonic position of the state, extending over a Precambrian crystalline shield, bathed by the ocean and into the Paleozoic sedimentary basin of the Parana and the climate factor. The products of erosion were accumulated negative element in the sedimentary basin. Thus, most of the rivers moved inward, to the Paraiba do Sul River or the Parana basin. The Serra da Mantiqueira Hills and Serra do Mar Escarpment led the formation of newer drainage on slopes steeper. Background levels closer and lower arisen due to the post-Cretaceous tectonism in southeastern Atlantic Plateau forced a progressive reversal of parts of the drainages that went into the interior through multiple river captures. In this case, river captures have a relationship with soils, especially Histosols inside the wind gaps. Histosols were found at least in four areas located in Serra do Mar Escarpment and reverse, they are: Paraiba do Sul basin's wind gap, Guaratuba basin's wind gap, Capivari basin's wind gap and Cotia basin's wind gap.

In all these cases, Histosols have an important role in the development of drainage in cases of drainage anomalies and river captures in humid and forested tropical areas.

Keywords：*Histosols, river capture, wind gap.*

O67-1

[IDS5B] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Stability in Soils: Mechanisms of C Sequestration and Fertility Improvements

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Application of biochar (BC) to soil strongly contributes to C sequestration and may improve soil fertility and plant productivity. However, the mechanisms of these improvements as well as chemistry of BC fractions responsible for the stability of sequestered C remain unclear. Up to now only very few studies investigated the decomposition of BC and so, experimentally analyzed its stability in soils.

After short literature overview, the results of unique 9-year-old incubation experiment with 14C labeled BC will be presented. Only about 6% of initial BC have been decomposed in soil to CO2 by incubation during 9 years. The BC decomposition rates estimated by 14CO2 efflux between the 5th and 9th years were about 7 - 10-4 % per day. This corresponds to decomposition of about 0.3% BC a-1 under optimal conditions. Considering much slower BC decomposition under field conditions, the mean residence time of BC in soils is about thousands of years. This confirms the extreme high stability of BC compared to all other natural organic compounds. Addition of energy sources for microorganisms (namely glucose) or aggregate destruction strongly accelerated BC decomposition, but this effect was shorter than one month.

Three years after the incubation was started, the BC transformation was traced by 14C incorporation into microbial biomass, dissolved organic carbon (DOC), phospho-, neutral- and glycol-lipids, sugars and benzene polycarboxylic acids (BPCAs). The most 14C (>80%) remained in condensed aromatic moieties - BPCAs, and only traces were recovered in lipids and sugars after 3 years. Incorporation of 14C from BC into microbial biomass was ~ 0.5%. The BPCAs were the most stable fraction compared to all other biochar compounds and explained the extreme high stability of biochar in the soil.

We concluded that despite very high stability of BC and very slow decomposition rates, the application of 14C labeled BC opens new directions for very sensitive tracing of BC transformation products in released CO2, microbial biomass, DOC, and SOM pools with various properties.

Very high intrinsic stability of BC sounds contrasting to its potential to improve the quality of low fertile soils because the direct matter exchange with microbiota and roots is absent. This apparent discrepancy will be discussed based on physicochemical properties of BC and results of field experiments. It will be shown that environmental and agronomic benefits of BC are based on its potential to reduce abiotic nutrient losses and to stimulate biotically driven cycles of C and nutrients in soil.

Keywords：*Biochar stability, Carbon sequestration, Soil fertility, Black carbon decomposition, Biochar transformation, Isotopic approaches, Microbial utilization*

O67-2

[IDS5B] Biochar Soil Amendment for Environmental and Agronomic Benefits

A Classification System for Biochars Applied to Soils

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A biochar classification system (Camps Arbestain et al., 2014) aimed to optimise the sustainable use of biochar in agriculture has been developed. It builds upon biochar product definition and testing guidelines deloped by International Biochar Initiative (IBI, 2012) and European Biochar Foundation (EBC, 2012), and IBI's biochar carbon stability method (Budai et al., 2013. The classification system envisions enabling stakeholders and commercial entities to identify the most suitable biochar to fulfil the requirements for a particular soil and/or land use. It is based on current knowledge and the intention is to periodically review and update the document based on new data and scientific knowledge. We have classified the potential effects of biochar in soils into five categories with corresponding classes: (i) carbon storage value, (ii) fertiliser value, (iii) liming value, (iv) particle-size, and (v) use in soil-less agriculture.

The carbon storage value (sBC+100) of a specific biochar is calculated by multiplying the fraction of organic C in biochar that is estimated to remain stable in soil for more than 100 years (BC+100) (Budai et al., 2013) with the organic C content in the biochar. Five classes of sBC+100 have been established: <300 g kg-1, 300-400 g kg-1, 400-500 g kg-1, 500-600 g kg-1, and ≥600 g kg-1, and these correspond to Class 1, 2, 3, 4 and 5, respectively.

The fertiliser classes are based on the available contents of P, K, S and Mg in biochar. Five classes have been contemplated based on the nutrient requirements of a major crop (corn) considering a maximum application rate of 10 t ha-1: Class 0 (available K2O < 0.5%, available P2O5<1.0%; available S < 0.15%; available MgO < 0.3%); Class 1 (biochar with a fertiliser value for one of these four nutrient elements); Class 2 (biochar with a fertiliser value for two nutrient elements); Class 3 (biochar with a fertiliser value for three nutrient elements); Class 4 (biochar with a fertiliser value for four nutrient elements). For example: a biochar with a fertiliser class of 2 (P3t Mg9t) for corn is such that it fulfils the needs of P and Mg, at biochar doses 3 and 9 t ha-1, respectively. A calculator is also provided to estimate the fertiliser value based on other crop nutrient removals.

The classification system considers four classes of biochars based on their liming equivalence (CaCO3-eq): Class 0 (CaCO3-eq < 1 %), Class 1 (CaCO3-eq: 1-10%), Class 2 (CaCO3-eq: 10-20%), Class 3 (CaCO3-eq ≥ 20%).

Biochar particle-size classes are based on a triangle system. The triangle classifies biochars as (i) powder (> 50% biochar fraction < 2 mm), (ii) kernel (> 50% biochar fraction between 2 and 16 mm), (iii) lump (> 50% biochar fraction > 16 mm), or (iv) blended (other particle sizes). Supplementary information on the fractions < 2 mm and > 16 mm is provided in two additional reference triangles.

Finally, with regard to the use of biochar as a substrate amendment for soil-less plant production, our classification system recommends the use of existing standards for soil substrates of which biochar becomes a part. However, specific test methods are proposed by Camps Arbestain et al. (2014) to help assess the suitability of biochar as a substrate amendment for soil-less plant production. Moreover, the authors propose and describe test methods to be used in this biochar classification.

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Keywords：*classification fertility liming particle-size carbon storage*

O67-3

[IDS5B] Biochar Soil Amendment for Environmental and Agronomic Benefits

Assessing Long-term Impacts of Contrasting Biochars on Soil Functionality and P Availability

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While much emphasis has been placed on assessing the stability of carbon (C) in biochars once applied to soil, there is a paucity of information on the longer-term impacts of biochars on soil nutrient status, interaction with applied fertilisers and biological functionality. In 2006, a sub-tropical pasture was established on a highly phosphorus (P) sorbing Ferralsol to which contrasting biochars were applied- greenwaste vs. feedlot manure (both produced by slow pyrolysis at 550 deg C at 10 dry t ha-1 to 0-100mm) in a factorial design ± lime, ± fertiliser and a nil amendment. Early results (2007- 2008) (Slavich et al., 2013) from this work suggested that the feedlot manure biochar improved the P availability, resulting in improved pasture production and higher fertiliser N-use efficiency. This work raised questions as to whether the feedlot manure biochar provided a direct P fertilisation effect, or whether this biochar interacted with the soil to increase P availability from either applied fertiliser or native sources.

To improve our understanding of the form of P within the biochars (especially relating to bioavailable fractions), solid-state characterization was carried out using P -edge XANES spectroscopy on the 16A1 BM Tender X-ray beamline at the National Synchrotron Radiation Research Center, Taiwan. While it was clear that the feedlot manure provided a short-term fertiliser effect resulting in increased pasture production, improvements in available soil P were maintained even after seven years of pasture biomass removal from the plots. This sustained increase in P availability and increased pasture productivity suggests an interaction between the biochar, fertiliser and native P sources.
As low P availability is an identified stressor in this soil, a constraint which was addressed by manure biochar and to a lesser extent, lime application, the effect of alleviating P limitation on the soil microbial community function was investigated using mineralisation of a 14C labelled low molecular weight C substrate. When soils were dosed with 300 mM P, significant reductions in C substrate half-life were observed across all treatment combinations confirming bioavailable P limitation to microbial functionality. This effect however was less evident with manure biochar amended soils suggesting P limitations to microbial functionality were not as important with this treatment. Again, this suggests the manure biochar can address P constraints in this soil.

To further investigate the impacts of these biochars on soil functionality, we quantified both microbial size and the activity of a range of soil enzymes (using MUB substrates) at the commencement of the 7th year harvest cycle. Enzymes including acid and alkaline phosphatases, pyrophosphatase, arylsulfatase, beta-glucosidase, chitinase, glucuronidase and leucine-aminopeptidase were assayed. The field plots fertilised with NPK had a reduced microbial size (assayed by ds DNA), possibly a result of the acidification effect of applied N, and reduced activity of all enzymes except glucosaminidase. The impacts of biochars on microbial functionality assessed using enzyme methodologies however did not detect any significant interactions with amendments. Preliminary assessment of data reveals P is limiting microbial function in controls (nil biochar) and greenwaste biochar treatments, while the manure biochar attenuates these constraints. This higher P availability in soil treated with manure biochar is partly due to direct inputs of P from the biochar, but also from the longer-term interaction between the biochar and applied fertiliser. Results from the pasture harvest after 7 years clearly indicate longer-term benefits of manure biochar for pasture production and nutrient use efficiency.

Slavich PG, Sinclair K, Morris SH, Kimber S.W.L., Downie A and Van Zwieten L (2013) Contrasting effects of manure and green waste biochars on the properties of an acidic ferralsol and productivity of a subtropical pasture. Plant and Soil 366: 213-227.

Keywords：*biochar, soil functionality, phosphorus availability*

O67-4

[IDS5B] Biochar Soil Amendment for Environmental and Agronomic Benefits

XPS, NEXAFS and FTIR Spectroscopy of aged Biochar in Soils

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Biochar stability is crucial for the long-term carbon (C) storage in soils. Some proportion of biochar-C is mineralised with ageing in soil, particularly at high temperatures. The oxidation of biochar-C may leads to the development of carboxylic surface functional groups that can increase biochar's reactivity and may contribute to the cation exchange capacity of soil. We used diffuse reflectance FTIR (DR-FTIR) spectroscopy, near-edge X-ray absorption fine structure (NEXAFS) spectroscopy and X-ray photoelectron spectroscopy (XPS) to characterize the light fraction of unamended and biochar amended soils to determine changes in the C functional groups of biochar after ageing.

Four soils (one each of Inceptisol, Oxisol, Entisol and Vertisol), with contrasting soil properties including clay mineral composition, were incubated separately with two biochars at 2% wt/wt. The two biochars were produced at 450°C (B450) and 550°C (B550) from eucalyptus woody biomass. The details of the incubation experiment, and soil and biochar properties used in the study are described elsewhere (Fang et al., 2013). The light fraction (< 1.8 g cm-3) from the soil-biochar mixtures (and control soils) was recovered on day 0 (i.e. immediately after mixing soil and biochar), and 6, 12 and 24 months after incubation at the three temperatures, i.e. 20, 40 and 60 °C.

DR-FTIR spectra of the light fraction showed contrasting absorption bands representing native soil organic C, biochar-C and mineral constituents present in the soils; the mineral bands were consistent with the XRD data of the clay fraction of the four soils. Analysis of the DR-FTIR spectra in the ν(C-H) showed that the ratio of the aromatic ν(C-H) bands increased relative to the aliphatic ν(C-H) bands with increasing mineralization of biochar-C in the B550 amended soils. However, such a relationship was not observed for the B450 amended soils that contained significant labile aliphatic C.

The NEXAFS spectra of fresh biochars and the light fraction of control and biochar amended soils showed two distinct peaks at ~285.1 and 288.5 eV, which were attributed to the C1s-π*C=C transitions of aromatic C (and protonated and alkylated aromatic C) and C1s-π*C=O transitions of carboxylic C, carboxyamide C and carbonyl C. The proportion of aromatic C and the aromaticity index (aromatic C/carboxyl and amide C) were substantially greater in the light fraction of the biochar amended soils than the corresponding light fraction of the unamended soils. Also, the proportion of aromatic C was much higher in the light fraction of the B550 amended soils than in the corresponding B450 amended light fraction of the Inceptisol and Oxisol. The proportion of aromatic C in the light fraction of biochar amended soils did not show any systematic change after ageing for 12 months at various temperatures. Consistent with the NEXFAS results, XPS analysis also showed the dominance of aromatic C and protonated, and alkylated aromatic C in the light fraction of the biochar amended Inceptisol. The XPS analysis of C functional groups in the ground light fractions of the four soils did not show any consistent trend with ageing and incubation temperature. However, the proportion of carboxyl groups in the hand-picked samples of the Inceptisol increased with increasing ageing time (up to 2 years) and the incubation temperature.

DR-FTIR, NEXAFS and XPS techniques show good potential for the characterisation of C rich fraction isolated from natural soil and soil amended with biochar. The limited data suggest that much longer ageing time may be needed for the development of significant amount of carboxyl groups on biochar surfaces. The trend in the ratio of the aromatic and aliphatic bands derived from DR-FTIR spectra requires further investigation using different types of biochars aged for longer period in soils.

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Keywords : *XPS, NEXAFS, FTIR, spectroscopy, biochar, soil carbon*

O67-5

[IDS5B] Biochar Soil Amendment for Environmental and Agronomic Benefits

Aggregate Dynamics Influenced by Biochar Addition using 13C Natural Abundance

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Soil aggregate dynamics is generally controlled by the organic matter input, microbial activity, and soil mineralogy. Addition of organic matter into soil initiates the aggregate dynamic cycle by forming macroaggregates mixed with microbial mucous and mineral particles, followed by the breakdown of macroaggregates into microaggregates as organic matter is being decomposed, and closed the cycle with re-formation of macroaggregates by combining microaggregates and newly added organic matter. This study investigated the effect of biochar addition on formation of soil stable aggregates. Using the difference in 13C natural abundance between biochar produced from C4 plant (corn) and soils under C3 plantation, the contribution of biochar in soil aggregation was identified. Biochar was produced with steam activation; in slow pyrolysis with 7 0C/min of heating rate at 450 0C of peak temperature. For steam activation, the pyrolyzed samples were further treated with 5 ml/min steam flow for 45 min under the peak temperature. After 66 day incubation of soils treated with 5% corn biomass and biochar which have undergone periodic rainfall events, soils were wet sieved using 53 μm, 250 μm, and 1000 μm screens. To remove free biochar or biomass which are not included within aggregates, density fractionation using NaI (1.85 g cm-3) was conducted. Carbon concentrations and δ13C values were analyzed for each sized aggregates. Results showed that the percentages of biomass-derived C in the aggregates size of 53-250 μm (mesoaggregates) and 250-1000 μm (macroaggregates) were 28% and 39% while those of biochar-derived C in the same sized aggregates were 15% and 50%, respectively. This indicated that both biomass and biochar played a significant role in the formation of stable aggregates. The stability of macroaggregates in the biochar treatment was greater than those in the biomass treatment. Analysis on bulk soil after incubation showed that biochar- and biomass-added soils had higher microbial dehydrogenase activity, microbial biomass C, β-glucosidase, N-acetylglucosaminidase, and hot water extractable C than the control. Spectral analysis of biochar and biomass showed that the presence of aromatic C in the biochar (with the appearance of peaks between 885 and 775 cm-1) compared to the biomass. Overall results suggest that aggregate turnover in the biochar added soil is slower than that in the biomass added soil, maintaining the soil structure with macroaggregates dominant, favoring for water holding and better aeration.

Keywords：*biochar, 13C natural abundance, aggregates, soil structure*

O67-6

[IDS5B] Biochar Soil Amendment for Environmental and Agronomic Benefits

Impacts of Phosphorus Type and Spatial Relation to Biochar on Bean-mycorrhizal Symbioses and Crop Phosphorus Nutrition in a Degraded Acrisol

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Biochar may have promise for enhancing plant-microbial associations and crop productivity in degraded and weathered soils. Previous work has shown a variety of plant responses to mycorrhizae (AM) in biochar-amended soils, and clearer understanding is needed of the way that soil fertility regime affects biochar/AM impacts, and of mechanisms through which biochar may alter the plant-mycorrhizal symbiosis. We tested the interactions of AM, bean (Phaseolus vulgaris) plants, and biochar (hardwood, 450C pyrolysis temperature) under different phosphorus (P) fertility conditions in a P-fixing, acrisol subsoil with a P-efficient bean variety (CIAT BFS 10) grown to flowering in a pot study. Phosphorus sources compared to controls were ambient P in the biochar feedstock (2 kg P•ha-1 equivalent), insoluble iron phosphate (Fe-P, 50 kg•ha-1 equivalent) and soluble sodium phosphate (Na-P, 50 kg•ha-1 equivalent). Fe-P and Na-P were applied to soil in a gradient of proximity to biochar: mixed with wood before charring (Bef); adhered to biochar before this was applied to soil (Aft), and mixed with soil before biochar addition (Soil), as well as no-biochar controls with the same P sources added and zero-P controls. With these P sources we compared beans inoculated with the AM Glomus clarum to uninoculated controls. Biochar effects on soil pH, water limitation, and nutrient limitations other than P were controlled for. Bean P uptake, root/char flatbed scans, microbial biomass-P, and 16:1ω5 neutral lipid fatty acid (NLFA) biomarker for mycorrhizal fungi tested the responses of the plant-fungal symbiosis to these biochar and P applications. Flatbed scans of roots and char and showed that roots were linked to char by AM hyphae, with char-root linkage strongly correlated to AM colonization. Bean P uptake increased with Na-P application, but was not affected by biochar or AM for Na-P Aft or Soil treatments. For Fe-P at 50 mg•P pot-1, biochar increased mean shoot P uptake from 3.1 to 3.8 mg•pot-1 and total P uptake of roots plus shoots from 5.3 to 6.2 mg•pot-1, including a positive AM-biochar interaction in which AM increased shoot P 12% more with biochar than without biochar. With the exception of the Na-P Bef. treatment, localization of P on char or in soil (Bef. vs. Aft. vs. Soil) did not influence shoot or total P uptake suggesting general facilitation of mycorrhizae by biochar, as well as physical sequestering of P within Na-P Bef. biochar. However, in the Aft. treatments, mycorrhizal colonization was increased by 5% for Fe-P adhered to biochar, and reduced by 13% for Na-P applied to biochar, suggesting that the pathway of P uptake (root vs. AM) was altered by the localization of P sources on biochar. Percent root length colonized by AM was also increased by biochar at low P levels. The 16:1ω5 NLFA AM biomarker in soil was positively correlated to AM root colonization and less abundant in treatments with soluble P. Comparison of NLFA content of biochar floated out of soils versus that in biochar+soil allowed interpretation of whether biochar was enriched in AM fungi with P-enriched biochar versus biochar without P addition (results pending). Microbial biomass P did not respond in a consistent way to biochar or mycorrhizal colonization, but increased between treatments without additional P (with or without biochar) and those where Fe-P or Na-P was applied.

Keywords：*Phaseolus vulgaris; biochar; mycorrhizae; Glomus clarum; phosphorus*

O67-7

[IDS5B] Biochar Soil Amendment for Environmental and Agronomic Benefits

Inhibitory Effects of Biochar on Phenol Oxidase in Agricultural Soils

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Biochar additions on agricultural fields have acknowledged as a promising technology to sequester carbon in soil and to increase agricultural productivity. However, feasibility of achievement of both aims is still controversial because slower decomposition is needed to secure carbon stabilization, which may hinder high productivity of crops due to slower mineralization of nutrients. Microorganism produces various enzymes to mediate those processes, which represents a critical step in determining whether a system would sequester carbon in the long-term. In this study, we measured a suite of enzyme activities in agricultural soils amended with biochar to assess the issue. We prepared 2 sets of experimental test beds planted with maize or grass, and amended with 2 types of biochars (oak or rice chaff), respectively. Microbial enzyme activities were determined twice over a 1-year period. Phenol oxidase, which is involved in the decomposition of recalcitrant organic carbon, exhibited consistently lower activities in plots with biochar additions compared with control plots. In contrast, other hydrolases (ß-glucosidase, ß-xylosidase, N-acetylglucosaminidase, phosphatase, and arylsulfatase) were not changed or slightly activated by biochar additions, suggesting that regeneration of nutrients and decomposition of simple carbons may not be impeded. Overall results of this study suggest that biochar addition facilitate stabilization of recalcitrant carbon in agricultural soils by reducing phenol oxidase, while it maintain high productivity by similar rates of mineralization of key inorganic nutrients and decomposition of cellulose or hemicellulose.

Keywords：*soil enzyme; phenolics; microbial activity; recalcitrant organic matter*

O67-8

[IDS5B] Biochar Soil Amendment for Environmental and Agronomic Benefits

Production of Charred Plants and Subsequent their Distribution, Behavior and Function in Soils

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A recent escalation in interest for biochar as a soil amendment can be attributed to its potential role in agricultural, environmental and economical benefits. Biochar is a stable form of C, consisting of charred biomass products involving plants. Accordingly, the findings obtained in our studies (described below), in which the changes in the physicochemical and spectroscopic properties of plants before and after burning and the temporal and spatial distribution, behavior, and function of charred plant residues in soils have been investigated, may provide invaluable information on a better understanding of the role of biochar. (1) Comparison of various properties (i. e. atomic H/C and O/C ratios, ^{13}C NMR spectra, and X-ray diffraction patterns) in herbaceous and woody plants before and after burning indicated that dehydrative polycondensation reactions occurred during the burning, although the extent of progression of the reactions was influenced by burning conditions such as plant species and heating temperature. (2) When the charred plant residues collected after a fire event of grassland, in which Susuki (Miscanthus sinensis) plants predominated, were added to a sample of volcanic ash soil (Andosols) and incubated at 25℃ under moist conditions, the residues were hardly mineralized by soil microorganisms even after 40 weeks, although fresh Susuki was easily mineralized. In a cumulative volcanic ash soil, charred plant fragments were detected even in the old, buried A horizon (ca. 12.8 cal ka), indicating that they were a pool of C with a long residence time. (3) Charred plant fragments in volcanic ash soils were isolated by specific gravity method before and after HCl-HF treatment of soil samples and quantified. The amounts of the fragments obtained after the treatment were much larger than those obtained before the treatment. Microscopic observation of these fragments suggested that the size of charred plant residues produced during vegetation burning became smaller and that the amount of inorganic particles associated with them increased, with the progression of weathering and biological degradation in soils. The amounts of the fragments obtained after the treatment were highly correlated to those of total organic C, active Al, or black (Type A) humic acids of soils. (4) Volcanic ash soils were physically divided into several particle size fractions. Silt-sized aggregate fraction (2-20 μm) was an important reservoir of charred plant fragments and other organic constituents, forming the complexes with inorganic components. (5) In the volcanic ash soils of Japan and chernozemic soils of foreign countries studied, charred plant fragments contributed up to 33% and 10% of total organic C contents of soils, respectively, and affected the quality and quantity of soil organic matter. (6) Soil organic matter in Andosols and Chernozems is characterized by the predominance of black humic acids with a high degree of darkening, a graphite-like structure and a high content of carboxyl group. When fresh charred plant residues produced during the burning were oxidatively degraded with HNO_3 or H_2O_2, the yields of black humic acid-like substances greatly increased, and those of fulvic acid-like substances were limited. Furthermore, the charred plant fragments, which were detached from several volcanic ash soils, displayed higher atomic O/C ratios (direction of oxidation) than the fresh charred plant residues, and contained large amounts of black humic acids (up to 44 % of black humic acids in the soils) and small amounts of fulvic acids (~10% of fulvic acids in the soils). These findings indicate that charred plant residues, produced during the burning of vegetation by human activity and wildfires, are subjected to weathering and biological degradation (involving oxidative depolycondensation, hydrolysis, and carboxylation) under terrestrial soil conditions after burning, and are transformed to fulvic acids and especially black humic acids. (7) In conclusion, after burning, the charred plant residues with a graphite-like structure become smaller fragments with the progression of abiotic and biotic degradation in soils. This process results in the formation of black humic acids and fulvic acids. Then, part of the fragments, containing these acids, are more stabilized by forming the complexes with inorganic components in the silt-sized aggregate fraction, presumably active Al (Fe) in the volcanic ash soils and Ca in the chernozemic soils. Thus, their complexes are preserved in the fraction for a long period of time.

Keywords：*Andosols, Black humic acid, Carbon sequestration and storage, Charring process of herbaceous and woody plants, Chernozems, Fulvic acid, Organic-inorganic complex, Silt-sized aggregate fraction*

O67-9

[IDS5B] Biochar Soil Amendment for Environmental and Agronomic Benefits

Functions of Biochar on Physical Properties and Erosion Potential in a Hardsetting Soil

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Mudstone soil is considered as a hardsetting and a degraded soil in Taiwan. The soils were characterized by poor soil qualities, such as high pH (>8.5), low soil organic matter (≤0.5%), high bulk density (Bd) (≥1.60 Mg m-3), penetration resistance (PR) (~14 kg cm-2) and erosion potential (EP) (≥160 Mg ha-1 per year). Rice hull biochars used in this study was pyrolized at 400℃ and 700℃ in a anaerobic condition to, which were denoted to RHB-400 and RHB-700. As comparison with the control, incorporation of these 2 biochars into the soils reduced Bd by 11%-30% and PR by 50%-90%, and increased porosity, aggregate size, field water contents and soil loss contents by 6%-18%, 0.30 mm-1.05 mm, 3.8%-17% and 35%-90%, respectively, after 168 d incubation. Biochar application rate is a major factor to influence improvement efficiency.

Keywords：*Mudstone soil, Hardsetting soils, Rice hull, Biochar, Erosion potential*

O67-10

[IDS5B] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Addition to Soils: Implications for the Efficacy of Pesticides

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Biochar addition to soil is being considered as an option for mitigation of climate change in several countries including Australia. Multiple benefits of biochar in soil, such as potential sequestration of carbon in soil, the reduction of emissions of greenhouse gases, and improvement of soil fertility is increasingly being demonstrated in rapidly growing body of research on this topic. Consequently, soil amendment with certain types of biochars is being seen as a favourable option from agronomic and environmental standpoints. However, less attention has so far been paid towards the potential implication of soil amendment with biochar on the environmental fate and efficacy of soil applied pesticides (Kookana, 2010; Kookana et al. 2011). Due to their high specific surface areas, biochars in soils have been found to be very effective sorbents of organic compounds such as pesticides (Yu et al. 2006, 2010). The incorporation of relatively small amounts of fresh biochars in soil (5-10 t ha-1) has been shown to bind pesticides strongly, inhibit their microbial degradation as well as reduce their plant uptake (Yu et al. 2009) and efficacy (Nag et al. 2011). While this can be beneficial in remediation and detoxification of contaminated soils and sediments, biochar amendments to soils may significantly compromise the bioavailability and efficacy of pesticides. Research conducted in our laboratory shows that in biochar amended soils, the application rates of pesticides may need to be increased for an optimal efficacy, especially soon after application of biochar (Nag et al. 2011). However, biochar may lose its extraordinary ability with time in soil due to organo-mineral interactions (Martin et al. 2012). There is a need to identify management options to alleviate any negative impact associated with biochar application to soil.

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O67-11

[IDS5B] Biochar Soil Amendment for Environmental and Agronomic Benefits

An Investigation of Soil-biochar Aggregates and Internal and External Surface Deposits on Biochar Particles in a Sandy Earth using Scanning Electron Microscopy

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Biochar is a soil amendment that is capable of improving the chemical, physical and biological properties of soils. While biochar is generally considered to be recalcitrant and persistent in the soil, biochar actually undergoes several changes including: surface oxidation, leaching of nutrients, interactions with soil particles and colonisation by microbes. To explore these changes scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDS) were used to analyse biochar grains and soil aggregates containing biochar. These were extracted from a soil in Western Australia three years after addition of the biochar followed by continuous cropping with wheat. The SEM images of the aggregates show biochar particles attached to soil particles thus constituting complex aggregates in the soil. They also show the presence of abundant fungal hyphae in the soil-biochar aggregates. The individual biochar fragments had various soil particles adhering to their external surfaces, including clay minerals, anatase and iron oxides. Several minerals, including calcite and apatite occurred inside the biochar grains removed from soil and these minerals, which are common constituents of biochar, have evidently been protected against dissolution in the acid soil. This is a significant finding that relates to both the fertiliser and liming values of biochar and has not been reported in previous papers. Conversely, there was also evidence that clay minerals, iron and aluminium oxides and possibly anatase, have been eluviated from the surrounding soil and deposited within internal biochar pores. While other authors have detected clay-size particles on the surface of biochars taken from the soil, none have reported on the presence of these minerals inside biochar fragments. The present findings indicate that while some regions of the biochar grains were poorly accessible to soil water and consequently remained unoccupied by soil fauna, fungi and plant roots, in other regions water did penetrate into the biochar interior where it dissolved minerals, deposited clay-size minerals and supported biological activity.

Keywords：*biochar, SEM, EDS, scanning electron microscopy, aged, field trial, internal, external, aggregates*

O68-1

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Plant-fungal Interactions under Elevated CO_2: Impact on Soil Organic Carbon

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Mycorrhizal fungi (MF) form associations with roots of ~80% of land plant species and obtain carbon (C) from their host plants in return for mineral nutrients. Mycorrhizal fungi utilize a large proportion (up to 20%) of net plant photosynthates under ambient CO2 concentration. The stimulation of mycorrhizal fungi by elevated atmospheric CO2 has been assumed to be a major mechanism facilitating soil C sequestration by increasing C inputs to soil and by protecting organic C from decomposition via aggregation. This hypothesis, however, has not been vigorously tested because the net effect of CO2-stimulation of mycorrhizal fungi on soil organic C dynamics has rarely been evaluated. Two major types of mycorrhizal fungi, arbuscular mycorrhizal (AM) and ectomycorrhizal (ECM) fungi, differ in their modes of nutrient acquisition and their ability in accessing organic nitrogen. Emerging evidence also indicates that they may thus possess different potentials in controlling the stability and accumulation of soil organic C. Together, these findings suggest that ecosystem models should incorporate MF effects on organic C to better predict the ecosystem C balance under climate change scenarios.

O68-2

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Integrating Omics to Understand Soil C Cycling Responses to Precipitation Variation

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Grassland soils (mollisols) store more than 30% of the terrestrial organic C in the continental U.S. and are expected to experience dramatic changes in precipitation patterns with climate change. Our project used three complementary omics approaches to evaluate the impact of altered rainfall patterns on microbial C cycling in a Kansas native prairie soil. The study used the Rainfall Manipulation Plots (RaMPs) experiment at the Konza LTER, which was established in 1997. It maintains ambient and altered precipitation timing on intact prairie using an array of rainout shelters and sprinklers. Through every growing season, altered treatment soils receive an equal amount of water, in larger and less frequent events, than ambient soils, thereby extending the drought periods experienced by soil microbial communities. Soils were sampled during a wet-up event (before, 1 and 5 days after water addition) two times in 2011 (early and late summer). We measured the functional response of the microbial community along with the omics response (metatranscriptome and metaproteome). The omics data were analyzed using a custom, "active metagenome" based on sequencing BrdU-labeled DNA in conjunction with a comprehensive manually curated and validated database focused on specific biochemical functions and pathways of importance for soil microbial ecology. The use of BrdU-labeled DNA improved assembly and enhanced the identification of transcripts and proteins from metatranscriptome and metaproteome datasets compared to a metagenome built from unlabeled DNA. Microbial functions responded to wet-up events differently in the early and late summer. For example, microbial C-use efficiency was higher in altered than ambient and also higher in dry (September) soils, and C-acquiring enzyme activities (β-glucosidase, cellobiohydrolase, and phenol oxidase) increased after rainfall in moist (June), but not dry (September) soils. These differences were often mirrored by metatranscriptomic responses. For example, the relative abundances of transcripts associated with oxidative phosphorylation showed a similar response to wet-up as did soil microbial respiration and transcripts for cellobiose transporters showed similar trends as β-glucosidase activity.

Keywords：*Metagenome, metatranscriptome, metaproteome, C cycling*

O68-3

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Raising Atmospheric Carbon Dioxide : Effect on Structure of Soil Microbial Communities and Functions Related to Terrestrial N Cycle

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CO2 in atmosphere is approaching an alarming 400 ppm mark, which is a big concern for present day environment. There is a lack of understanding on how potential it is in altering microbial structure and functions in soil and in particular those that are involved in N-cycle. Terrestrial C and N cycle are closely linked so we believe that there should be a direct role of raised CO2 on microbial functions involved in soil N cycle. To fill this gap soil microbial communities and functional genes involved in N cycling in soil were studied .

To carry out this study special fields were designed where high levels of CO2 (550 ppm) were maintained in an experiment called Free Air Carbon dioxide Enrichment abbreviated as FACE. Soil samples were collected from rhizosphere and bulk of wheat crops . To compare FACE experiment site soil, a control field having same variety of wheat but with normal atmospheric CO2 was maintained. Three replicates of each, rhizosphere and bulk from FACE site and three replicates from rhizosphere and bulk from control field were sampled to proceed with further studies. DNA was extracted and PCR was performed to prepare amplicons for bacterial and archaeal 16 S rDNA. These amplicons have been sent for sequencing. Sequencing results will give an estimate of microbial populations present in different conditions. Shifts in proteolytic communities producing alkaline proteases were studied using DGGE. Similarly neutral metalloproteases gene (npr)and other genes involved in N transformations including nifH (nitrogen fixation), amoA (Ammonia oxidation), nitrate reduction (nirS and nirK), will be studied using DGGE. All these genes are considered for this study as the enzymes coded by them not only take part in terrestrial N cycle but also are major components of soil health.Apart from shifts in communities, gene abundance will be studied using quantitative PCR.

Elevated levels of CO2 seems to have an effect on shifts in alkaline protease genes as observed in DGGE results. Furthermore it has been observed plant rhizosphere has a pronounced effect on proteolytic community structure under both conditions i.e. in soil from FACE site and in control . We are now working to see changes in gene diversity and abundance for other genes for N transformation i.e. npr, nifH, amoA, nirK and nirS.

Preliminary results suggest that the proteolytic communities in soil are adapting themselves in response to rising CO2 in soil. We are working on whether it also has effect on other functions related to N cycle. Interpretation of sequencing results will help us to understand the dynamics in soil microbial populations in response to carbon dioxide.

Keywords：*CO_2, FACE, microbial communities, N cycle, protease, nitrogen fixation, DGGE, qPCR*

O68-4

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Interactions and Feedbacks between Above and Below-ground Ecosystems under Elevated CO_2 and Elevated Temperature

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Rising atmospheric carbon dioxide (CO2) concentrations and elevated temperatures (eT) are of global concern. Forest soils have been identified as potential C-sinks under future climate forcing, as carbon inputs to soil are generally predicted to increase under eCO2. However, a key determinant of an ecosystems ability to efficiently sequester C is the availability and sustainability of other nutrients including nitrogen (N) and phosphorus (P). This presents great uncertainty in predicting the global capacity of terrestrial ecosystems to sequester C because there are major gaps in our understanding of the interactions and feedbacks between the carbon, nitrogen and phosphorus cycles. This uncertainty is largely driven by limited understanding of the interactions and feedbacks between above- and below-ground ecosystems under climate forcing. Key to this is improving our understanding of microbial-mediated nutrient cycling in response to multiple climate change factors (eCO2 and eT). Using whole tree chambers at the Hawkesbury Forest Experiment, that allow portioning of soil and plant CO2 fluxes, we determined the interactive effect of eCO2 (+200 ppm above ambient) and eT (+3 °C above ambient) on the structure and activity of soil microbial communities in soils growing under Eucalyptus globulus. Total soil respiration varied with time and treatment and was generally more responsive to eT than eCO2. The bacterial community structure (TRFLP) responded to both eCO2 and eT, which was coincident with an increase in below-ground carbon allocation, particularly under eCO2 treatments. Shotgun analysis of soil microbial communities demonstrated changes in community structure were responsive to eCO2 but not temperature, while functional genes were impacted by CO2 and, to a lesser extent, temperature. Genes associated with C, N and P cycling were impacted by eCO2, although the magnitude and direction of response varied within functional categories. Fungal communities (TRFLP) were less responsive to either global change driver. N-mineralisation was largely unaffected by both eCO2 and eT, but a large increase in the microbial C:N ratio under eCO2 and eT treatments, that became stronger over time, indicated increasing N-limitation within these systems and correlated with a decrease in plant leaf N under eCO2. Further, the strong interactive effect of eCO2 and eT, suggests that nutrient poor soils may have limited capacity to sequester C in the long-term.

Keywords：*elevated CO2, elevated temperature, microbial community structure and function, ecosystem function*

O68-5

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

The Effects of Continuous Cabbage Cropping on Soil Microbial Communities Structure

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Plastic greenhouse cultivation is becoming a predominant agricultural practice in China. An artificial environment in greenhouses may be modified for maximum plant growth and economic return. However, it often involves continuous mono-cropped production. After a long term continuous cropping of crops, soil fertility imbalance, the pathogenic species and numbers accumulation were becoming obvious, which shows continuous cropping obstacle. Cabbage is one of the major greenhouse vegetables present in China. Continuous cropping obstacle is also one of the main restriction factors in cabbage. The aim of this study is to investigate the population dynamics of microorganism in rhizophere soil of with continuously cropped cabbage. The dynamics of soil microbe population induced by continuous cropping of cabbage was studies using quantitative PCR, clone library, and PCR-denaturing gradient gel electrophoresis (DGGE) analyses. The results showed that the composition of microorganism population in rhizophere soil was altered by continuous cabbage. The microbial population grandly decreased with continuous cabbage cropping in Bacteria showed a greater decrease trend in population than Actinomyces and Fungi. The decrease of bacterial population in rhizosphere and bulk soil reached a significant level when the fourth and fifth cabbage crops were planted. The number of actinomyces occurred a decline tendency in the third cropping season. The data in this study also indicated that continuous cabbage cropping could induce a few fungal populations increasing as well. The major rhizospheric microbial physiological groups were also analyzed. The results indicated that there was significant decrease in the number of rhizoshpere azotobacter and aerobic cellulose-decomposing microbes, and great increase in nitrobacteria population. However, there was little variation in the number of ammonifying bacteria population when cabbage cropping continued. Soil enzyme activities showed Catalase and acid phosphatase activities declined, and Urease activities rose slight as intensive mono cabbage cropping was conducted. Besides, the number of fungi pathogen was increased as well. The change was one of the reasons in reducing the yield of continuous cabbages.

O68-6

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

A Polyphasic Approach to Study Arbuscular Mycorrhizal Fungi Activity and Community Structure Changes with Respect to Soil Salinity in Saemangeum Reclaimed Land of South Korea

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Salinity is one of the major abiotic stresses, which affects soil microbial community particularly arbuscular mycorrhizal fungi (AMF). Despite presence of many reports illustrating AMF community structure in salt affected sites, information on changes in mycorrhizal activity and community with different level of soil salinity is inadequate. Mycorrhizal activity such as percentage root colonization, spore production, hyphal length and mycelium structures are considered important in ecosystem functioning. In this study, we have determined the impact of different salinity levels on AMF root colonization, spore count, glomalin related soil protein (GRSP) content and community structure in Saemangeum reclaimed land, South Korea. Soil samples were collected and primarily grouped into five distinct salt classes based on electrical conductivity of soil saturation extracts (ECse). Mycorrhizal root colonization, spore count and GRSP were measured under different salinity levels. AMF community structure was studied using spore morphology, terminal restriction fragment length polymorphism (T-RFLP) and denaturing gradient gel electrophoresis (DGGE). Results revealed that, root colonization ($P < 0.01$), spore count ($P < 0.01$) and GRSP ($P < 0.01$) had a significant negative linear relationship with soil salinity. Spore morphological study showed the predominance of genus Glomus in Saemangeum reclaimed land. T-RFLP and DGGE analysis revealed significant changes in diversity indices between non (ECse <2 dS/m) and extreme (ECse >16 dS/m) salt classes and confirmed dominance of Glomus caledonium only in soils with ECse <8 dS/m. However, ribotypes of Glomus mosseae and Glomus proliferum were ubiquitous in all salt classes. Interestingly, we found a relationship in the results obtained from spore morphology, T-RFLP and DGGE analysis. Richness of genus Glomus in DGGE and relative abundance of Glomus by spore morphological studies showed similar kind of results, where both are higher in very saline salt class (ECse 8-16 dS/m) compared to other salt classes. In addition, 58% of the identified ribotypes in T-RFLP belonged to Glomus, which was consistent with our spore morphological study results, where total Glomus distribution in Saemangeum reclaimed land was 62%. Similarly, eight percent of the identified fragments belonged to Gigaspora and Scutellospora in T-RFLP, which also matched with results of spore morphological studies. DGGE followed by dominant band sequencing supports the results obtained in T-RFLP. Polyphasic approach of combining spore morphology, T-RFLP and DGGE analysis showed a pronounced shift in AMF community across salt classes. The results of this study improves our understanding on AMF activity and dominant species present in different levels of soil salinity and will substantially expand our knowledge on AMF diversity in reclaimed lands.

Keywords：*Arbuscular mycorrhizal fungi, Community structure, DGGE, GRSP, Root colonization, Saemangeum*

O68-7

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Variation in Drought Tolerance Capability of Endophytic Bacteria Isolated from Different Tissues of Chickpea

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Global warming ranks at the top of environmental issues and climate models indicate the worldwide increasing aridity with prolonged drought which is adversely affecting the world agriculture. Endophytic bacteria can play role for mitigating drought stress in plants. In our study, endophytic bacteria were isolated from different roots, stems, leaves and pod tissues of disease-free chickpea plants grown under different arid/semi-arid regions of Punjab, Pakistan. Maximum numbers of endophytic bacteria were isolated from roots followed by stems, leaves and pod of chickpea plants. On the basis of colony morphology and prolific growth isolates were selected for in vitro screening of their drought tolerance capability at different water potentials i.e. -0.04, -0.28, -0.70 and -1.25 MPa developed by using polyethylene glycol (PEG 6000). Endophytic bacterial isolates showed variable growth at different water potentials. Most of the endophytic bacterial isolates exhibited growth up to -0.70 MPa. However, few isolates were able to grow at -1.25 MPa water potential. Interestingly, endophytic bacteria isolated from roots show better growth at lower water potential. Drought tolerance ability of these endophytic bacteria makes them attractive option to be used for inducing drought tolerance in cops of arid/semi arid regions. Further investigations are required for exploring their potential to enhance the plant growth under water limited/drought conditions.

Keywords：*Endophytic bacteria, drought, chickpea, PEG 6000*

O69-1

[IDS14] From Science to Policy – is the Knowledge on Diffuse Pollution by POPs Sufficient to Support Policies

Sustainable Development Goals: a Possible Instrument to Tackle Diffuse Soil Pollution?

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Soil pollution by POPs has highly localized costs and effects however the source-sink relationships leading to it do not stop at national borders. The basic underlying drivers and pathways leading to it are of a global dimension. These kinds of transboundary soil pollution processes are global challenges that need global answers. A coordinated global science and policy approach is thus needed to tackle the issue.

As the world population grows, is moving up the food chain and increasingly depends on biofiber and bioenergy, the world is facing a growing demand for fertile and healthy soil. In the light of this, awareness that fertile soil is scarce, impossible to expand at short notice and prone to degradation has raised. In 2012 at the Rio+20 Conference on sustainable development the world community realized that the protection of soil and land resources is a global task. In the Rio+20 outcome document 'The Future We Want' UN member states 'recognize the need for urgent action to reverse land degradation". "In view of this," they agreed to "strive to achieve a land-degradation-neutral world in the context of sustainable development'.

Land degradation neutrality means that on the one side land degradation has to be minimized while unavoidable land degradation needs to be offset by restoration and rehabilitation efforts on the other side. The envisaged Sustainable Development Goals (SDGs) are a possible instrument to implement the concept of land degradation neutrality on a global level. The decision to develop and adopt SDGs is another outcome of the Rio+20 Conference. These SDGs are supposed to address the three dimensions of sustainable development (economical, ecological and social). They are, furthermore, supposed to be global in nature, while respecting different national realities, policies and priorities. In conclusion, they will be politically yet not legally binding. The SDGs are going to be further defined by specific and quantifiable targets, which in turn will be measured and monitored by indicators.

Availability of appropriate indicators will thus play a crucial role in addressing land degradation neutrality in the SDGs. So far proposals for possible indicators include changes in land productivity in a sense of net primary production and changes in soil organic carbon content. Both indicators are not suitable to address soil pollution caused by POPs. Coming up with an indicator that is appropriate to capture soil pollution caused by POPs, applicable on global level and broad enough to serve as a proxy for soil pollution in a wider sense is a major scientific challenge. At the end of the day, however, the choice of indicators will determine what types of soil degradation will be covered by a SDG on land degradation neutrality. Therefore, indicators that cover quantitative and qualitative aspects of soil fertility and healthiness are needed.

The Rio+20 conference opened up a window of opportunity to put diffuse soil pollution caused by POPs on the global agenda. A well coordinated and concerted science-policy-dialogue is now needed to make use of this window of opportunity.

Keywords：*Global Governance, Soil pollution, Soil policy, Science Policy Interface, , Sustainable development Goals, Rio+20,*

O69-2

[IDS14] From Science to Policy – is the Knowledge on Diffuse Pollution by POPs Sufficient to Support Policies

Polluted Ground, a Ticking Time Bomb- the Neglected Issue of Diffuse Soil Pollution

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Agricultural, urban and industrial activities have caused a strong increase in the number and concentration of diffuse pollutants in the environment. In the European environment alone, at least 700 emerging pollutants are found (NORMAN 2013). Knowledge of the current state of global soil pollution - with some hundreds of different classes of compounds - is very limited. Whereas (inter)national water monitoring programs have been established for years in Europe, the USA and other countries, no (inter)national soil monitoring programs exist. There is little public awareness of diffuse soil pollution probably due to the fact that environmental and human health effects are not directly visible, and the soil science community is not very active in public debates. Soils serve as sinks for any kind of diffuse pollutants that directly or indirectly reach them. This occurs directly through application of agrochemicals - and indirectly by wind or water transport of chemicals released to the environment from urban or industrial activities. As such they present a trans-boundary challenge. Increasing amounts of soil pollutants pose an environmental risk for the soil ecosystem and the connected aquatic environment. Yet, the effects of many single pollutants or pollutant mixtures on the soil ecosystem are not known.
Applying the concept of "planetary boundaries", which delimitate a "safe operating space for humanity" (Rockström et al. 2009), pollutants in soils potentially pose a planetary boundary threat. Specifically, they meet the conditions proposed for consideration as a chemical pollution planetary boundary threat (Persson et al., 2013) in that they 1) can cause a large scale reduction of vital soil processes, 2) their disruptive effects may not be discovered until they are inevitable, and 3) their environmental effects cannot be readily reversed.

At this point, no critical thresholds and loads for different pollutants (or mixtures of them) in soils are defined - and it would be a gigantic task to undertake. Soil ecosystems react more slowly than aquatic ecosystems. Decay, transformation and transport of pollutants in soils under field conditions often differ significantly than what is predicted by laboratory tests. In some cases, persistent organic pollutants that have accumulated in soils can be detected in high concentrations decades after a chemical compound is forbidden, e.g. DDT in Chinese soils (Zhang et al. 2009).

Soil pollutants can have a direct effect on human health risk when they are (i) inhaled and/or deposited on the skin, e.g. during wind erosion events, (ii) taken up by plants and ingested with food, or by (iii) entering aquatic systems and drinking water supplies. The potential effects of pollutants strongly depend on current application forms and doses taking into account constraints such as soil types, climate conditions and chemical properties of the pollutants. Understanding the processes and the influencing factors requires an interdisciplinary approach.
Considering all this, the question must be posed: Is the soil ecosystem as a sink for pollutants over the last decades a ticking time bomb for the environment?
The need for international legal frameworks and conventions to address soil pollution and environmental implications crossing national borders will be addressed and plans "Towards sustainable management of pollutants" will be discussed.
We will suggest development of a global screening strategy to build a data base on the pollution of global soils from pesticides, and a risk assessment approach to create a holistic picture of actual global soil pollution. Independent of this, new approaches to efficient, environmentally friendly production systems and plant protection are urgently needed.

Keywords：*soil pollution, diffuse pollutants, emvironmental risk, sustainable management*

O69-3

[IDS14] From Science to Policy – is the Knowledge on Diffuse Pollution by POPs Sufficient to Support Policies

Comparative Study on Toxic Metal Contamination in Balu River Water in Bangladesh

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An extensive study was carried out in the Balu river water during the year of 2011 – 2012 with a view to observe and identify the water quality regarding the different toxic metal contamination. A total of 72 surface water samples collected from four different locations adjacent to the Balu river area of Dhaka – Narayangonj – Demra area, during wet (July to September' 2011) and dry season (November to January' 2011-12). To determine the spatial distribution and seasonal variation of toxic metals (Pb, Cr, Ni, Cd, and Zn) details laboratory analysis was performed in the Soil Science Division of Bangladesh Institute of Nuclear Agriculture (BINA) following standard procedures. Among the different locations, the maximum mean concentration of Pb, Cr, Ni, Cd and Zn was also observed at Termuni area as 0.10, 0.096, 0.263, 0.118 and 1.31mgL-1, respectively. Considering locations and seasons, the highest concentration of the analyzed parameters was found at Termuni area during dry season as Pb (0.13), Cr (0.11), Ni (0.30), Cd (0.161) and Zn (1.772). The minimum concentration of Pb, Cr and Zn was noted at Demra area during wet season as 0.04, 0.048 and 0.697, respectively. The Cd and Ni concentration was observed as 0.025 and 0.133 mgL-1 at Nagarpara area. Finally the study revealed that the concentration of Pb, Cr, Ni and Cd exceeded the standard level of drinking, irrigation, fishing and surface water set up by WHO, GOB, USEPA, DOE and FWPCA for the dry season.

Keywords：*Toxic metal contamination and Balu river*

O69-4

[IDS14] From Science to Policy – is the Knowledge on Diffuse Pollution by POPs Sufficient to Support Policies

Impact of Sea Level Rise on Contaminant Mobility and Cycling

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Climate change and resulting sea level rise is a growing problem globally, particularly as the percentage of the world's population increases in coastal areas. In the United States, over 53% of the population lives along the coasts. In the Middle Atlantic Region of the USA, sea level rise is increasing at a faster pace than in other parts of the world due to both climate change and subsidence. By the end of the 21st century, seas are expected to rise up to 1 m. This is also the part of the United States where there are a multitude of old industrial sites that are contaminated with trace metals and organic chemicals. Sea level rise risk studies have thus far been limited to above surface processes. However, the first impacts of sea level rise will be alterations in sub-surface hydrology and chemistry, due to salinization and rising water tables. These events could lead to the release and migration of sediment-bound contaminants through ion-exchange and sorption/desorption processes that alter contaminant speciation, mobility, and toxicity. Arsenic and chromium contaminated soils, from abandoned industrial sites and within the 1.0 m sea level rise scenario, were reacted with seawater of varying ionic strength using microcosm reactors. Temperature and pH were controlled and Eh was varied to reflect inundation and retrenchment scenarios. Effluent and solid samples were collected at various times for analyses. Effluent was analyzed via ICP-MS to monitor changes in As and Cr mobility, and ICP to determine concentrations of other ions. Solid phases samples were analyzed by synchrotron-based micro- X-ray fluorescence (XRF) and X-ray absorption spectroscopy (XAS) to determine distribution and association and direct speciation, respectively, of As and Cr under different environmental conditions. Low seawater treatments showed no detectable desorption. Soils exposed to 100% seawater displayed an initial increase in As and Cr desorption, followed by a steady release for the duration of the trial (48h). This desorption pattern was unique to the 100% seawater treatment. Speciation of both As and Cr in solution displayed mixed oxidation states. These studies provide important information on the impact of sea level rise on the cycling, mobility, and speciation of redox sensitive heavy metals in contaminated soils.

Keywords：*trace metals, arsenic, chromium, sea level rise, synchrotron, XAS*

O69-5

[IDS14] From Science to Policy – is the Knowledge on Diffuse Pollution by POPs Sufficient to Support Policies

Diffuse Contamination of Forest Soils: Causes, Influencing Factors and Effects

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Concentrations of risk elements (REs) and persistent organic pollutants (POPs) and their fate in the environment are influenced by (anthropogenic) emissions and also factors influencing their translocation and (re)distribution in environmental compartments. Due to the ban of production of some persistent organic pollutants (DDT, PCB) their concentrations in the environment continue to decline. Concentrations of others (REs, PAH, dioxins) can increase. However, because the fate of both groups is influenced by many factors they can be accumulated in some parts of environment with possible negative effects.

Significant amount of pollutants remains stored in soil and sediment due to their persistence and affinity for organic carbon. Background soils are therefore an important reservoir of REs and POPs in the environment. POPs can be released, from these reservoirs back to the atmosphere and be re-address to long range transport. E.g. very important is a processes of POPs mobilization by volatilization from water and soil surfaces. The majority of the studies concluded that the mobility of POPs in the environment will increase due to re-emission from soils.

Diffuse contamination of forest soils is regarded to be a consequence of these processes. Among most important factors which influence the diffuse contamination of forest soils belong climatic conditions, topography, land cover and soil conditions. Preliminary results of a project shows that the main factors influencing the distribution of REs and POPs in forest soils is altitude and composition of forest tree species. However the importance of these factors is different for individual substances. In case of DDT and HCH an important factor is also location close to agricultural soils with an intensive management in the past.

Based on the methodology of the project it is also possible to count balances and pools of REs and POPs in top soil layers (organic and first mineral horizon for forest soil and plough layer for agricultural soil). For the area of the Czech Republic it was calculated that in case of PCB, there are about 95 t and 35 t stored in agricultural and forest soil respectively.

Keywords：*forest soils, diffuse soil pollution, risk elements, persistent organic pollutants*

O69-6

[IDS14] From Science to Policy – is the Knowledge on Diffuse Pollution by POPs Sufficient to Support Policies

Risk Management for Semi-volatile Organic Soil Pollutants in South Korea

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The soil quality standards in South Korea have been used for preliminary criteria to establish soil clean-up target to prevent potential hazard or injury to public health and environment due to soil contamination. Those standards are applied to 21 pollutants with dividing land into Area 1, 2, 3 based on land use. Standards may be too strict to be clean-up target levels for soil management. Nevertheless, Site specific risk assessment is not used to determine clean up goal of SVOCs

Of semi-volatile organic compounds(SVOCs), PCBs(polychlorinated biphenyls) and TPHs(total petroleum hydrocarbons) are regarded as soil contaminants which are determined by Soil Environment Conversion Act. PCBs are evaluated total amounts by the peak-pattern method. 12 Dioxin-like PCBs which are considered to possess dioxin-like toxicity have been monitoring using a monitoring network by POPs(persistent organic pollutants) Control Act. 20 SVOCs except for PCBs also monitored in soil by the act. TPHs which include many derived petroleum products from C8 to C40 are managed in total concentration in aspect of petroleum pollutions. TPHs determination does not allow a risk assessment of contaminated soil, since TPHs include compounds with very different physicochemical and toxicological properties. A fractionation process must be performed to quantify TPHs risk. Several fractionation methods proposed to sort out this problem are commonly set based not only on aliphatic and aromatic compounds, but also by their equivalent carbon number(EC).

Risk assessment guideline and committee for verification will be operated for risk assessment of petroleum contaminated sites on the basis of exposure pathways, toxicities and so on. As more SVOCs are synthesized and emitted to the environment, there is a growing need to regulate emerging SVOCs selected from CROSS(Chemical Ranking of Soil Pollution Substances) program.

Keywords：*SVOCs, soil quality standard, management strategy, South Korea*

O69-7

[IDS14] From Science to Policy – is the Knowledge on Diffuse Pollution by POPs Sufficient to Support Policies

Adsorption of Selected Pharmaceuticals in Representative Soils of the Czech Republic

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The presence of human and veterinary pharmaceuticals in the environment has been recognized as a potential threat. Pharmaceuticals may contaminate soils and consequently surface and groundwater. Study was therefore focused on the evaluation of selected pharmaceuticals adsorption in soils, as one of the parameters, which are necessary to know when assessing contaminant transport in soils. The goals of this study were: (1) to select representative soils of the Czech Republic and to measure soil physical and chemical properties; (2) to measure adsorption isotherms of selected pharmaceuticals; (3) to propose pedotransfer rules for estimating adsorption coefficients from the measured soil properties. Batch sorption tests were performed for 7 selected pharmaceuticals (Atenolol, Metoprolol, Carbamazepin, Clindamycin, Clarithromycin, Trimetoprim and Sulfamethoxazol) and 13 representative soils (soil samples from surface horizons of 11 different soil types and 2 substrates). The Freundlich equations were used to describe adsorption isotherms. Multiple-linear regressions were applied to predict the Freundlich adsorption coefficients from measured soil properties (soil particle density, soil texture, oxidable organic carbon content, cation exchange capacity, pH_H2O, pH_KCl, CaCO3 content, salinity etc.) Evaluated pedotransfer rules for different pharmaceuticals included different sets of soil properties. In general all relationships included organic carbon content. Some equations contained also cation exchange capacity (Atenolol, Metoprolol, Carbamazepin, Clarithromycin, Trimetoprim), pH_KCL (Metoprolol, Carbamazepin, Clindamycin, Clarithromycin, Sulfamethoxazol) and clay content (Atenolol).

Acknowledgement: Authors acknowledge the financial support of the Czech Science Foundation (No. 13-12477S).

Keywords: *pharmaceuticals, adsorption isotherms, pedotransfer rules*

O69-8

[IDS14] From Science to Policy – is the Knowledge on Diffuse Pollution by POPs Sufficient to Support Policies

Uptake of Pharmaceuticals by Soil Minerals

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Swelling clay minerals are an important soil component. They have strong affinities for many ionizable drugs, resulting in a higher amount of drug adsorption. The adsorption occurred on the external surfaces and, mostly, in interlayer spaces, attributed to cation exchanges between hydrated metals cations previously adsorbed on clays and the ionizable drugs in cationic and zwitterionic forms. The consequences of cation exchange of organic cations for inorganic cations would result in interlayer expansion due to the larger sizes of organic cations and different interlayer configurations. The intercalated cationic drugs are more stable against desorption by regular water. However, multiple cycles of desorption using Al3+ could remove the intercalated drugs from the interlayer. The intercalated antibiotics may render their antimicrobial activities due to a much lower equilibrium solution concentration of the drug. The inhibitive effect of antibiotic intercalation may lead to development of increased antibiotic resistance of bacteria once in contact with the antibiotic-intercalated clay system over prolong periods of time.

Keywords：*clay minerals, pharmaceuticals, adsorption, desorption*

O70-1

[IDS15] Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Recent Advances in Soil Remediation Technologies with Particular Emphasis on Mined Lands

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Mining is of economic significance to many countries worldwide because, in addition to providing export income, it is also a major source of energy, construction materials for infrastructure and manufactured goods. However, regardless of how mining or its products are used, mining does impact the environment and poses a set of unique environmental problems. Major environmental challenges faced by the minerals industry include:

- greenhouse gas emissions
- non green house gas emissions
-preserving biodiversity
- final voids and closure
- acid mine drainage
- tailings management
- waste management
- ecosystem establishment.

Greenhouse gas and biodiversity issues will not be discussed in this paper as biodiversity is more of a policy issue while greenhouse gas emissions are subject of discussions globally. All of the remaining mining environmental challenges listed above are associated with high concentrations of toxic metal(loids).

Environmental impacts of active mine sites

Quarry operations result in topographic changes, usually with little waste rock generated. At the other end of the spectrum, strip mining produces huge tonnages of waste rock and spoil, and often an extensive final void (e.g. coal mines in the Hunter Valley and Bowen Basin in Australia, with similar voids seen in coal mines in other countries).

Until recently, the minerals industry in Australia was operating largely in semiarid or arid areas distant from cities, towns and farmland. Contrastingly, in most other countries the industry tends to operate in close proximity to villages supporting local people. The recent influx of mining for coal and coal seam gas in Australia has resulted in many mining operations shifting to arable land. Under these circumstances, mineral operations may pose health risks for humans if heavy metals contaminate soils and thus potentially enter the food chain or are inhaled with dust. Many such examples have been recorded in the literature, including Port Pirie in South Australia and coal mining in the Hunter Valley.

Abandoned mine sites and mineral tailings

While strip mining activities (including quarries stockpiled in close proximity to mines) may generate dust or cause siltation of drainage channels, the tailings and residues of beneficiation processes potentially pose an even greater threat to the environment. Tailings, or mill tailings, are the materials remaining after extraction and beneficiation of ores. Mine tailings disposal sites at inactive or abandoned mines are prevalent in arid and semiarid regions throughout the world. Such tailings are associated with elevated levels of metal(loid)s such as arsenic, cadmium, copper, manganese, lead, and zinc1, all of which pose risks for human health and the environment. The global impact of such mine tailings disposal sites is enormous, as unreclaimed mining sites generally remain unvegetated for tens to hundreds of years, and exposed tailings can spread over tens of hectares via eolian (wind-borne) dispersion and water erosion2. In Australia, many abandoned mine sites still exist with both unfilled voids and tailings wastes.

Mining wastes often contain no organic matter or macronutrients, and usually exhibit acidic pH, although some tailings may be alkaline3. For these reasons, tailings and some other mine wastes develop abnormal soil structure and support a severely stressed heterotrophic microbial community4, which makes mine closure a challenging operation.

Until the early 1990s there was no legislation in Australia forcing minerals industries to remediate or contain tailings piles and waste rock dumps. Now, many developed countries mandate mining companies to do this. Despite the wide contemporary body of knowledge on the environmental and health impacts of tailings and waste rocks,, many developing countries have no such requirements and still allow mine tailings to be dumped into bodies of water, thus escalating the problem of thousands of abandoned mine tailings sites worldwide.

Technologies to manage or remediate contamination

Technologies currently being used to manage metal-contaminated sites include excavation (physical removal of the contaminated material), on-site stabilization of the metals in the soil using recyclable resources, growing plants to stop the spread of contamination or to extract the metals from the soil (phytoremediation), and microbial immobilization of metals. This paper presents an overview of recent advances in technologies for the remediation of metal(loid)-contaminated mined soils and the challenges faced by both regulators and minerals companies from pit closure and acid mine drainage issues.

O70-2

[IDS15] Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Arsenic Fate in a Copper Hydro-metallurgic Circuit to Develop a Soil Remediation Strategy

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Introduction
The anthropogenic sources of As include mining and smelting, industrial processes, and agricultural practices. In polluted soils, the originally-reduced As species undergo geochemical transformations, such as oxidation to As(III) and As(V). The secondary minerals formed have increased but variable solubilities and mobilities depending mainly on pE and pH conditions, in turn influencing the soil's ability to release them from the solid phase. To design remediation strategies, accurate identification of individual arsenic species in mining processes and contaminated environments is critical.
In a copper mine located in a dry place of the north–east of Mexico, the fate of As in the circuit of hydro-metallurgic process was studied. The mining complex consists of:open-pite copper mine, flotation concentrator, hydrometalurgic process, copper smelter and copper refinery (including precious metals). In the same complex, sulfuric acid is produced with the SO2 from the smelting processes in a contact-plant. The impure sulfuric acid (ISA) is used to lixiviate the dust from furnaces of the smelting process, in order to recovery copper. During the lixiviation of the dust, the arsenic compounds are dissolved. The ISA is used in the dump leaching operation. The waste rock also contains arsenopyrites. The leach liquor (PLS) is processed in the solvent extraction plant and the copper is refined in the electrolytic plant. In order to developed a friendly remediation technology to control safely the arsenic, a study of the fate of this element in the copper hydro-metallurgic circuit was done.
Methodology.
Those samples were collected: concentrates, dust, slag, waste rock (0-27m), acid waste effluents, leached solution and sediments in the pond, feed solution of the solvent plant (PLS), fine solids of the interface solvent-solution, spent electrolyte, waste rock (superficial and sub-superficial up to 27 m) and tailings. The following analyses with standard methods of USEPA and ASTM were carried out: pH, electrical conductivity as well as the digestion and quantification of total and extracted trace elements by ICP-AES. Complementary water soluble arsenic (1:20 solid:water w:w) and sequential extraction of As (H2O, HCO3-, OH-, HCl) in waste rock were done. The As speciation was measured by polarography and AAS methods. Selected samples were analyzed by XRD and SEM-EDS. Retention and isothermes sorption experiments were done.
Results and discussion
The As is concentrated in the converting furnace-flue dust=5.27%, electrical furnace dust=0.76%, ISA=0.90% (25.2 % As(V) and 74.8 % As(III)) and electrolyte=1.45%. The ISA after the lixiviation of dusts had 2.2% of arsenic, while the leaching solution and the sediment of the pond had only 117.7 and 49.2 mg/L, and the PLS 6.35 mg/L, indicating the retention of As in the dump. It is important to mentioned that it was observed the solubilization of Mn of the waste rock (Mn in ISA= 3.28 mg/L and in PLS= 493 mg/L).
Dusts contained arsenolite and adamite, and jarosite in waste rock and tailings (XRD). The analyses of waste rock indicated higher concentration of Mn, Ti, Fe than dust and ISA, but these are richer in As, Cd, Cu, Mo, Ni, Pb, Se and Zn. As in the profile (0-27m) presents a very high variability, not observed in other elements (Fe, Cu, Pb, Zn) except in Mn that have the opposite behavior. Between 15 and 20 meters the concentration of As is 10% of the values from the surface. The waste rock retains As in a lower rate than oxidized tailings but forms stronger bonds, because desorption is lower than tailings. Among increases the contact time of the waste rock with the spent acid, the soluble As (III) diminish (from 10- 50% to <2.7%). After 8 years of irrigation, the As in the waste rock is mainly extracted with NaOH or is not recovered (≅61%), and the soluble fraction is practically null. However in the dumps recently irrigated, the soluble and the bicarbonate fractions are important (20-30%), indicating weaker complexes. In deep samples soluble As and total Mn were very low, indicating the oxidation of As and the formation of soluble Mn(II) that is being concentrating on the pond.
Conclusion
The results of this study, show the As(III) oxidation by Mn(IV) present in the waste rock and formation of jarosite and/or inner complexes with Fe(III) oxide-hydroxides.This process could be the base of a remediation method.

Keywords：*arsenic, mine wastes, remediation*

O70-3

[IDS15] Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Chemical Properties, Arsenic Distribution and Remediation in Leonardite from Mae Moh Mine, Thailand, for Possible Use as Soil Amendment

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Leonardite is a low grade coal naturally occurring in soils. Its reduced form, lignite, which may be present in soils near leonardite layers, can be mined for energy generation. Since leonardite cannot be used for such application, this mineraloid can be collected as a waste product at lignite mine sites, such as the one in Mae Moh power plant site, Lampang Province, Thailand. Leonardite can be used as an agricultural soil amendment given its high contents of organic matter, macro and micro nutrients, as well as its ability to retain cations and water in soils (Pertuit et al., 2001). Its chemical properties, however, may vary depending on the sources of leonardite. Preliminary analyses of the leonardite from Mae Moh mine showed that it contained a high amount of arsenic, which is toxic to human. Therefore, this study aimed to characterize the chemical properties of leonardite from Mae Moh, with an emphasis on arsenic distribution in the mineraloid, using three sequential extraction techniques: 1) CIEMAT (Larios et al., 2012) 2) Keon (Keon et al., 2001), and 3) Hall (Hall et al., 1996) methods. Additionally, this research provided a method to effectively remediate arsenic from the leonardite sample, as well as recommendations on possible uses of Mae Moh leonardite as a soil amendment. Results showed that the leonardite sample was acidic (~ pH 4) and had a high organic matter content (43 %), cation exchange capacity (53.78 centimoles per kilogram), as well as macro and micro nutrients, especially iron, sulfur, calcium, nitrogen, potassium, and magnesium. Low contents of toxic elements, e.g. cadmium, chromium, lead, and mercury were measured, except arsenic (As), which was present at a concentration of ~ 41 milligrams per kilogram. Results from Fourier Transform Infrared (FTIR) spectroscopy analyses indicated that the leonardite sample from Mae Moh had similar functional groups than the leonardite standard from the International Humic Substances Society (IHSS). These analyses also showed that the sample contained inorganic minerals and thus did not consist of purely leonardite. This was supported by results from X-ray diffraction (XRD) analyses, which showed that the sample contained primary and secondary minerals. Results from the three sequential extraction methods indicated that less than two percents of As in leonardite was readily soluble. Most As was adsorbed on surfaces of the sample's components, especially on iron oxyhydroxides, while the As amount contained in the recalcitrant part of leonardite represented a minor fraction of the total amount of As in the mineraloid (i.e. less than 20 %). Washing the Mae Moh leonardite with 0.5 M NaH2PO4 or water at pH 2 (adjusted with HCl) could decrease the concentration of As in the leonardite by more than 50 %. This study thus demonstrated that the use of leonardite from Mae Moh for agricultural purposes is possible, but its pH should be increased before use as soil amendment in regular pH soils, and the amount of As should be reduced in the mineraloid.

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Keywords: *leonardite, lignite waste, Chemical properties of leonardite, As distribution and remediation in leo*

O70-4

[IDS15] Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Development of Treatement Agents Synthezied by Acid Mine Drainage Sludge (amds) for Adsorption of As(iii) and As(v) in Contaminated Soil: a Field Study

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The remediation of arsenic contaminated soil in agricultural area by conventional remediation process such as soil washing, physical seperation process, and stabilization / coagulation is too expensive or less effective. Adsorption process using treatment agents as an adsorbent could be an alternative for agricultural areas and was suitable for arsenic contaminated soil remediation. Two types of treatment agents (i.e. acid mine drainage sludge coated sand (AMDSCS) and acid mine drainage sludge mortar (AMDS mortar)) were synthezied and these were made by acid mine drainage sludge (AMDS) which is cost-effective waste-reclaimed material. Waste-reclaimed material, AMDS contains iron oxide (i.e. geothite) approximately 77.6% and iron oxide can provide the functional group for arsenic adsorption. The present investigations on the adsorption of As(III) and As(V) on AMDSCS and AMDS mortar in batch experiments offer fundamental information in terms of adsorption kinetics, pH effects, and adsorption isotherms. The kinetic results using AMDSCS indicated that adsorption of As(III) and As(V) matched well with the pseudo-first order kinetic model. On the other hand, the kinetic results using AMDS mortars indicated that adsorption of As(III) and As(V) fitted well with the pseudo-second order kinetic model. The pH between 3.0 and 8.0 was optimized for As(III) and As(V) adsorption using AMDSCS. In addition, the pH from 3 to 11 was optimized for As(III) and As(V) adsorption using AMDS mortar. The maximum adsorption capacity of AMDSCS for As(III) and As(V) using Langmuir model were 1.60 mg/g and 1.50 mg/g, respectively. Moreover, the maximum adsorption capacity of AMDS mortar 1, 2, and 3 for As(III) using Langmuir model were 16.64, 14.49, and 20.62 mg/g, respectively and for As(V) were 29.59, 27.32, and 31.35 mg/g, respectively. AMDS mortar was choosen for the optimum adsorbent and column experiment was conducted. The result of column experiment revealed that soluble arsenic was not eluted in the columns with AMDS mortar. Therefore, AMDS mortar as a blocking adsorbent was applied to field study for adsorption of arsenic in soil. Field study aimed to evaluate the performance of adsorbent to block arsenic contaminated soil and to confirm the uptake and tranlocation of arsenic in chili grown in soil at two different sites. Arsenic was detected in chili root at control site and concentration of arsenic in chili root was 26.3 ug/L. However, in test field site, concentration of arsenic in chili root were decreased 96%, compared with chili root at control site because AMDS mortars may play an important role in adsorption and in inhibition of arsenic from soil.

Keywords：*Treatment agent, adsorption, AMDS mortar, field study, chili*

O70-5

[IDS15] Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Limiting Factors for Ecological Remediation of Abandoned Rare Earth Elements (REEs) Mine Tailings and a Field Survey of Rees Hyperaccumulating Plants in Ganzhou, China

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Ganzhou is famous as “Rare Earth Kingdom” accounting for over 30% ion-absorbed rare earth elements (REEs) deposit of China. However, the historically unreasonable exploitation (e.g. dump leacing technique using (NH4)2SO4) has led to severe ecological and environmental problems such as occupution of agricultural land by REEs mine tailings, damage of vegetation, soil erosion, and water eutrophication. Therefore, the ecological remediation of such REEs mine tailings has aroused increasing attention, and there is an interest for phyto-extraction and recovery of REEs from mine tailings because of the high economic values of REEs.

The aims of this study were 1) to examine the limiting factors that influence plant colonization and revegetation in the abandoned REEs mine tailings, and 2) to investigate REEs concentrations in the soil-plant system of REEs mine area in attempt to find REEs hyperaccumulating plants. Soil samples were collected at ten mine tailings with different abandoned periods (one to ten years) in Nanfeng village, Dingnan county, together with three control sites for comparison. Four dominant fern species and their rhizospheric soils were also collected for REEs anaylsis at surrounding mine area.

The results showed that soil bulk density of mine tailings ranged from 1.25 to 1.43 g cm-3, much higher than that in the control sites (0.90-1.16 g cm-3). The organic matter content of tailings was extremely low (less than 0.2%), and it was difficult for tailings to form large (> 0.25 mm) and stable aggregates. The microbial quantities in tailings were 1.2-26.7 mg kg-1, far lower than those recording in the control sites (125.1-195.2 mg kg-1), and they were not improved with the increase of abandoned time. In addition, the contents of alkaline hydrolysis nitrogen and ammonium nitrogen of tailings were also lower than normal level. Therefore the poor physicochemical properties may be one of the major factors that inhibit plant revegetation on of REEs mine tailings.

The total REE concentrations varied significantly within four tested fern species. The shoot concentrations of REEs in Dicranopteris dicthotoma and Blechnum orientale reached 1351 and 710 mg kg-1, with a translocation factor (the ratio of REEs in aboveground parts to underground parts) of 4.6 and 1.7, respectively. In particular, D. dicthotoma showed a strong ability for accumulation of REEs from the soil with a bioconcentration factor of 9.9-18. The crust-normalized ratios (LREEN/HREEN、LaN/YbN、LaN/SmN、GdN/YbN) of four plant samples were all over one, indicating that these ferns were enriched in the light REEs and depleted in heavy REEs. Our study suggest that D. dicthotoma could be regarded as a potential REEs hyperaccumulating plant, and future work is needed for revealing the uptake, tranlocaiton and accumulation of REEs in this species.

Keywords：*hyperaccumulator; phytoremediation; rare earth element; revegetation; fern*

O70-6

[IDS15] Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Production of Poly -Hydroxybutyrate by Different Mixed Culture in a Revised Sequencing Batch Reactor

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Poly -hydroxybutyric acid [P(3HB)] is an intracellular thermoplastic biopolymer possessing properties such as biocompatibility and biodegradability that is belonging to the polyesters class. The invention is similitude this material based on biotechnological model and in this way, suitable diazotroph in N-free medium with hydrophilic adjuvants viz, perlite was doing nitrogen fixation in incubator with concentration of 6% sucrose, dioxide carbon relative concentration and temperature 37ºC, and final production was produced during 14 days. This solution had high concentration of P(3HB) that it had significant difference as blank. Therefore, invention had capability of nitrogen fixation and could apply for P(3HB) production in polymers industries.

Keywords：*Nitrogen, Fixation, Biotechnology*

O70-7

[IDS15] Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Stabilization of Arsenic and Heavy Metals in Contaminated Agricultural Soil Around the Mine Areas

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The problems of contaminated agricultural soils by toxic metals and metalloids have been sensitive issues for a long time in Korea. Korean coal and metal mining industries had prosperity in the early 20th century, but most of the mines were closed in the 1970s due to economic feasibility remaining thousands of abandoned mines. Korean government has recognized the severity of contaminated agricultural soil around abandoned mine areas as contaminated crops from those areas could affect human health.
Based on the Mine Pollution prevention and Reclamation Law enacted in 2005, Mine Reclamation Corporation (MIRECO) was established to perform systematic mine reclamation management for both active and abandoned mine in 2006. First stage (5 years from 2007) reclamation projects were carried out which includes agricultural soil remediation, improvement of water quality, restoration and prevention of ground subsidence etc. The objective of this paper is to present the achievement and know-how of MIRECO during first stage mine reclamation project focusing on agricultural soil remediation.
The soil remediation project in MIRECO consists of remediation investigation (RI), feasibility study (FS) for remediation method, work design, and execution on target mine area. Also preliminary and follow-up monitoring is carried out to efficient management. Remediation investigation (RI) including the basic survey, precise investigation, the assessment of contaminated soil such as levels and range of heavy metal in soil, is the first step in soil remediation strategy. Through these processes, the total area and amount of contaminated soil are estimated in target land. Various remediation methods have been proposed for the decontamination of As and heavy metals from soils, such as biodegradation, phytoremediation, soil washing/flushing, electro-kinetic separation, physical separation, thermal desorption, vitrification and stabilization. The stabilization of toxic element in soil is one of the remediation technique used to reduce the mobility of an element in soil by adding immobilizing agents (Kumpience et al., 2008). Stabilization of contaminants in soil can be achieved by amendments able to adsorb, complex or (co)precipitate trace elements (bolan et al., 2003). Stabilization is a widely applied technique at Superfund sites in USA, cost-effective in situ techniques. Moreover, stabilization is the most optimum technology in agricultural soil because it can retain nutrients for vegetation and crop in soil after remediation.
MIRECO have developed effective and eco-friendly stabilization with covering-up method including various immobilizing agents and diverse mixing ratios according to the contamination characteristics of each mine site. In order to apply optimum remediation method, various scale demonstration tests are designed and conducted. The demonstration test consists of lab scale test (batch and column tests) and on-site pilot tests. Through these tests, the optimal and field applicable methods are selected. Then selected remediation method is applied with various covering-up methods under field conditions. MIRECO has made an effort to protect healthy agricultural products through the preliminary and follow-up monitoring in the abandoned mine areas. At the same time, follow-up monitoring for lands is taken to evaluate sustainability and stability of applied remediation methods. Annual monitoring of agricultural soil and crop plants will promote not only for wellness of local residents but also for consumption of healthy agricultural products and further, contribute to revitalization of local economy.
During first stage-mine reclamation projects (from 2007 to 2011), MIRECO has completed soil remediation project for 49 mines and about 260 ha, and continuing 2nd stage-mine reclamation projects (from 2012 to 2016) including development of advanced decontamination technology.

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Keywords：*stabilization, heavy metals, soil remediation*

O70-8

[IDS15] Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Assessment of Trace Elements Contamination in the Gold Mine Soils of Komabangou, Tillaberi, Niger

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Tillabéri region is the main gold mining area in Niger. Modern mining companies and traditional units are installed in several areas. In Komabangou, gold is exploited in the traditional way for decades using dangerous chemicals such as mercury or cyanide. The objectives of this study were to determine the degree of soil metal pollution and to assess the risk to human health. For this, 44 soil samples were collected in Komabangou area and the concentrations of metals such as Al, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Pb and Zn were analysed by inductively coupled plasma-mass spectrometry (ICP-MS). The results showed that the metal concentrations in soils varied widely according to the site and the elements. The average mean concentration of metals in soils followed the order: Fe>Al>Mn>As>Zn>Pb>Cr>Cu>Ni>Co>Sb>Cd>Mo>Hg. Trace element concentrations reached up to 18,832 mg/kg, 45,949 mg/kg 1691 mg/kg, 1317 mg/kg, 1150 mg/kg respectively for Fe, Al, Mn, As and Zn. The concentration of Hg in some soils was higher than 1.0 mg/kg. Fe, Al and Mn are common soil metals which are not particularly at high concentrations. However, Al and Mn solubility might strongly be affected by acid pH due to the use of strong acids (i.e. HCN and H2SO4) in the process. The As contamination is probably linked to the ore extraction as it is present as a significant component in the ore. For Zn, the specific contamination is due to the use of Zn pellets in the metallurgical process for Au recovery from acid ore-leaching solutions. Mercury is also used in the process and its concentration in these soils reaches sometimes 100-fold the background geogenic concentration. For other elements (i.e. Cd, Pb), they are probably associated as trace contamination of the Zn pellets. On most sites, the regulatory limit values were exceeded for at least one trace element. The index pollution values were generally high due to the metals presence in the soil at relatively high contents. This could pose toxicity for plants, animals, and local population. Adjacent soils are being used for agriculture (through irrigation) and the mine polluted materials could contaminate them through hydric erosion or aeolian dust contamination. Therefore the establishment of monitoring and treatment of contaminated soils program would be necessary to reduce human contamination risks by identifying the preferential transfer pathways.

Keywords: *Trace metals, Soil, Risk, Golg mining, Komabangou*

O70-9

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Environmental Assessment of Coal Mine Wastes for in-Pit Disposal of Tailings

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Open cast mining activities produce significant amount of spoils and tailings which need to be deposited to get access to a coal vein. Spoils and tailings can be returned to the mine by in-pit disposal. In-pit disposal of tailings refer simply the process of backfilling of open pit with tailings, which is very attractive to mine operator because of cost benefit and structural stability. However, characterization of tailings should be carefully conducted due to the potential for groundwater contamination around the pit. The major problems caused by tailings are the generation of acid mine drainage, release of saline water and mobilization of heavy metals and metalloids from the breakdown of residual sulfide minerals.

The objective of this research is to assess environmental impacts of in-pit disposal of tailing, especially in relation to the geochemical properties of coal mine rejects and tailings. In addition, potential release of salts and trace elements depending on the mode of disposal was tested. Physicochemical properties of coal mine rejects and tailings investigated include particle size, surface area, pH, electrical conductivity (EC), acidity, total element concentrations and serial batch leaching tests. Statistical analysis using correlation matrix, principal component analysis (PCA) and cluster analysis was performed. Correlation matrix showed that Se-particle size, Fe-S, S-SO42-, EC-acidity, EC-SO42- and SO42—acidity were strongly correlated, which indicates that pyrite is a major mineral controlling salt chemistry in coal tailings. The first component of PCA mainly explains acidity and related salts and the second component mainly addresses trace element concentrations. Based on PCA and cluster analysis, samples required special considerations in in-pit disposal of tailings could be identified. Kinetics of serial leaching showed good agreement with PCA score of samples. Therefore, tailings can be grouped in relation to their environmental risk and managed accordingly when they are disposed in pit.

To reduce environmental risk of in-pit disposal, tailings can be co-disposed. Co-disposal of coarse and fine tailings will reduce the volume of total wastes and produce a more stable deposit. Salt and metal adsorption results showed that benign fine tailings have metal sorption capacity and controls leaching of salts and metals when they are disposed together with tailings having high salts and metals. Column leaching results showed that leaching of salts and metals can be controlled by mode of tailings disposal. Especially, benign tailings placed in the bottom of column could reduce leaching of trace elements by sorption. Hydraulic conductivity of tailings can be used to control water infiltration through the tailings deposited in pit. If tailings with low hydraulic conductivity are placed on the top of the pit, it will prevent water infiltration, thereby reducing reaction of tailings with water. If tailings with low hydraulic conductivity are placed on the bottom of the pit, it will prevent seepage water to flow to ground water.

In summary, for in-pit disposal of tailings geochemical properties of tailings should be assessed first and disposed by layering in pit depending on their properties to reduce environmental risk.

Keywords：*tailings, in-pit disposal, co-disposal, coal, backfill*

O71-1

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Combining Advanced Analytical Methods to Assess Interfacial Change during Bioweathering of Silicates and Sulfides: Mineral-organic-microbe Interactions Alter Bioaccessibility of Toxic Metal(loid)s

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Combining advanced analytical methods to assess interfacial change during bioweathering of silicates and sulfides: Mineral-organic-microbe interactions alter bioaccessibility of toxic metal(loid)s during root growth

During incipient soil formation, infusion of water and plant- or microbially-derived biomolecules affects the rate and congruency ofmineral weathering,as well asthe associated formationof secondary mineral-organic products. We postulate that incongruent bioweathering alters the bioavailability of lithogenic nutrients, toxic metal(loid)s, and organic matter.

In a series of controlledexperiments supported by a suite of advanced analytical techniques, we tested the impacts of mineral-organic-microbe-metal interactions on the chemistries of pore solutions andsecondary precipitates, and on microbial community composition, during plant growth and root turnover in porous primary mineral assemblages. Replicated experiments were conducted in porous media comprising granular silicate rock (basalt, granite, rhyolite, and schist) and mine tailings (sulfide-ore derived).Porous geomediawere subjected to water addition and plant germination/growth in the presence of closely monitored and dynamic microbial consortia. System dynamics were monitored for the experimental time series using a combination of macroscopic (e.g., pore solution chemistry), molecular spectroscopic (e.g., x-ray absorption and fluorescence, Fourier transform infrared), and molecular microbial (e.g., iTag, pyrosequencing, qPCR) methods.

Results reveal that plant growth stimulates biotransformation of mineral solids, thereby affectingmetal(loid) lability and organic matter stabilization. In silicate rocks, controlling major element transformations involved predominantly Si, Al, and Fe, whereasin tailings systems,oxidation-reduction of Fe, S, and Mnexerted strong control. Labile organic matter fueled a heterotrophic microbial consortium that releasedlithogenic nutrients to solution form, but that also promoted formation of secondary solid-phase products that complexed labile organic matter at neo-formed mineral surfaces, thereby diminishing its lability. For example, when primary silicate dissolution supersaturates pore solutionswith respect to colloidal Al-hydroxide, reactive surface hydroxyls are shown to undergo ligand exchange with O-containing biomolecularfunctional groups, stabilizingorganic matter against microbial degradation.Toxic metal(loid)s weresignificantly stabilized in situ duringbioweathering. For example, in metalliferousmine tailings, biological weathering incorporatesAs(V) into neo-formed Fe (oxyhydr)oxides;Pb, Cd, and Zn are sorbedto thermodynamically-stable Mn oxides;and plant transpiration minimizesdissolved contaminant flux to depth.

In sum, disequilibrium imposed by water and carbon addition results in an accretion of neutrophilic heterotrophic microbial biomass, a time evolution of microbial community ecology, and a concurrent time series of inorganic speciestransformations. Growth of organo-mineral precipitates and aggregates affects speciation change of rock-derived nutrients and toxins by adsorption, co-precipitation and hetero-aggregation.

O71-2

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Non-invasive Localization of Organic Matter in Soil Aggregates using SR-µCT

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Knowledge of the location of soil organic matter (SOM) and its spatial association to soil structure is an important step in improving modeling approaches for simulating organic matter turnover processes. Advanced models for carbon mineralization are able to account for the 3D distribution of SOM which is assumed to influence mineralisation. However, their application is still limited by the fact that no method exists to non-invasively determine the 3D spatial distribution of SOM in structured soils. SR-based X-ray microtomography (SR-µCT) is an advanced and promising tool in gaining knowledge on the 3-dimensional organization of soil phases (minerals, organic matter, water, air) which on a voxel level could be implemented into spatially explicit models. However, since the contrast of linear attenuation coefficients of soil organic matter on the one hand and mineral components and water on the other hand are relatively low, especially when materials are finely dispersed, organic matter within the soil pore space is often not resolved in ordinary X-ray absorption contrast imaging. To circumvent this problem we have developed a staining procedure for organic matter using Osmium-tetroxide since Osmium is an element with an absorption edge at a higher X-ray energy level. Osmium is known from transmission electron microscopy analysis (TEM) to stain organic matter specifically and irreversibly while having an absorption edge at approximately 74 keV.

We report on the application of a novel Osmium vapor staining method to analyze differences in organic matter content and identify small scale spatial distribution of SOM in soil aggregates. To achieve this we have taken soil aggregate samples (6-8 mm across) obtained from arable soils differing in soil management. Aggregate samples were investigated by synchrotron-based X-ray microtomography (SR-µCT) after staining the sample with Osmium-tetroxide (OsO4) vapor. We utilized the monochromatic X-ray beam to locate osmium bound to SOM in the stained soil aggregate samples by scanning the aggregates at different photon energies: 30 keV at which the attenuation contrast is optimal for distinguishing other soil constituents, 70 keV (below the absorption of osmium) and 78 keV (above the absorption edge of osmium). The results suggest that particulate organic matter, which was not visibly by scanning samples at energy levels optimal for resolving soil structure (30 keV), was identified after osmium staining and scanning the samples at energy levels just below (70 keV) and above (78 keV) the absorption edge of Osmium. Subtracting the images below from the images above the osmium edged we were able to isolate stained particulate organic matter which otherwise would have been wrongly interpreted as pore space without staining. Combining both pore space and organic matter distribution we are able to investigate the association of SOM with soil structure.

Keywords：*X-ray tomography, synchrotron, soil organic matter, image analysis*

O71-3

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Assessment of the Effect of the Microbiology of the Extreme Soil Surface on Hydrological Properties Revealed by X-Ray Imaging

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The soil surface is a crucial interface where many factors contributing to soil productivity, such as supplying crop water and nutrient needs interact. Many soils have a distinct but thin layer at their surface, referred to as a crust, which can be generated by different mechanisms. A 'physical' soil crust develops due to both the compactive and dispersive energy associated with raindrops impacting the soil surface. This results in aggregate breakdown and the supply and re-organisation of disaggregated soil particles which can form a surface layer (up to 10 mm deep) that is less porous and more compact than the underlying bulk soil. The presence of a physical crust can alter the characteristics of the soil surface by smoothing and sealing the soil surface, thus decreasing rainfall infiltration and increasing the volume and velocity of water runoff. Physical crusts often inhibit plant seedling emergence which can have agricultural, hydrological and environmental effects potentially compromising our food security. 'Biological' crusts also develop, comprised of distinct communities very different in composition to those in the underlying soil matrix. In particular, in arable and horticultural field-based systems the microbial community phenotype in the soil surface zone modulates soil water interactions and structural resilience when raindrops impact the surface.

We have conducted a laboratory study to investigate the ultra-fine-scale spatial and temporal dynamics of structural seal formation in two textural soil types used in horticultural production. To do so, we used X-ray micro computed tomography (CT) to enable a non-invasive and non-destructive 3D quantification of soil structure at high resolution (24 μm). Analysis of the CT images permitted us to track and characterise the dynamics of soil crust development and understand the relative roles that fungi, bacteria and photoautotrophs play in mediating the biophysical properties of the developing soil surface.

Results showed significant variations in porosity between different types of crusts. The pores connected to surface (enabling the exchange of water, gases and nutrient) were discriminated from other types of pores. Their volume varied significantly between the two soil types and was consistently higher in the soil with the higher clay content. Specifically, fungal and photoautotroph dominated systems showed increased porosity, but reduced hydraulic connection, than bacterial dominated systems.

Keywords：*X-ray CT scanner, microbial community , hydology, porosity , soil surface crust*

O71-4

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Microfluidics for Soil Science

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Soil is a mixture of organic remains, clays and rock particles that covers a small fraction of the surface of the Earth. Pores and interstitial sites in the soil have dimensions in the order of micrometers (10-6 m). Hence, soil constitutes a unique micro chemical environment. Some of the key challenges of soil science derive from our inability to fully describe, either theoretically or experimentally, the complex interactions between physics, chemistry and biology that occur at the micro scale. Forces that are negligible in standard macro scale tests might instead be dominant in natural soil settings. As an example, the capillary force is significant at small scales. Similarly, laminar flow conditions (small Reynolds number) are readily observed at the micro scale; in such conditions reaction rates are likely to be limited by diffusion rather than chemical kinetics. In the field of mineral weathering in soils, there exist a long-standing debate on the origin of kinetic rates differences between the laboratories and the field. Such discrepancies might be attributed, at least partially, to mass transfer limitations that exist in the natural soil pores but not in stirred or flow through lab-bench experiments.

Microfluidic is a science of relatively recent development that deals with the handling and manipulation of small amount of fluids in micrometer-size channels. Key features of microfluidic systems include small amount of sample required for chemical analysis, laminar flow conditions as well as the possibility to integrate several chemical operations on a compact and small platform known as the lab-on-a-chip. Microfluidic research is expanding in many areas and now encompasses traditional fields such as analytical chemistry and biology.

To date, soil science has not yet been engaged with microfluidic research. The present contribution discusses some possible applications of microfluidic devices in soil science, highlighting advantages and limitations of this technology. The versatility of microfluidic devices is demonstrated by discussing examples from microfluidic literature. The following topics are specifically addressed from a microfluidic perspective: i) kinetics and mechanism of mineral dissolution (weathering) ii) determination of hydraulic conductivities iii) mechanics of root penetration and iv) soil analysis in extraterrestrial spaces and environments with reduced gravity. It is hoped to create a debate on the use of microfluidics in soil science and to stimulate interactions between the two research communities.

Keywords：*microfluidics, transport phenomena, interfacial chemistry, chemical engineering*

O71-5

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Zn Sorption to Biogenic Bixbyite-like Mn_2O_3 Produced by Bacillus Cua Isolated from Soil: Xafs Study with Constraints on Sorption Mechanism

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Although most reported biogenic Mn oxides are hexagonal birnessites, other types of biogenic Mn oxides also commonly occur in the environment. Compared to hexagonal birnessites, the sorption characteristics and the underlying mechanism of adsorption of heavy-metal ions to those of the other biogenic Mn oxides are still poorly understood. Here, a strain of Mn-oxidizing bacteria isolated from Claypani-Udic Argosols was identified as Bacillus with 16S rRNA sequencing analysis. Characterization of the bacterial Mn(II) oxidation product showed it to be a poorly crystallized bixbyite-like Mn2O3 (α-Mn2O3). The maximum adsorption capacities of the Zn(II) adsorbed onto the biogenic Mn oxide at pH 6.00 and pH 4.00 were 644 mmol/kg and 570 mmol/kg, respectively. The coordination structure of Zn2+ adsorbed onto this biogenic Mn oxide with alternately arranged regular and distorted MnO6 octahedra was investigated by EXAFS. The results showed that at a relatively low Zn2+ loading (153 mmol/kg, pH 6.00), Zn2+ adsorbed onto the biogenic Mn oxide in a tetrahedral coordination by innersphere complexes. Two types of complexes for the adsorbed Zn2+ with the MnO6 octahedra could be distinguished: (1) coordinated with one regular/distorted MnO6 octahedron as a monodentate-mononuclear complex and (2) coordinated with two MnO6 octahedra (two regular, two distorted or a regular and a distorted) as a bidentate-binuclear complex. At a relatively high Zn2+ loading (570 mmol/kg, pH 4.00; 644 mmol/kg, pH 6.00), the Zn2+ was adsorbed in an octahedral coordination and also bonded with MnO6 octahedra by two types of complexes: (1) coordinated with one regular/distorted MnO6 octahedron as a monodentate-mononuclear complex and (2) coordinated with one regular MnO6 octahedron as a bidentate mononuclear complex. This research extends further insights on the formation of biogenic Mn oxides in the environment and the adsorption mechanism of heavy metals onto low-valence Mn oxides with distorted structures. The application of low valence biogenic Mn oxides to efficiently remove heavy metals from water is also shown to be promising.

Keywords：*Biogenic Mn oxide, Mn-oxidizing bacteria, Bixbyite, XAFS, Zn_2+ adsorption*

O72-1

[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Remote Sensing and Geographic Information Systems and Global Soil Partnership Roles in Soil Monitoring

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The existing soil maps in many world countries with different applied methods are highly different, in assumptions, scales spatial, spectral and temporal resolutions. Therefore, producing new maps with taking account the needed harmonization and/or simplification is not possible in a short term while updating, re-sampling, generalization the new soil data and maps can be performed based on remotely sensed data and GIS. But the main question that will be raised is how? Where and When? The application of remote sensing on the one hand and the problem of desertification confusion on the other hand have recently been research topics, but combination of remote sensing and desert is an interesting topic research that has not been widely discussed. In fact, a review of recent achievements in the field of remote sensing in arid regions is needed, because all methods and disciplines related to remote sensing in desert areas have not been reviewed widely yet. Therefore the majority of the research was concerned with arid and semi- arid region. Furthermore, geographic, Hydrologic, Geologic and vegetative perspectives are needed to improve soil monitoring algorithms which is due to the nature of both remote sensing and desert. Therefore, we review and search several important topics critical to remote sensing in arid regions, including, the nature of desert, soil erosion and soil salinity problems, desert varnish, soil surface crusting and etc. We then describe the component of the application of remote sensing in desert; our focus in this study is on evaluating literature in the mentioned field and to reintroduce the successful application of remote sensing to the researchers to categorize the associated research problems.

Keywords：*soil, remote sensing, monitoring, harmonization, important topics*

O72-2

[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Quantification and Visualisation of Dairy Pasture Soil Macroporosity Using a Computed Tomography Scanning Technique

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Soil compaction, caused by dairy cattle trampling, reduces macropores important for root growth and infiltration of water and nutrients. A study was conducted to evaluate the feasibility of an X-ray computed tomography (CT) technique for determining resolution of macropores using three sample sizes. Macropore parameters measured included total number of pores, number of macropores between 50 and 75, 75 and 150, 150 and 300, 300 and 500 and > 500 μm diameter, and pore connectivity. Undisturbed soil samples were collected from two areas within a commercial dairy paddock: a low compacted area (general paddock area) and a heavily compacted area (where stock congregate), using three sizes of PVC tubes (50, 65 and 72 mm internal diameter) at 0-10 and 20-30 cm depths. At each sampling location, samples were taken from four randomly selected points. Cores were scanned using a GE Phoenix v|tome|x x-ray CT system. Images were analysed using a combination of VG studio Max (v2.1) and ImageJ software (including the plugin SCAMP for soil analysis). Soil water contents of undisturbed samples were determined at three matric potentials (-10, -20 -40 and -100 cm) using a ceramic plate bubble tower. Total porosity (TP) was determined using a traditional method as TP = 1-bd/pd (where bd is the soil bulk density, Mg/m3; and pd is the particle density, taken here as 2.65 Mg/m3). Macroporosities greater than >300, >150, >75 and >30 μm diameters were determined using the traditional method as the difference between TP and water contents at -10, -20 -40 and -100 cm matric potentials respectively. The CT scanning macroporosity values were compared with those determined using the traditional method. Practical implications of using soil cores of different diameter for determining macroporosity using the CT scanning method are discussed. Scans are being included into online visualisation products to promote understanding of soil properties and function.

Keywords：*soil compaction, pore size distribution, pore space connectivity, grazed dairy systems*

O72-3

[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Quantifying the Impacts of Land Use Change on Soil Water Movement using Environmental Tracers on the Loess Tableland of China

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Soil water movement in the unsaturated zone plays an important role in the transformation between precipitation and groundwater, and has been reported to be sensitive to vegetation cover. With severe soil and water loss on the Loess Plateau of China, substantial changes in vegetation condition have been detected due to vegetation restoration for soil erosion reduction. Therefore, it is necessary to quantify the impacts of land use change on soil water movement and further discuss its relationships with groundwater recharge. Three vegetation types on the loess tableland, i.e. farmland, grassland and apple orchard, in which the latter two types has been transformed from the first one about 25 years ago, are used to investigate the effects of land use conversion on soil water. After sampling soil water within the depth of 10 m profile, the stable isotope compositions of hydrogen and oxygen and chloride mass balance method are used to qualitatively and quantitatively analyze the soil water infiltration rates under different land use type. Results show that the water contents under three land use types are quite different with gravimetric water content of 15.5%, 17.2% and 20.0% averaged across the whole vertical profile under apple orchard, farmland and grassland, respectively. The soil water contents above 3.8 m fluctuate greatly due to the significant impacts of precipitation and evapotranspiration; however, those below 3.8 m are relatively constant. The vertical distribution of soil water implies that short-term soil water movement is greatly influenced by precipitation in the shallow layers, which has also been proved by the results of the stable isotope compositions of hydrogen and oxygen. Long-term water infiltration rates in the soil profiles quantified by the chloride mass balance method are 19, 28 and 32 mm/year under apple orchard, farmland and grassland, respectively. The conversion from farmland to apple orchard, which is the popular land use changes driven by economic forces in the past 20 years, decreases water infiltration rate by 32%; however, the conversion from farmland to grassland increase water infiltration by 11%. Therefore, land use change has great impacts on soil water movement, and the land use pattern adjustment for the restoration construction should pay more attention to its hydrological effects.

Keywords：*land use change; soil water movement; stable isotopes; chloride mass balance*

O72-4

[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Advanced Method for Quantifying Soil Hydrological Properties in the Laboratory

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A knowledge of soil hydraulic properties—the water retention curve and unsaturated hydraulic conductivity—is required for soil water modelling and for various studies of soil hydrology. Taking measurements using classical techniques is time consuming, the equipment is costly and the results can be uncertain. The evaporation method is frequently used for the simultaneous determination of hydraulic functions of unsaturated soil samples, i.e. the water retention curve and hydraulic conductivity function. Due to the limited range of common tensiometers, all the methodological variations of the evaporation method suffer from the limitation that the hydraulic functions can only be determined to a maximum of 70 kPa. The extended evaporation method (EEM) overcomes this restriction. Using new cavitation tensiometers and setting the air-entry pressure of the tensiometer's porous ceramic cup as a final tension value allow both hydraulic functions to be quantified close to the wilting point. Here, the HYPROP system was selected, a commercial device with vertically aligned tensiometers optimised to perform evaporation measurements. The HYPROP software was developed for recording, calculating, evaluating, fitting and exporting hydrological data. A good match between the results of soil hydraulic functions was shown when those obtained from traditional methods and the extended evaporation method were compared. Systematic deviations were not found. Additionally, soil shrinkage dynamics as well as soil water hysteresis can be quantified. For shrinkage measurements, the HYPROP® evaporative device was modified and combined with a circumference meter. A preliminary investigation confirmed that the sample diameter decreased linearly during evaporation from the bottom to the top. To sum up, recording the perimeter change in the middle position of the sample during drying-out together with the corresponding tension and water content was sufficient to determine (i) the increasing dry bulk density and (ii) the hydraulic functions under consideration of shrinkage in the range between saturation and close to the permanent wilting point. Measurements were carried out on 25 samples different in texture and origin. Taking soil water content measurements on shrinking soils in the field can lead to an underestimation of soil water content differences if the changing dry bulk density is not considered. However, the degree of misinterpretation depends strongly on the soil and its shrinkage activity and ranges from negligible to strong. The unsaturated hydraulic conductivity function was only slightly influenced by shrinkage. The advantages of the presented method are: (i) the water retention curve and the hydraulic conductivity function can be determined simultaneously, taking into consideration shrinkage, with a high resolution over the whole range from wet to dry, (ii) the method and device are simple and robust to use, (iii) little time is required for measurement, between 3 and 10 days, (iv) the functions are described over the whole tension range, using numerous user-defined data points, (v) the evaluation of the soil water content measurement in shrinking soils is improved and (vi) common data models can be fitted to the hydraulic data as well as to the shrinkage data.

Keywords：*Soil hydraulic properties, soil shrinkage, extended evaporation method, HYPROP*

O72-5

[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

A Multifunctional Heat Pulse Probe for Soil Physical Property and Process Assessment

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Soil physical properties as well as transport processes are fundamental to understanding ecosystem function and services within the earths' environment. Estimates of hydraulic- and heat-fluxes are key to describing biogeochemical processes, yet typically require a variety of different sensors or methods of measurement and each would be spatially separated, making detailed observations difficult to accurately assess. A multifunctional heat-pulse probe has been developed that is capable of measuring soil temperature and fitting thermal properties (conductivity and diffusivity) to temperature rise data yielding estimates of soil heat flux and calculated soil water flux, heat capacity and volumetric water content. A novel self-calibration algorithm allows the sensor to determine critical needle spacings in place and at varying water contents. These innovative measurement approaches potentially provide valuable tools for water balance calculations including evaporation rates for separation of transpiration from ET and in addition infiltration rates may be measured providing estimates of deep percolation. Additional measurement capabilities are being explored to further the possibility of obtaining expanded and more accurate point-scale soil property and process assessments.

Keywords：*Soil Physical Properties, Heat Pulse Sensor, Soil Measurement Methods*

O73-1

[C3.2-1] A: Soil Erosion and Degradation on Agriculture Land

Continental Present-Day Erosion Rates in a European Context

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Soil erosion is one of the major drivers of landscape evolution in Europe. However, depending on land use and on the geological and topographical settings, the miscellaneous forms of erosion may lead to very diversified morphological evolution. Moreover, erosion processes may not be continuous within a catchment, and runoff and erosion responses to rainfall events differ in function of the spatial scale of observation. Many of the underlying mechanisms of this scale effect are still unknown and/or not well described. In addition to spatial heterogeneities, erosion processes are also varying depending on the temporal resolution of measurements from the effect of the temporal dynamic of successive rainfall events to more seasonal variations either influenced by climate or anthropogenic land use changes. These spatial and temporal variations interact nonlinearly and are subject to thresholds,underlining the complexity of erosion processes. The objective of this paper is to identify and illustrate these scale effects on runoff and erosion, from the field scale to the river catchment scale in the context of temperate to Mediterranean conditions. The analysis of sediment budgets at different spatial and temporal scales together with simulation studies of prospective scenario of global changes permits to identify some of the dominant processes in the different contexts, and also to distinguish natural from anthropogenic influences.Concerning upland physical soil surface erosion rates, we find that the average travel distance of eroded particles may be limited, implying a strong decrease in physical erosion rates when moving from the local scale (m^2) to the river basin scale (> 103 km^2). Chemical erosion rates are less sensitive to scale and can either decrease or increase with increasing area in function of lithology, anthropogenic land management and topography. The results also highlight the predominant role of surface connectivity to characterize the fraction of sediment exported out of river drainage areas by physical soil surface erosion. For the export of dissolved sediment originating from weathering processes, the catchment physiography and connectivity does no longer play the dominant role. A direct link between soil production rates and exported dissolved fluxes tends to show that, contrary to the suspended particles, which are transport-limited, the dissolved matter seems to be supply-limited.

O73-2

[C3.2-1] A: Soil Erosion and Degradation on Agriculture Land

Mapping Land Degradation at Global Scale, a Reflection

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The article reviews the constraints and methodologies for a global land degradation assessment. It starts with a discussion on the evolving concept of land degradation from a one-dimensional focus on agricultural production to the currently preferred multifaceted approach of ecosystem goods and services (G&S). Yet, a straight forward mapping of G&S degradation at the global level poses various difficulties. First, the different G&S are incommensurable. Second a data inventory shows that no global data sets are available to map the prevailing G&S degradation in a comprehensive way. Concerning data paucity reflections are made on new cartographic data and remote sensing techniques, in view of their potential contribution to provide a global picture of the state of land degradation. Other questions that are raised refer to land degraded by human management or by natural causes; the role of hard data as compared to expert decisions and the problem of defining a time baseline for monitoring. Possible strategies and technical solutions are illustrated, with particular reference to the conceptual innovations introduced by the Land Degradation Assessment in Dryland Areas project.

Keywords：*land degradation, ecosystems services, global assessment.*

O73-3

[C3.2-1] A: Soil Erosion and Degradation on Agriculture Land

Agricultural Water Balance in Korea

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Agricultural water balance was calculated based on the estimation of the input and output elements of the water balance in Korea. The period of the cultivation for paddy rice and upland crops was from May 10 to Sep. 20 and May 10 to Oct. 31, respectively. During the paddy rice cultivation, the amount of precipitation [Rr] was 913.2mm, percolation [Pr] was 1,041.2mm evaluated by the measurement and the weighted area according to soil texture. The amount of runoff [Fr] and submergence [Sr] was 60.6mm and 45.0mm, respectively. The amount of evapo-transpiration [ETr] of paddy field was 992.0mm evaluated by potential evapo-transpiration) and crop coefficient. Therefore, the amount of irrigation requirement [Ir] was 1,225.6mm calculated by the water balance equation. During the upland crops cultivation, the amount of precipitation [Ru] was 1,008.2mm, percolation [Pu] was 188.1mm evaluated by saturation period, saturated hydraulic conductivity and weighted average of area according to the soil texture. The amount of runoff [Fu] was 434.3mm evaluated by modified USLE, named as the E&J model (Eom & Jung, 2013). The amount of evapo-transpiration [ETu] of upland crops was 556.2mm evaluated by potential evapo-transpiration), crop coefficient based on the average of the crops. Therefore, the amount of irrigation requirement [Iu] was 170.4mm calculated by the water balance equation. This study was carried out with the support of 'Research PG (P.No. PJ009870)', R.D.A. Korea.

Keywords：*Water balance, Evapotranspiration, Runoff, Percolation*

O73-4

[C3.2-1] A: Soil Erosion and Degradation on Agriculture Land

Gully Expansion in Agricultural Fields in Andalucia: the Role of Slope Failure and Water Erosion in Relation to Land Management, Cover, and Rooting

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Slope instability and soil erosion are important processes in agricultural fields in the Mediterranean. Orchards often intensively cultivated and strongly affect degrading processes such as slope stability and gully development. Although most research on how vegetation affects erosion processes has been focused predominantly on the vegetation cover, the below ground biomass is at least as important in controlling soil loss on slopes.

This research has focused on analysing how the root systems of crop vegetation affects slope stability and gully development for cereal fields and olive groves in Andalucía, Spain. Two land use types in a hilly environment were studied in which gully systems are very quickly expanding. Root densities, distributions and tensile strengths have been studied for these crop covers, as well soil properties.

The research has revealed that while in the olive site the high spatial variability of the root parameters between profiles was associated mainly with the distance to the nearest tree, at the cereal site this variability was mainly associated with the vegetation health state and with the row-inter-row alternation.

Furthermore, the study has shown that both types of crops have their advantages and disadvantages in dealing with soil reinforcement and erosion processes. Olives have higher root reinforcement values than cereals, but the spatial variability is quite high and they have a tendency to be vulnerable in between the olive rows, the area with the lowest vegetation cover. On the other hand, cereals have a good vegetation cover and a uniform root density in the top soil that gives them an advantage against overland flow. The role of both surface processes and slope stability processes will be discussed as well as the impact of land management for these two contrasting field sites.

O73-5

[C3.2-1] A: Soil Erosion and Degradation on Agriculture Land

Soil Erodibility Model for the Dry Tropics of North-eastern Australia

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Soil erosion has been identified as a major source of pollution threating the Great Barrier Reef in north-eastern Australia. As a result there is demand for soil information over extensive areas of the dry tropics that identifies a soils inherent erodibility. This paper describes the soil erodibility models developed for the Burdekin Catchment, Queensland, Australia. The models aim to provide enough soil information to effectively understand, prevent and manage erodibile soils in the catchment. Because gully erosion dominates and the majority of soils in the study area have a strong texture-contrast in their profile, separate models have been developed for surface soils (A horizon) and subsoils (B horizon). The surface model, categorises A horizons into four categories: stable (1), non-cohesive (2), dispersive (3) and vertic (4). These categories are determined using a hierarchal decision tree with soil texture, soil sodicity and clay activity as inputs. Each of these categories represents a particular soil property or type. This is not meant to be a ranking, risk or hazard assessment; however the number for each of these particular soil properties has been assigned into increasing order of vulnerability. The subsoil model categorises B horizons into four categories: non-dispersive (1), weakly dispersive (2), dispersive (3) and highly dispersive. These categories are determined using a hierarchal decision tree with soil texture, soil sodicity, soil salinity and Ca/Mg ratio as inputs. These categories represent increasing likelihood that the B horizon would disperse if exposed to water. To aid with interpretation of the model outputs, A and B horizon models have been combined into 17 soil groups that can be described as:

• structured non-dispersive soils;
• gradational dispersive soils with structured protective A horizons;
• massive sandy non-cohesive soils;
• texture-contrast soils with massive sandy surfaces over non-dispersive or dispersive subsoils;
• uniform soils that are clayey throughout and either non-dispersive or dispersive
• cracking clays that are non-dispersive or dispersive.

The resulting models reflect the attributes that are significant to soil erosion in the Burdekin catchment. Soil properties not significant in this study area have been left out. This simplicity allows the models to be implemented using quantitative digital soil mapping (DSM) techniques. The models have been develop using empirical relationships between soil properties and a number of measures of erodibility, including laboratory dispersed silt and clay, field dispersion and slaking tests and observations of soil erosion. The models have been found to predict soil type and dispersibility well. Subsequently, the models have been implemented using DSM derived soil attribute surfaces for each input. The derivation of these soil attribute surfaces and the eventual mapping of soil erodibility will be discussed in a separate DSM paper.

Keywords：*soil erodibility models mapping north-eastern Australia dry tropics*

O74-1

[C3.3-4] A: Soil Management Strategy for Enhancing Crop Yields

Are Soil Nitrogen and Organic Matter Contents Declining due to Continuous Application of Nitrogen Fertilizers in Cereals?

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Fertilizer nitrogen (N) applications in cereals rely on the premise that applied N, rather than indigenous soil N supply, is the major source for crop uptake. But it has been found to be inconsistent with considerable evidence obtained from 15N-tracer investigations (Stevens et al., 2005, Agronomy Journal, 97, 1046-1053). With yield based N management strategies, all those factors which promote consumption of N fertilizers, have often been advocated as insurance against the N limitation. So convincing has this rationale been that the input of fertilizer N in intensive cereal based systems is likely to be guided by it for many years to come. On the other hand, fertilizer N use efficiency is governed by uncertainty faced by farmers in deciding the amount of fertilizer to be applied. This uncertainty can be reduced by knowing the N supplying capacity of the soil determined by factors such as soil N and soil organic matter (SOM). But long-term fertilizer experiments (LTFEs) indicate that SOM and total N contents of the soil are changing due to continued application of N fertilizers. Thus SOM and soil N supply as altered by fertilizer N application may dictate the fertilizer N use efficiency.

Maintenance of SOM is an important goal in agriculture, both in terms of soil fertility and increasing the sequestration of atmospheric CO2 in soil. Because of the tight C:N ratio in SOM, sequestration of C requires sufficient N. With growing dependence on fertilizer N, the assertion has often been made that these inputs are a positive factor in maintaining or increasing SOM. After several decades of high-input agriculture, the benefits should be readily apparent from LTFEs but Khan et al. (2007) (Journal of Environmental Quality, 36, 1821-1832) have cited a large number of references which show decline in SOM due to continuous application of N fertilizers. Perhaps this trend has seldom been acknowledged, because N fertilizer practices have been predicated largely on short-term economic gain rather than long-term sustainability. The LTFEs initiated in virgin soils show that cultivation leads to reduced SOM level whereas organic matter additions and fertilization maintain or increase it.

As in the case of SOM, Mulvaney et al. (2009) (Journal of Environmental Quality 38, 2295-2314) have cited several LTFEs involving a wide variety of soils, regions, and tillage practices showing a decline in total soil N due to continuous application of fertilizer N. That mineral N stimulates microbial carbon decomposition, promoting the loss of SOM which serves as the major reservoir of soil N, was cited as the major reason for this trend. Powlson et al. (2010) (Nature, 433, 204-205) criticized the way the data was interpreted, but it was Ladha et al. (2011) (Journal of Environmental Quality 40, 1756-1766) who resolved the controversy - whether fertilizer N application to agro-ecosystems leads to decrease in organic C and N contents or not. Based on data from 114 LTFEs located all over the world, they found that approach followed by Khan et al. (2007) and Mulvaney et al. (2009) does not take into account the changes in organic C and organic N over time when no fertilizers were applied. The absolute change in total soil organic C and N after long-term fertilizer N application as reported by Khan et al. (2007) and Mulvaney et al. (2009) follows the time-response ratio and thus show a decline. However, when the data were analysed following time by fertilizer N response ratio using mixed model, declines of 7 to 16 % in organic C and 7 to 11% in organic N were found with no N amendments but with soils receiving fertilizer N, the rate of SOM loss decreased. The time-fertilizer response ratio approach based on changes in the paired comparisons showed average increases of 8 and 12 % for organic C and organic N, respectively. It suggests that declining fertilizer N use efficiency in cereals is not due to the effect of continuous fertilizer N use on SOM and soil N. Rather uncertainty in quantifying the soil N supply may result in application of fertilizer N doses which are not adequate but excessive thereby leading to low fertilizer N use efficiency.

Keywords：*fertilizer nitrogen, soil nitrogen, soil organic matter, fertilizer N use efficiency, cereals*

O74-2

[C3.3-4] A: Soil Management Strategy for Enhancing Crop Yields

Consider of Non-exchangeable and Exchangeable Potassium Status of Soils under Sugarcane Cultivation in Some Fields with Different Ages

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Depletion of fertile agricultural soils of essential nutrients such as potassium in continuous cultivation becomes a one of agriculture serious problems in developing countries.
Sugarcane is a continuous cultivation in southwestern Iran lands, Potassium uptake by plants and don't use of any potassium fertilizers, in recent years, concerns regarding the lack of this element in the soil and thus reduce the quantity and quality of soil productivity is established in the near future.
Some researchers believe that one of the reasons for reduce in soil productivity in old farms is decrease in soil potassium supply.
This study was designed to investigate the depletion of potassium in soils under sugarcane cultivation, which has different history of cultures and that soils have been compared with similar soils that not cultivated yet.
For these study 300 samples from three Iranian sugarcane Agro-Industrial company (Haft Tape, Karoon and Sugarcane and by Industrials development), that have 40, 20 and 2 years history of continuous cultivation of sugarcane were collected.
These samples have 0-30 and 30-60 cm in depth. Profile locations were chosen randomly so that cultivated soils located adjacent to non cultivated soils.
In each of the soil samples collected from farms in addition to soil physical, chemical and mineralogical properties, soluble, exchangeable and non-exchangeable potassium were measured.
Soluble, exchangeable and non-exchangeable potassium decreased in all soil samples, especially in the non-exchangeable form, soil potassium decrease percentage directly depends to farm cultivation history. These results indicate the important role of non-exchangeable potassium in the sugarcane cultivation.
As percent reduction of non-exchangeable potassium in cultivated fields that have two years history is 22.28%, with 20 years is 43.90% and with 40 years is 73.81%.
These results showed necessary more attention to potassium element in sugarcane farms in order to maintain the quantity and quality of the produced sugarcane in long term and intensive cultivation periods.

Keywords : *Non-exchangeable, exchangeable and soluble potassium, Sugarcane cultivation, Iran, quantit*

O74-3

[C3.3-4] A: Soil Management Strategy for Enhancing Crop Yields

The Influence of Tillage Sistems on Soil Physical Properties and on Oil-seed Rape Yield in Central Northern Area of Moldavian Plateau, Romania

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The effects of cropping systems and management practices on soil properties provide essential information for assessing sustainability and environmental impact. The present experiment takes part from a research study that aims at optimizing rapeseed cropping system for adaptation to biotic and abiotic stresses in 3 Agricultural Research and Development Stations from the central-northern area of Moldavian Plateau, Romania.

The fact of choosing a proper tillage system in a certain area, in rapeseed crop technology should be based on obtaining high and effective yield, conserving and increasing soil fertility in long term. It is known that, in time, conventional tillage affects soil structure quality and nutrient supply available for plants. Also, reducing tillage operations and retaining the plant debris on or near the soil surface – specific traits for minimum tillage, leads to an increase in soil water retention capacity, reduces temperature fluctuations, erosion risk, and improves soil structure, organic matter content, and often the yield. Using minimum tillage also reduces greenhouse gas emissions and global warming, increases carbon sequestration, with up to 40% less time and energy.

The trials are carrying out in three different locations from Central–Northern Area of Moldavian Plateau: Suceava, Secuieni–Neamț county, and Podu Iloaiei–Iaşi county. Their purpose is to establish the effects of tillage on soil properties and yield in oilseed rape crop (Brassica napus L). The experimental design has three factors (A x B x C type): A factor – location (Agricultural Research and Development Station of Suceava, ARDS Secuieni-Neamț county, ARDS Podu Iloaiei-Iaşi county); B – soil tillage (moldboard plough – MT, chisel – CT, disc-harrow – DT); C - with 50 graduations representing 50 oilseed rape cultivars commercialized in our country by 10 companies.

From august 2010 we are studying the evolution of soil bulk density (BD), total porosity (TP), compactation degree (CD), aggregates water stability (WS) and their mean weight diameter (MWD) as influenced by tillage treatments in all three locations mentioned above. Soil samples were taken before tillage operations, right after sowing and before rapeseed wintering. In mid july all 450 plots from each location were harvested using a small combine (Wintersteiger Classic) and yield per plot was assessed using an automated weighing sensor system (GrainGage HM800, Junyper Systems) mounted on the combine.

The soil physical parameters are strongly affected by tillage. A structured and loosened topsoil should be created by tillage, for easy access of air and water to germinating seeds and to developing root system. The disc harrow tillage reduces soil physical quality, leads to structure deterioration and loosens the soil only up to 8-12 cm depth. Accordingly, the root system do not optimally explore more profound soil horizons. On the other side, the use of chisel reduces the impact of tillage on soil, and modifies less MWD and WS. The quality of plowed soil is better than disc harrow tilled soil, but lower than chisel. The forming plowpan, and the partial destruction of soil aggregates in contact with the mouldboard are eliminated by using active bodys that are loosening the soil more in-depth without incorporating the superficial layer. The differences between tillage treatments concerning BD, TP, WS, and MWD were significant in rapeseed seeding. In time they have lost their significance because the soil tends to revert to the state before tillage, and because of the relatively high amount of rainfall during this period. The effect of tillage on rapeseed yield was significant, and the best treatment in terms of productivity was MT. The differences ($p \leq 0.05$) between MT and CT were significant in 1 of 4 years and for the entire period. MT and CT were significantly superior to DT in all years. The effect of cultivar on rapeseed yield was significant only in the first year of research, when the differences within the same company were statistically ensured ($p \leq 0.05$) in 8 out of 10 cases.

Current expansion of oilseed rape production in Central and Eastern Europe with low rainfall and high seasonal temperature variation face up farmers with the emerging problem of selecting productive and resistant cultivars for adaptation to such climatic conditions, and the proper cropping system in terms of sustainability and productivity.

Keywords：*soil tillage, soil compaction, soil structure, oil-seed rape yield*

O74-4

[C3.3-4] A: Soil Management Strategy for Enhancing Crop Yields

Soil Nutrient Diagnostics using Mid-infrared Spectroscopy

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Current research data suggest that several soil physical and chemical properties can be successfully predicted using mid-infrared spectrometric techniques (MIRS). While technical advances have made portability of the MIRS technology possible, improvements in statistical robustness have increased the confidence in the soil property predictions. The MIRS and the near infrared spectrometry (NIRS) have their own advantages and limitations. Recent studies determined that the NIRS was better for predictions of soil biological properties and the MIRS was better for physical and chemical properties. In order to understand the transferability of such predictions, fifty surface soil samples from north central and south Florida, USA, representing the five major soil orders- Ultisols, Alfisols, Spodosols, Entisols and Histosols- were scanned in the CSIRO laboratory at the Waite Laboratories, University of Adelaide, Australia using the MIRS for soil texture, pH, extractable phosphorus, calcium, magnesium, water content, carbon and nitrogen and microbial size and activity. The data from the MIRS scans is presented with statistical predictability ratings relative to wet chemistry and standard laboratory analytical data. The prediction data has to be validated and field calibrated in the long run in order for MIRS to be adopted as a standard procedure for soil nutrient diagnostics and nutrient recommendations.

Keywords：*Mid-Infrared Spectroscopy, soil nutrients, remote sensing, non-destructive sampling*

O74-5

[C3.3-4] A: Soil Management Strategy for Enhancing Crop Yields

Agronomic Assessment of Cover Crops in Illinois

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Recent interest in winter cover crops in the Midwest region has been gauged by sales promotions from companies who sell cover crops seeds and services and also by educational and promotional efforts that tend to emphasize the benefits of this practice generating a significant gap between these 'great expectations' and the results observed by farmers. Though the potential benefits from winter cover crops are multiple, the realization of that potential is highly dependent upon agronomic management, length of the growing season, plant species, soil type, and weather conditions among other factors. Failure to meet these high expectations in the near future could cause frustration and thus be detrimental to the long term cover crop use. Presentation will discuss pros and cons of cover crop use, general management strategies, incentive programs, on-going research and future needs to address the information gap in Illinois.

O75-1

[C4.5-2] Cultural Perspectives on Soils and Soil Science

Gods of Soil

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The gods of soil or earth can be found in many civilizations. This paper will discuss a couple of gods of soil in the Chinese culture. The first is Yu the Great (大禹) which was attributed for making the first soil map around 2000 BC by several authors. However early Chinese dynasty is usually filled with mythical figures. Yu is a demigod that was an emperor and founder of Xia dynasty in China (around 2100 BC). He is famous for controlling the great flood in China, and used a divine substance self-expanding soil 息壤, which is capable of self-regeneration. Later Yu is able to channel the water to form irrigation, allowing the flourish of agriculture in China. Yu's "soil map" was recorded in a 26 paragraphs chapter of the Book of History (around 500 BC), titled The Tribute to Yu (Yu Gong). It described Yu's accomplishment in dividing the world into (mythical) nine provinces within the four seas. He was said to travel over numerous mountains and lands, charting land, topography variation (the first topography map), and quality of soil, names of local tribes, their sources of revenue, and articles of tribute. So Yu classified soils to determine the tax quota.

"Between the Ji and the He was Yan Zhou. The soil of this province was blackish and rich; the grass in it was luxuriant, and the trees grew high. Its fields were the lowest of the middle class. Its contribution of revenue was fixed at what would just be deemed the correct amount; but it was not required from it, as from the other provinces, till after it had been cultivated for thirteen years. Its articles of tribute were varnish and silk, and, in baskets, woven ornamental fabrics."

As noted by Anne Birrell (1993) while the record has some actual locations, most were mixed with mythical names and locations, making it a mythical geography.

The ancient soil god is known as She 社, one of the most important deities associated with agriculture and fertility. The word "She" is a combination of altar and soil, with evidence of worship as far as the Shang dynasty (1500 BC). In later times, the god of soil is worshipped together with the god of grain, Ji, together known as She Ji 社稷, a combined patron deity of soil and harvests. However the supreme god She Ji is only worshipped by the emperor or high officials. For common people, the god of soil is more popularly known as Tu Di Gong (土地公) literally means Grandpa Soil. Its existence is recorded in the early Han dynasty (around 141-87 BC). Rather than the god, Tu Di Gong is a local god, which symbolised the agrarian-based community. He is still a popular deity and can be found today in many places in China, Taiwan and South East Asia. Tu Di Gong is considered to have a lower position in the world of gods with limited power, but a humble, friendly guardian of nature, agriculture and land. Tu Di Gong is also known as Hou Tu (后土 or the Earth deity), or Di Zhu Gong (lord of the land) can be found nowadays as small shrines, commonly located on the ground. Alessandro Dell'Orto considered that TuDi Gong functions as an anthropologist, as a witness, and recorder of events occurring in the places where he was placed, similar to soil recording history of human and environment.

Keywords：*gods, fertlity, culture, mythology, soil map*

O75-2

[C4.5-2] Cultural Perspectives on Soils and Soil Science

Soil and the Development of Agricultural Systems in South Korea since the Neolithic

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This paper addresses two aspects related soil and past agriculture in geoarchaeological research. One is soil conditions for ancient and historical agricultural practice and its management techniques over time to alter soils and its consequences. Role of soil and long-term changes regarding three forms of cultivation modes, slash and burn agriculture, dry cropping and paddy field, are examined. The second is to understanding the interaction between local soil conditions and various modes of agricultural practice, which plays a role to determine localized agricultural system and its long-term sustainability.

During the Neolithic, the cultivation mode remains questioned but slash and burn cultivation and dry cropping of millets are assumed, hinted by the recently excavated Neolithic field, Munam-ri site. Through soil analyses on the prehistoric dry field soil and ethnographic record regarding Korean indigenous slash and burn agriculture, the climatic conditions, vegetation types and role of soils for prehistoric dry cropping and certain modes of swidden agriculture appears to have been plausible but its sustainability is in question. Possibility of reduced fallow cycle and presence of various manuring schemes is also assumed, but their intensity is not known.

In Bronze Age, commencement of wet rice cultivation had begun and spread all over the Korean peninsula. Wetland and reclaimed lowland were used as rain-fed paddyfield, and advanced irrigation canals and reservoir were discovered in few archaeological sites. 50% of Bronze Age paddy field locales were also used as historical and modern paddyfields as well. However, the irrigation scheme and cultivation techniques changed as well as local hydrological regimes, which highly influenced the development of paddysoil as an anthroposol. The soil micromorphological and geophysical and geochemical analyses including ICP-AES, EDX and microprobe at two Archaeological sites, Gulhwa and Pyunggeo sites suggests evolution of paddysoil over time. It shows that Bronze Age paddysoil had been subject to the mechanical disturbance with common redoximorphic processes, but historical and modern paddysol are physically and chemically altered by intensive hydrolysis in association with development of rice farming techniques advanced over time.

Based on results of such soil analyses applied to archaeological research, potential and limitations of soil research in reconstructing past agricultural practice will be discussed.

Keywords：*soil, agricultural system, slash and burn cultivation, evolution of paddy soil, dry cropping*

O75-3

[C4.5-2] Cultural Perspectives on Soils and Soil Science

The Soil Legacies of 18th and 19th C Illicit Scotch Whisky

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Whisky has an important place in both the national identity and economy of modern Scotland (£ 4 billion / year GVA). Traditional Scotch whisky is made from malted barley and its manufacture involves multiple processes including malting, mashing, fermenting and distilling.

The rise in popularity of whisky in Scotland coincided with a boom in illicit whisky production in response to increased taxation and still regulation. However, although illicit whisky is mentioned frequently in literature, historical texts and court documents there is little documentary evidence concerning the organisation of the processes involved, and the part it played in local Scottish economies and social structures. Indeed, there has been a systematic romanticising of the industry in Scottish folklore. Getting to the truth of this trade is difficult as due its illicit nature there is little direct documentary evidence and still sites were concealed, either in remote locations in the highland glens, or in domestic and other unlikely locations, beneath the excise men's noses. As such the archaeological remains are also scant. However, there are potentially important lessons to be learned relevant to contemporary black market economies.

This study attempts to explore and understand the history of illicit whisky production in Scotland through its chemical and physical soil legacy. GIS analysis, multi-element soil analysis, soil characterisation and magnetic susceptibility have been used to explore the chemical pollution legacy of 18th and 19th Century whisky production in highland Scotland. The aim was to determine whether chemical soil legacies could be used to identify evidence of the whisky producing history of these sites and elucidate the nature and organisation of the production process.

The sites investigated to date include the supposed site of the famous legal Ferintosh distillery in Ross-shire, possible late 18th C illicit still sites in Strathconon Valley and Arran, remote highland areas both renowned for illicit whisky production, and a domestic barn in a pre-clearance settlement at Caen, Sutherland, which may contain the remains of in-situ distilling apparatus.

Promising results from the soil chemistry and magnetic susceptibility appear to confirm distilling activity at some of these sites and in some cases has helped to locate the still position. GIS analysis has also helped identify remote still locations in Arran based on proximity to resources, view sheds and transport links. However, further research is required to identify more subtle clues as to other parts of the process such as grain procurement, malting, mashing, fermenting, and distribution to unlock the more complex stories attached to this historically important black market activity.

Blackett, G. (2012) Contribution of the Scotch Whisky industry to the Scottish Economy. BiGGAR Economics.

Keywords：*soil legacies, illicit whisky, Scotland*

O75-4

[C4.5-2] Cultural Perspectives on Soils and Soil Science

The 'Living Soils' Project - Journey into the Earth

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Approach to a secret dimension of life by building bridges between sciences, fine arts, cultures and education

With its incredibly wealthy and diverse inner life the pedosphere forms a 'Critical Zone' whose mechanisms maintain the global equilibrium between hydrosphere, biosphere, lithosphere and atmosphere. Soils enable life on earth! - The 'Living Soils' project is a transdisciplinary model for education, research and design aiming to impart knowledge and understanding of the complex structure of living soils.
The starting point of our journey is the relationship of humans and soils from the archaic myths of humanity leading to today's age of globalisation and climate change. Soils are a merging world of phenomena and of life in dimensions and processes on a scale reaching beyond human life and comprehension. Against this backdrop, coordinates for a sublime approach to living soils are illustrated enhancing awareness and creating sustainable responsibility for humans managing soils and shaping life in innumerable scenarios.
The following subjects outline the general ideas of our contribution in three parts:
Soils - Basis for creating sustainable values by individuals and society
The relationship of humans and soils is fundamental. Each civilisation’s approach to soils is determined by contextually developed patterns of orientation. Thus the conception of humanity and world derived from the individual understanding of nature and culture shape values, on the basis of which we interpret the world. In view of an almost infinite diversity of human identities and systems in our globalised society the question arises whether there is a resilient basis for supporting the development of individual and societal values. In this sense the goods and services generated by soils are existential.
Soils - Experts for modelling dynamic complex systems in time and space
The diverse and complex relationship between living organisms and the phenomenal world occur as dynamic processes in space and time. The geographic location as well as geological, biological and climatic conditions play an equally important role as human beings. The pedosphere with its highly sensitive microbial life is the essential driving force for sustaining the biosphere. The concurrence of all life processes involved and their interaction constitute the basis for a holistic quality of life. This interplay is characterised by processes of self-organisation following universal principles.
Soils - Source for bridge building between nature and technology
A beneficial dialogue between nature and technology is based on the recognition and understanding of natural processes and their significance for diverse manifestations of life. The interface between nature and technology forms a creative potential for bridging ecology and aesthetics and its own quality and beauty. This can be perceived as an essential element of ecological aesthetics inspiring philosophy and fine arts to enter unknown territory. Human beings, as mediators in this dialogue, can experience themselves as a part of nature and so become aware of their role and responsibility in shaping culture in harmony with nature and technology.
The 'Living Soils' Project - Journey into the Earth is conceived as an itinerary for laying the foundation and raising awareness of a culture (Latin cultura “cultivation”, derived from “cultivate, worship, till, farm”) of soil, a limited resource that must be protected. The concept expands economic, ecological and social aspects of a sustainable approach to our precious base of life to include cultural-aesthetic and cultural-ecological dimensions, thus promoting the development towards a culture of sustainability.

Keywords：Building bridges between soil science, fine arts, culture and education; , Enhancing consciousness for the holistic cultural dimension of soils;

O75-5

[C4.5-2] Cultural Perspectives on Soils and Soil Science

Developments and Departures in the Philosophy of Soil Science

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Traditional soil science curriculums provide comprehensive instruction on soil properties, soil classification, and the physical, chemical, and biological processes that occur in soils.This reductionist perspective is sometimes balanced with a more holistic perspective that focuses on soils as natural, interactive, and vital components of the earth's terrestrial ecosystems. In western culture, all science was once considered a single field of study, which was termed philosophy. This arrangement was consistent with the most inclusive definition of philosophy, i.e. the pursuit of wisdom (philosophy = lover of Sophia, the Greek goddess of wisdom). In the 19th century however, science and philosophy began to disconnect into mutually exclusive fields of study. The social and natural sciences, chemistry, physics, and medicine became disciplines within science while logic, aesthetics, ethics, metaphysics, and epistemologycame under the sphere of philosophy.Today, science and philosophy remain on largely divergent paths with only limited or infrequent interaction, usually restricted to specialistsparticularly interested in this relationship. One notable exception relevant to soil science began in the mid 20th century with publication of Aldo Leopold's The Land Ethic. Leopold proposed that there were ethical principles that applied to soil that should affect how we treat soil resources. This view represented a sharp contrast with the prevailing position that ethical treatment is reserved for living, sentient beings. Leopold was influenced by the writings of an eccentric Russian mystic named P.D. Ouspensky'swhose book TertiumOrganum, proposed 'A living and rational universe'. The concept of soil as a living entity was followed on by Rene Dubos in The God Within and ultimately James Lovelock with The Gaia Hyphothesis. Each author supported a much more holistic view of the earth and soil where everything is connected and distinctions between 'living' and 'nonliving' and their relative value are much less clear or important.This world view presents an opportunity to take acloser look at the philosophy of soil science and soil scientists beyond the now established field of environmental ethics. Philosophy of soil science in thepresent context, referring to thefundamental beliefs, concepts, and attitudes of the profession, will be explored.

O76-1

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Release of K from Silicate Rock Powders

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In view of their relatively high price and limited geographical availability, there is a need to identify alternatives for farmers who find conventional K fertilizers inaccessible. Alternatives such as K silicate minerals, which are widely available with grades up to 16% K2O, exist, but have yielded mixed results in previous trials (Harley and Gilkes, 2000; Manning, 2009; Sanz-Scovino and Rowell, 1988). In this paper we present a protocol for experimental leaching that enables different rock materials to be compared, and the results of carefully designed growth experiments using leeks (Allium ampeloprasum) that demonstrate the effectiveness of specific K silicate minerals. Combining the two experimental approaches allows the mechanisms of K release to be understood. We have developed a standard batch and sequential leaching protocol intended to provide a rapid initial screening tool to compare the effectiveness of different silicate rock powders for plant nutrition. The protocol uses acetate and citrate pH buffer solutions, over the pH range 4-7, as these anions are: (i) representative of the most common rhizosphere exudates which minerals will directly interact with in soil, (ii) constituents of dissolved organic matter in soil solutions, (iii) known to enhance monomineralic K solubility. Observed dissolution mechanisms and rates differ between K bearing mineral sources such as microcline, biotite and nepheline syenite, with specific surface area being an influential factor. These tests provide data for the release of a range of elements, so that the ability of a crushed rock to release other essential nutrients for plant growth (e.g. P), or undesirable soil and plant contaminants, can be determined.
In addition, we have carried out growth experiments with leek as a model plant, using equivalent K applications in the form of KCl, microcline, nepheline syenite and biotite, in both artificial and natural soils. We show that leek growth with biotite provides statistically similar results to corresponding treatments with KCl.
Our experimental work has allowed us to make novel comparisons between K release in artificial and natural environments. The results strongly indicate that chemical assays, or laboratory-determined dissolution rates, may significantly underestimate the availability of plant nutrients from rock flour fertilizers once in the soil system. Thus, leaching release rates give a pessimistic assessment, and can be used as ‘a worst case scenario’. It appears from our work that growing plants can access a K reservoir that the chemical assays do not, and that K bearing minerals show promise as alternative fertilizers.

In addition, we suggest that comparison of macroscale plant growth trials to leaching release rates may provide an indication of natural dissolution processes at microscale of monomineralic crushed rock grains. For instance, enhanced K yields are consistently observed in citrate buffers suggesting that multidentate organic root exudates may play a role in enhanced K release in soils. This work contributes to developing a mechanistic understanding of how plants access K from silicate minerals, aiding alternative rock fertilizer development and design.

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Keywords：*Potassium, Potash, feldspar, crushed rock, fertilizer, rock powder, leaching, plant nutrition*

O76-2

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Potassium Release from Feldspar Powders: from Structure-property Assessment to Leaching Experiments

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The global demand for key nutrient fertilizer keeps increasing with increasing world population. In 2015, the annual global consumption of potash is predicted to exceed 30 million metric tonnes. Many regions in the world including Africa, Latin America, South Asia, East Asia, Central Europe, and Oceania have negative potash balances, compromising their ability to grow crops and feed the world population. A scalable route to exploit the potassium contained in earth abundant rock-forming minerals could therefore be of great interest for countries without access to traditional sedimentary potash resources. After a systematic materials characterization of syenite samples representative of a single geological site, a series of batch and flow leaching experiments have been conducted to assess the material performance as a source of potassium in soil- and crop-free conditions. Time resolved experiments were performed to understand the leaching behavior, rate controlling factors, reaction mechanisms, and structure-property relationships of the as-ground material. These fundamental results are used as a baseline scenario, in order to assess the suitability of such approach for fertilizing applications as well as provide guidelines for potential materials processing.

Keywords : *fertilizer, stonemeal, processing, minerals leaching, feldspar*

O76-3

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

The Enigma of Potassium Availability in Vertisols

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Most Australian soils are considered to contain adequate levels of potassium (K). However, historically high removal rates from crops such as silage maize, lucerne hay and cotton have depleted soil K pools. In a recent audit a negative K budget was reported for many areas and cropping systems in Australia. The frequency of occurrence of K deficiency is increasing, particularly in cotton and maize growing regions, and in some instances plant growth has not responded to moderate K applications. This study was undertaken in order to investigate the effect of soil depth and mineralogy on the response of maize and K dynamics in soil following K fertilisation. Soil samples were taken from 2 depths (0-10 cm, 10-30 cm) from 4 sites (Vertisols) in northern NSW for use in a glasshouse trial. K treatments of 0, 100, 200 or 500 mg/kg K were applied in a randomised complete blocked design with 4 replications. Three maize crops were grown in each pot for 7 weeks per crop. At each harvest shoot dry matter yield and K concentration were measured. Following the final harvest, exchangeable and non-exchangeable fractions of K were measured. The original soil samples were analysed for general soil properties, mineralogical properties by X-ray diffraction, different forms of K and quantity intensity characteristics.

The results obtained showed definite stratification of K between the surface soil and subsoil. There was no shoot yield response to applied K despite an increase in K uptake. Topsoils from sites with clay fractions dominated by interstratified smectite were more likely to fix K, while all subsoils had the capacity to fix K when high levels were applied. We suggest that non-exchangeable K pools, which slowly replenish exchangeable K pools, have been severely depleted by continuous K removal. The selectivity of these non-exchangeable sites has led to the fixation of applied K in the soils studied, where it is not immediately available for plant growth. The degree of K fixation and release from non-exchangeable sites varied for soils from different sites and for the same soil at different depths. Potassium dynamics in soils from different depths and sites will be discussed in the presentation.

Keywords：*Vertisols, K fixation, K dynamics, non-exchangeable K, available K*

O76-4

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Dissolution and Release of Silicon from Diatomaceous Earth and Its Effect on Rice in Acidic, Neutral and Alkaline Soils of South India

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Diatomaceous earth (DE) also referred as Diatomite is a sedimentary rock that results from the deposition of Si rich unicellular life forms known as diatoms. Diatoms are aquatic algae and found in both salt and fresh water. Fresh water DE deposits are rich sources of Si and thereby its evaluation in agriculture is gaining importance. Rice being a silicon accumulator plant, information on the use of DE as a source of silicon, extent of their usage, their effects on growth and yield and other parameters is not yet reported. Hence, an incubation and a pot culture experiment was carried out to know the dissolution of DE in acidic (pH 4.48), neutral (pH 6.51) and alkaline (pH 8.86) soils at different levels (0, 150, 300 and 600 kg/ha under field capacity and submergence moisture regimes. Incubation study was conducted for six (7, 15, 30, 60, 90, 120 days after incubation (DAI)) intervals and pot culture experiment was conducted for two (60 and 120 days after transplanting (DAT)) intervals. Findings revealed that moisture regime and graded levels of DE significantly influenced the pH of acidic and neutral soil. Soil pH was higher under submergence condition compared to field capacity moisture regime irrespective of application rates of DE. Pronounced increase in pH of incubated soil was observed at 120 DAI and attained near to neutral pH in acidic soil. However, there was no significant increase in pH with the application of DE material in neutral soil. In general, there was increase in the pH of both acidic and neutral soils irrespective of application rates of DE material under both the moisture regimes. There was a significant decrease in the pH value under both the moisture regimes in alkaline soil. Increase in Plant Available Silicon (PAS) was observed at 30 DAI in acidic and neutral soil whereas highest was observed at 15 DAI in alkaline soil. Irrespective of application rates of DE there was decrease in PAS at 90 DAI in all three types of soil.

In pot culture experiment, there was a significant increase in the plant growth parameters with the application of graded levels of DE along with the recommended dose of fertilizer (RDF) in three types of soil under both the moisture regimes. There was a significant influence of moisture regime on plant height of rice in three types of soil irrespective of application rates of DE. The higher plant height and biomass was recorded under submergence than field capacity irrespective of DE treatments. In all the three soils, there was a significant variation in the number of tillers with the application of DE under both moisture regimes. The most conspicuous differences were recorded from 60 DAT till harvest. Plants grown under submergence recorded more tillers than field capacity. There was significant increase in the straw and grain yield and yield attributes (number of panicle per pot, panicle length, panicle weight) with the application of graded levels of DE along with the RDF in all three types of soils under study. Application of 600 kg DE per ha along with the RDF increased the yield and yield attributes of crop grown in soil under submerged condition compared to field capacity moisture regime. There was significant increase in the silicon content of grain and straw under submergence condition than field capacity moisture regime. Application of 600 kg DE per ha along with RDF significantly increased the straw and grain silicon content and its uptake from all the soils. The PAS of post harvest soil samples were on par among the treatments and found to decrease in the soils treated with DE and RDF compared to absolute control and plants grown with the application of only RDF in all the three types of soil. The PAS in post harvest soils decreased in acidic, neutral and in alkaline soils with the application of 600 kg DE per ha + RDF compared to control under both the moisture regimes. This study revealed that there is positive effect of DE on growth and yield of rice in different soils and need to exploit its usage in different crops and soils.

Keywords：*Diatomaceous earth, Diatomite, Silicon, Rice, Moisture regime*

O76-5

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Fertilizing Ferralitic Soils in Cameroon using Basalt Powder from the Cameroon Volcanic Line: an Application with Maize Farming in South Cameroon

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An evaluation of the fertilizing potential of pyroclastic basalts from the Cameroon Volcanic Line in the Mbos and Noun of plains were carried out through their petrographical and geochemical study and field tests for maize Zea Mays) farming on ferralitic soils formed on gneissic rocks in equatorial south Cameroon (Yaounde area). Petrographically, The Mbo plain basalts are trachy-basalts (Ekoh cone) and trachy-andesites (Ndon cone) with similar microlitic and vacuolar texture and constituted plagioclases, olivine, basaltic hornblende, opaque oxydes. In the Noun plain, basalts are of microlitic porphyritic texture (Mfeusset cone) and microlitic texture (Pouolom cone). Vacuoles are a common structure in Noun plain basalts and the mineralogy is formed by plagioclases, augite, olivines and opaque oxydes. Great amounts of glass (30%) exist for all studied basalts and petrographical difference in both regions is the restriction of basaltic honblende and augite in the Mbos and Noun plains respectively. Mother rock in the farming area is the garnet-bearing Gneiss. Geochemically, basaltic rocks are alkaline and sodic; rocks from the Mbo plain are more acidic (SiO2 = 50.35 wt %) than those of the Noun plain (SiO2 = 46.13 wt %) and SiO2 content of the gneiss is 61.98 wt %. Field tests concerned additions of 150g, 300g and 450g of basalt powders to plots of 0.25 m2 and revealed a noticeable increasing pH (5.2 to 6.4) in the soil during the early stages of growth of maize plants. Parameters such as leaves lengths, weight of dry biomass, weight of maize cobs, corn kernels weight were recorded at harvest. The results indicate the average output with respect to the cultivated surfaces 1.28 t/ha, 0.36 t/ha, 0.28 t/ha, 2.855 t/ha for Ekoh, Ndon, Pouolom and Mfeusset basalts respectively and 0.274 t/ha for the zero % powder plot.

Keywords：*Rock fertilizers, basalts, ferrallitic soils, maize, cameroon*

O76-6

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Influence of Cropping Practices on Clay Mineralogy: Insights from the Morrow Plots Experimental Fields

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The Morrow Plots were established at the Urbana campus of the University of Illinois in 1876 to answer agricultural questions. They are the oldest agronomic experiment fields in the United States with a recorded history of cropping practices (systematic monoculture, crop rotations, fertilization, etc…). The exceptional series of samples available thus represent a unique opportunity to investigate both short- and long-term influence of cropping practices on the status of potassium, an essential plant nutriment. As clay minerals represent, together with K-feldspars and micas, a major reservoir of potassium potentially available for plants their mineralogy is likely to be impacted by potassium uptake resulting from plant growth.
In 2012, top soils were sampled from four plots representing continuous corn crops with and without fertilization (CC_F and CC_NF, respectively) and corn-oats-fodder rotations with and without fertilization (CR_F and CR_NF, respectively). The clay size fraction of the samples was sub-fractionated, and 2.0-0.2 μm, 0.2-0.05 μm, <0.05 μm sub-fractions were separated and X-rayed in their Ca-saturated form. X-ray diffraction (XRD) patterns were simulated using a trial-and-error approach both to determine structure models for discrete and mixed layer contributions, and to quantify their relative contributions.

Discrete chlorite, kaolinite, and chlorite are present in all samples together with randomly interstratified illite-expandable (ill-exp), kaolinite-expandable (kaol-exp), and chlorite-expandable (chl-exp). Logically, the relative content of discrete minerals decreases with decreasing size fraction for all samples, chlorite being systematically absent in the finest fractions. In all samples, illite and ill-exp dominate the 2.0-0.2 μm fraction with 66-71%, the global proportion of these two contributions decreasing to 38-45% in the 0.2-0.05 μm fraction, and to 27-29% in the <0.05 μm fraction. Simultaneously, the relative proportion of kaol-exp increases from 9-17% in the 2.0-0.2 μm fraction, to 33-49% in the 0.2-0.05 μm fraction, and to 61-64% in the <0.05 μm fraction. The chl-exp contribution decreases only slightly with decreasing size fraction from 10-16% in the 2.0-0.2 μm fraction to 7-9% in the <0.05 μm fraction. The proportion of chlorite layers in chl-exp systematically increases in the sequence CC_F<CC_NF<CR_F<CR_NF, whereas no systematic trend is observed for kaol-exp.

The behavior of illite and ill-exp contributions is most relevant with respect to the fate of K in these soils. Although when considered globally these two contributions are similar for each fraction of the different samples, there is a major difference between CC and CR plots however. The 2.0-0.2 μm fraction of the latter samples is dominated by illite (38-43% compared to 28% of ill-exp), whereas ill-exp dominates in CC samples (45-49% compared to 21-23% of illite). The contrast between CC and CR samples is less pronounced for finer fractions, although the composition of ill-exp differs in the 0.2-0.05 μm fraction between the two sample sets with 27-28% and 48-52% of illite layers in ill-exp in CC and CR samples, respectively.

Illite thus appears most degraded, and possibly transformed to ill-exp, in continuous corn plots compared to crop rotation ones. This effect is enhanced when size fraction is decreased likely owing to the increased specific surface areas of the finest fraction which promotes K uptake by plants. The increased corn yield induced by fertilization favors also the degradation of illite and the formation of ill-exp. Formation of kaol-exp appears as a major process in these soils and kaol-exp systematically dominates the finest size fractions of all samples.

Keywords：*K-speciation, clay mineralogy, mica, mixed layers, X-ray diffraction, cropping practices*

O76-7

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Weathering of Palygorskite in the Rhizosphere of Rapeseed

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Weathering and the changes in the composition of a sedimentary palygorskite sample and a palygorskite dominant soil were investigated in the rhizosphere of rapeseed using the factorial experiment by a acompletely randomized design with three replications. The ability of plant to absorb magnesium ,plant dry weight, and soil available magnesium were also studied. The plants were grown in 1 kg pots under greenhouse condition. Pots were filled with a mixture of quartz sand as filling material and sedimentary and soil palygorskite as different treatments. After 3 and 6 months, the plant biomass were measured. Plant Mg uptake and soil available Mg were measured by atomic absorption. XRD and XRF analyses confirmed the weathering of soil and sedimentarty palygorskite. Appearance of the smectite peak in the XRD patterns at the end of the growth, and the disappearance of palygorskite, confirmed the smectitization of palygorskite. The dry weight, soil available Mg and Mg uptake were higher in sedimentary palygorskite treatments with complete nutrient solution.

Keywords：*Palygorskite, Smectite , Rhizosphere , Weathering*

O77-1

[C2.2-3] A: Behavior and Fate of Pollutants Entering the Soil Environment

Dissolved Organic Matter Induces the Mobilization of Arsenic in Soil

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In this work, the effects of dissolved organic matter (DOM) on the reduction, and subsequent mobility and bioavailability of arsenate [As(V)] was examined using both spiked and field contaminated soils. The DOM-induced mobility and bioavailability of As(V) were examined using leaching, earthworm, and soil microbial activity tests. DOM addition increased the reduction of As(V) both in the spiked and field contaminated soils. DOM also increased the solubility of both As and Fe in the soil treated with increasing levels of goethite. DOM addition decreased microbial activity but increased As concentration in the earthworm tissue. DOM-induced increases in As mobility and bioavailability may be attributed to the reduction of As(V) to As(III) and dissolution of iron oxides, thereby releasing bound As(V). The DOM provides carbon as an electron donor for the reduction of As(V) and Fe(III), and also serves as a complexing agent thereby facilitating As mobility and bioavailability.

Keywords：*Arsenic species, reduction, iron species, bioavailability, leaching, earthworms, ecotoxicity*

O77-2

[C2.2-3] A: Behavior and Fate of Pollutants Entering the Soil Environment

Volatilization Processes of Diesel oil from Selected Soils

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Nonaqueous-phase liquids (NAPLs) can contaminate surface and subsurface porous media and groundwater resources in different ways, usually as a point source, with the contamination from light nonaqueous-phase liquids (LNAPLs) being especially serious. An important migration and transformation process of LNAPLs in the vadose zone includes volatilization. In fact, the process of transport into the atmosphere by volatilization cannot be ignored; this process has been found to transport as much as 58% of diesel oil during one year. The purpose of this work was to evaluate diesel oil volatilization with three selected uncontaminated soil materials collected from a petrochemical area. The objective of this study was to evaluate the effects of wind speed, vessel diameter, and mean grain size of soil particles on diesel oil volatilization and to ascertain whether volatilization is regulated by the boundary layer. Three selected field soil materials were evaluated: Silty Clay Loam, Fine Sand, and Coarse Sand along with six individual sand fractions of the Coarse Sand. The six separates from the Coarse Sand included: very coarse sand (0.90 to 2.0 mm), coarse sand (0.45 to 0.90 mm), medium sand-1 (0.30 to 0.45 mm), medium sand-2 (0.20 to 0.30 mm), fine sand (0.125 to 0.20 mm), and very fine sand (<0.125 mm), which included small amounts of silt (0.002 to 0.05 mm) and clay (<0.002 mm). To study the effect of wind speed, an experimental setup was designed which consisted of an axial fan, a ventilating tube, and a temperature-sensitive anemometer. Wind speeds of 1.02, 2.10, 3.21, and 4.42 m/s were evaluated which covered the range detected for the Linzi District, China. In addition, the effects of vessel diameter on diesel oil volatilization were evaluated. Aluminum cylinders with diameters of 5.20, 6.50, 7.00, 8.00 and 10.00 cm with 4.50 g diesel oil added evenly to the surface were examined. Volatilization was found to be affected by wind speed. Coefficients of determination were greater than 0.92 with fitting a second order polynomial equation for the volatilization rate coefficient versus the five wind speeds tested with the three soils. Results indicate that increasing wind speed accelerates the diesel oil volatilization process. The low-carbon components of diesel oil were found to volatilize more rapidly, with the effects of wind speed more pronounced on Carbon-10 to Carbon-15 volatilization than on Carbon-16 and higher. Diesel oil volatilization rate coefficients were found to be linearly correlated with vessel diameter. Increasing vessel diameter was found to increase the volatilization rate. The migration depth of diesel oil in the Silty Clay Loam material was the least for the three materials studied due to a larger number of small pores. At the same time, the contact area between diesel oil in the Silty Clay Loam material and air is the largest according to the surface area of the porous media. The volatilization rate coefficient was negatively correlated with mean grain size of soil particles when evaluating all materials (three soils and six fractions of the Coarse Sand) with no wind. A power function with mean grain size of the soil (50% of cumulative distribution of soil particle diameters) explained 92% of the variation in the rate coefficient. Soil materials with coarser particle size appear to block diesel oil volatilization to some degree relative to finer particle size. This illustrates that the diesel oil volatilization depends upon the mean grain size of the porous media. All processes (wind speed, vessel diameter, mean grain size) were included in an equation which explained over 92% of the measured diesel oil volatilization rate coefficient variations for the experiments. Diesel oil volatilization was found to be boundary-layer regulated to some extent. At the same time, it is controlled by characteristics of soil particle size. Based on the results of this study, a relationship including parameters for wind speed, mean grain size of soil, and vessel diameter was developed to describe the volatilization rate coefficient. Thus, it is speculated that finer particle materials can enhance the volatilization of diesel oil due to two processes: the slower downward transport of diesel oil in the finer material and the enhanced contact area with the higher surface area of the finer particles.

Keywords：*diesel oil, porous media, boundary-layer regulated processes, mean grain size*

O77-3

[C2.2-3] A: Behavior and Fate of Pollutants Entering the Soil Environment

Lithium, an Emerging Environmental Contaminant, is Mobile in the Soil - Plant System

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Lithium (Li) is a non-essential element for living organisms with background concentrations in soils ranging from <1 - 200 mg kg-1. Major uses of Li include lubricating greases, ceramics, and Li-batteries. Lithium production has tripled since 2000, with current global production >34,000 tonnes. Most of this increase, which is projected to continue, is due to the widespread introduction of Li-ion batteries in portable electronic devices. Although Li-ion batteries can be recycled, much Li will ultimately be dispersed into the environment through the inappropriate disposal and processing of electronic waste. There is a lacuna of information on the behaviour of Li in the soil-plant system. We aimed to determine: (1) the Li concentrations in various soils and pastures from around New Zealand, (2) the sorption of spiked (exogenous) Li by a silt loam, (3) the relative uptake of Li by selected vegetables and (4) the distribution of Li within sunflower with a view to elucidating likely transport pathways within the plant.

We measured Li in soils and pastures from around NZ. Batch experiments were used to measure the sorption of Li by the Templeton Silt Loam (TSL) at various pH values. We grew rye grass (Lolium perenne), beetroot (Beta vulgaris), broccoli (Brassica oleracea), carrot (Daucus carota), leek (Allium porrum), lettuce (Lactuca sativa), radish (Raphanus sativus), spinach (Spinacia oleracea), corn (Zea mays), tomato (Solanum lycopersicum), and courgette (also called zucchini - Cucurbita pepo) in the TSL (pH 6.2). We grew sunflower (Helianthus annuus L.), lettuce, beetroot, black mustard (Brassica nigra L.) and ryegrass was in the TSL spiked with 0, 10 & 30 mg kg-1 Li. Mature plants were dissected and the portions were analysed for Li and other elements.

Lithium concentrations in soils from around New Zealand ranged from 0.08 mg kg-1 to 92 mg kg-1. The soil Li concentration correlated positively with the clay fraction. Most endogenous Li in soil is insoluble and hence unavailable to plants. Pasture concentrations ranged from 0.5 - 6 mg/kg, some tenfold lower than the soils.

When grown in the TSL soil without added Li, the Li concentrations in the edible portions of the plants tested ranged from 0.01 - 2.62 mg/kg. Salt tolerant plants, namely B. vulgaris and S. oleracea took up the most Li, while seed and fruit crops had the lowest Li concentrations. Pasture grass (L. perenne) had the highest bioaccumulation factor for Li of any of the plants tested.

When exogenous Li was added to soil, there was only limited sorption of Li. Kd values (sorbed / solution concentration quotient) ranged from <1 to 8. Lithium sorption increased with increasing soil pH and decreased with increasing Li concentrations. Compared to other cations in soil, Li is relatively mobile and may leach into receiving waters or be taken up by plants.

In a soil spiked with just 5 mg kg-1 Li, the plants took up several hundred mg kg-1 Li into the leaves with no reduction in biomass. At such high Li concentrations, only a small amount of plant material would need to be consumed to exceed the Tolerable Daily Intake for Li (0.02 mg Li / kg body mass / day). The highest Li concentrations occurred in the older leaves and the lowest concentrations occurred in the seeds or fruits. Therefore, planting fruit or seed crops on Li-contaminated soil may reduce the risk posed to human health.

Our research shows that endogenous Li in soil (i.e. background concentration) is largely immobile and probably present within the silicate fraction of the soil. Soluble Li that enters soils is only weakly retained on the soil colloids and is therefore highly leachable. This soluble Li is readily taken up by plants and accumulates in the major water sinks, namely the leaves. Lithium does not appear to be mobile in the phloem. Future work should focus on the release of Li from electronic waste and industrial sources. Lithium mobility and plant uptake could be tested in tropical environments where much informal e-waste reprocessing occurs.

Keywords: *bioaccumulation, e-waste, human health*

O77-4

[C2.2-3] A: Behavior and Fate of Pollutants Entering the Soil Environment

Quantifying the Effect of Interactions between Soil Minerals and Organic Matter on Butachlor Sorption

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The effect of interactions between soil minerals and organic matter as a function of aggregate size on butachlor sorption was quantified in contrasting natural soils. The smallest size clay microaggregates sorbed most butachlor (58% to 71%) and the fine sand fraction sorbed the least (less than 4.3%). When normalized to organic carbon, butachlor sorption to the clay microaggregates was even smaller than to the silt and sand fractions under specific soil conditions. The sum of sorption to the different fractions was, on average, above 78% greater than sorption to the bulk soils, with the greatest differences in the soils with relatively higher ratios of clay to soil organic carbon (RCO). This suggests that minerals can physically protect favorable sorption sites within soil organic matter (SOM), and inhibit butachlor sorption by influencing SOM physical conformation. Comparisons of changes in butachlor sorption coefficients (both Kd and Koc) in two series of contrasting soils, with the same mineral components but gradients of total organic carbon (TOC) and RCO values also showed that minerals can directly contribute to soil butachlor sorption processes, which may be even more pronounced in soils with relative higher RCOs. A mathematical method was proposed and verified to quantify the net contribution of minerals to butachlor sorption, based upon 38 different soils. This study has increased our ability to quantify the positive direct contribution of soil minerals and their negative indirect contribution through associated effects on SOM physical conformation during butachlor sorption in contrasting natural soils.

Acknowledgment

This work was financially supported by the National Natural Science Foundation of China (41130532, 41322006), the National High Technology Research and Development Program of China (863 Program, No. 2012AA06A203), the fundamental research funds for the central universities, and Zhejiang University K.P.Chao's High Technology Development Foundation.

Keywords: *Butachlor; Sorption; SOM-mineral association; Aggregate size fraction; Quantified contribution*

O77-5

[C2.2-3] A: Behavior and Fate of Pollutants Entering the Soil Environment

Classification and Modelling of Non-extractable Residue (NER) Formation from Xenobiotics in Soil - a Synthesis

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This presentation provides a comprehensive overview about the formation of non-extractable residues (NER) from organic pesticides and contaminants in soil and tries classifying the different types. Anthropogenic organic chemicals are deliberately (e.g. pesticides) or unintentionally (e.g. polyaromatic hydrocarbons [PAH], chlorinated solvents, pharmaceuticals) released in major amounts to nearly all compartments of the environment. Soils and sediments as complex matrices provide a wide variety of binding sites and are the major sinks for these compounds. Many of the xenobiotics entering soil undergo turnover processes and can be volatilised, leached to the groundwater, degraded by microorganisms or taken up and enriched by living organisms. Xenobiotic NER may be derived from parent compounds and primary metabolites that are sequestered (sorbed or entrapped) within the soil organic matter (type I NER) or can be covalently bound (type II NER). Especially type I NER may pose a considerably environmental risk of potential release. However, NER resulting from productive biodegradation, which means the conversion of carbon (or nitrogen) from the compounds into microbial biomass molecules during microbial degradation (type III, bioNER), do not pose any risk. Experimental and analytical approaches to clearly distinguish between the types are provided and a model to prospectively estimate their fate in soil is proposed.

Keywords：*Pesticides, non-extractable residues, microbial degradation*

O78-1

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Considering Stakeholder Perceptions and Institutional Settings for Mitigation Projects in Rice Production

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Rice production in predominantly flooded fields is a source of methane. While the overall source strength corresponds to 1.5 % of all global Greenhouse Gas (GHG) emissions, this percentage is much larger at a national scale in many rice-producing countries (> 10% at national scale in Vietnam, Cambodia, Thailand and the Philippines). Considerable efforts have been directed towards identifying mitigation options by altered crop management. Various crop management strategies have been suggested, ranging from the selection of potentially low-emitting rice cultivars to proper post-harvest management, but alternate-wetting-and-drying (AWD) is clearly the most promising option at this point. AWD was introduced as a water saving technology in early 2000 while the mitigation potential of this approach has been highlighted only in recent years. The process, rate, and extent of AWD adoption, however, seem to vary across agro-ecological environments and institutions. The former tells us a priori that certain rice areas are necessarily more suitable for AWD than the others while the latter, on which this paper focuses, speaks of the laws and norms of behaviour that characterize the stakeholders be they individuals or organizations.

Moreover, the uptake of AWD in a given area is driven largely by water shortages. According to rcent literature surveys, AWD has CH4 mitigation potential of about 43%. The adoption rate as well as the actual mitigation effect of AWD is strongly dependent on the incentives and constraints (which takes various forms) for the farmers. Thus, it is imperative to know how stakeholders' perceptions (which presuppose awareness and to some extent knowledge) and attitude toward AWD influence their acceptance and eventual adoption of the technology.

The stakeholder analysis of AWD dissemination process will be approached in four levels: national, system, irrigator's association (IA), and farm. On the national level, we compare the cases of Philippines and Viet Nam looking at how AWD was mainstreamed into their national programs. We look into how laws and policies and their enforcement, i.e. institutions, have pushed AWD dissemination forward. The support of the national government and agency on AWD, not only as water saving but also as GHG emission reducing irrigation technique, may have an impact on the process by which AWD is implemented at the system level.

The chances of uptake of mitigation technologies could greatly be enhanced if farmers could be compensated for changes in farming practice. In most irrigation schemes farmers have no immediate revenue from lower water consumption, so that additional incentives from carbon credits could be a pivotal step for large-scale implementation. One option could be seen in Clean Development Mechanism (CDM) projects, but the pre-requisite for any CDM project is an approved methodology for quantifying emission reductions. In 2011, a small-scale methodology titled "Reduction of methane emissions by switching from transplanted to direct-seeded rice practice with adjusted water management" has been approved by the respective UNFCCC board, but has not been implements as an actual CDM project as of now.

In the long run, mitigation in the land use sector will probably get greater stimulus from government programs, e.g.

• NAMA (Nationally Appropriate Mitigation Action) Plans that are voluntary proposals submitted by developing countries to receive funds from the newly established "Green Fund" (as agreed in the Copenhagen Agreement at the 15th Conference of Parties) and/or

• national programs on technology dissemination such as the 20-20-20 program in Vietnam aiming at a 20% reduction in GHG emissions from the agriculture sector in 2020.

Moreover, mitigation technologies may also be promoted by the private sector to ensure low carbon food print of marketed rice and rice-based products. However, it remains to what extend these tendencies will actually curtail emissions from rice.

Keywords：*rice, methane, nitrous oxide, alternate-wetting-and-drying, Philippines, Vietnam*

O78-2

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

On-going Research Activities to Mitigate Greenhouse Gas Emission from Paddy Fields in China

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Rice is the most important crop in China. Rice paddy occupies 20% of China's total cropland area, while greenhouse gas (GHG) emission from rice paddy was estimated to account for more than half of total GHG from all croplands in China, with methane (CH4) being by far the dominant contributor. Research activities at various scales are be conducted in China to reduce GHG emission from croplands in China. Both the Ministry of Agriculture (MOA) and the Ministry of Science and Technology launched national research projects to sequestrate carbon in and mitigate GHG from croplands. Within both projects, GHG emission mitigation from rice paddy is a major effort. Among all factors that affect CH4 emission from rice paddy, water regimes and organic substrates and their combination are crucial, and thus on-going efforts to reduce GHG emission from rice paddy focus on these two factors.

Most Chinese rice paddies are cropped twice a year, and thus straw of previous crop is often directly incorporated into soil at the beginning of rice transplanting, thus greatly stimulating CH4 emission. Two technologies are being developed to avoid direct incorporation of crop straw, including biochar production and fast decomposition of straw with microbial inoculant. Biochar has been shown to reduce CH4 emission as compared to direct incorporation of crop straw as well as to straw-free treatment, while the effect of fast decomposing inoculant has not yet been clarified.

In Southwest China, seasonal drought and shortage of irrigation water is often a threat to rice production. Plastic film mulching cultivation has increasingly been adopted to save irrigation water. For such practice, rice field is divided into beds and ditches. Water is delivered only to the ditches and the beds are covered with plastic film. Rice is then transplanted on the beds by making holes on the film. Because the majority of rice field is not flooded, CH4 emission is dramatically reduced. This practice also lowers CO2 emission by saving cost of irrigation water, fertilizer top dressing, and weed control. N2O emission usually increases as a result of plastic film mulching and can be reduced reduce by using nitrification inhibitors.

Several drought-resistant rice varieties have been developed in China in recent years. These rice varieties gave similar rice yields with those of traditional varieties while using only 30% irrigation water of traditional varieties and thus were expected to reduce CH4 emission. Field measurement showed that when cultivated at the same irrigation levels, these drought-resistant rice varieties emitted significantly more CH4 than traditional ones, probably due to more root excrete release. However, since normal rice yield was obtained at 30% normal irrigation water, CH4 emission at this irrigation level was smaller than that emitted from traditional rice at normal irrigation water.

The effect of rice-duck cultivation system on CH4 emission has been studied in south China and results showed that this practice reduced nearly one third of the CH4 emission from traditional rice cultivation system. Dissolved oxygen concentration in flood water was significantly higher in rice-duck system. Other mitigation technologies under development in China include cropping rotation, alternative drying and wetting, and methanogenesis inhibitor application.

O78-3

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Effectiveness of Surface Drainage during Fallow Seasons on Mitigating Methane Emissions from Poorly-drained Paddy Fields in Japan

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Introduction
Methane (CH4) is a greenhouse gas regarded second to carbon dioxide in its ability to cause global warming. Paddy fields are a major source of atmospheric CH4. In our previous study, CH4 emissions from the drained field by subsurface drainage system were much lower than from the non-drained field despite similar field and crop management practices. The CH4 emissions during rice growth seasons were positively correlated to soil moistures in early spring before submergence. Therefore we conducted 2-years intensive field experiments to evaluate the effects of surface drainage during fallow seasons on CH4 emission following rice-growing seasons from poorly-drained paddy fields.

Materials and Methods
The field experiments were conducted in a rice paddy field located in Nagaoka, Niigata Prefecture, Japan (37°36′N, 138°51′E). Rice can only be grown as a single summer crop. On Sep 2010, one paddy field was divided in two parts by a levee. One part was drained rain and snow melt water during fallow season by making open ditches which about 0.1 m depth from Oct 2010 to April 2011 and Oct 2011 to April 2012, respectively (D part). The other part was not drained in this period (ND part). Each part had 3 treatments of organic applications, rice straws and rice husks (SH), rice straws (S), and non applications (N). Those organic materials were incorporated in Oct 2010 and Oct 2011, respectively. After first submergence in April 2011 and April 2012, rice cultivation and field management was similar on each part.

Results and Discussion
In 2011, CH4 fluxes in ND-SH and ND-S were observed first only 5 days after transplanting (DAT), whereas those were not observed until 15 DAT in D-SH and D-S. CH4 flux of ND-SH was more rapidly increased than that of ND-S. In contrast, CH4 fluxes in D-SH and D-S were later increased than that of ND-S, and both were similarly increased. CH4 fluxes of ND-N and D-N were much lower than that of other plots. All CH4 fluxes were deceased after the start of mid-summer drainage in June 2011. In 2012, CH4 fluxes in ND-SH were first observed 15 DAT and in D-SH were observed 22 DAT. The orders of CH4 fluxes were similarly in 2011. However, in 2012, CH4 fluxes in each plot until mid-summer drainage were lower than in 2011.
Just before first submergence, ferrous iron (Fe2+) concentrations in fresh soils were only a little in each plot of D part in both 2-years, whereas in each plot of ND part were 2 - 4 g kg-1 in 2011 and 0.5 - 1 g kg-1 in 2012, respectively. These results indicated that the ND part soils were already under reductive conditions before first submergence, whereas the D part soils were under oxidative conditions. After submergence, Fe2+ concentrations of all plot soils were increased with soil reduction. Especially, in ND part soils, those were reached the peaks before the start of mid-summer drainage in 2011. In contrast, Fe2+ concentrations of D part soils were increased lower than in ND part soils and not reached the peaks in both 2-years. These indicated that the ferric iron (Fe3+) which then acted as an electron accepter and inhibited CH4 production was kept in D part soils until the start of mid-summer drainage.
In the same organic application treatments, global warming potentials (GWPs) which combined cumulative CH4 and nitrous oxide (N2O) emissions during rice-growing season were significantly lower in D part than ND part. Mean reduction rate depend on the surface drainage during fallow season was approximately 50 %.

Conclusions
Surface drainage during fallow seasons in poorly-drained paddy fields greatly reduced CH4 emissions in the following rice-growing season by improving aerobic conditions and reducing CH4 production potentials.

Acknowledgements
This work was supported by a grant for the Development of Mitigation and Adaptation Technologies to Global Warming in the Sectors of Agriculture, Forestry, and Fisheries from the Japanese Ministry of Agriculture, Forestry, and Fisheries (MAFF).

Keywords：*fallow season, ferrous iron, methane emission, paddy, surface drainage*

O78-4

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Nitrogen and Water Management Practices for Sustainable Rice Production and Reducing Green House Gas Emission

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A field experiment was conducted at Bangladesh Agricultural University farm during Aus (May-August) season 2013 to evaluate the effects of deep placement of urea briquette and NPK briquette compared with broadcast of prilled urea on water NH4-N concentration, rice yield and N2O & NO emissions under continuously flooded (CF) and alternate wetting and drying (AWD) conditions. Nitrogen was applied as prilled urea (78 and 104 kg N ha-1), urea briquette (52, 78 and 104 kg N ha-1) and NPK briquette (51 and 78 kg N ha-1). Prilled urea was applied in 2 splits and urea briquettes were placed at 7-10 cm depth between 4 hills of rice at alternate rows after 10 days of rice transplanting. The NH4-N concentration of floodwater was measured over the first week after each application of fertilizer. N2O and NO emissions were measured continuously using automated closed chamber technique from selected treatments. Prilled urea broadcast resulted in higher concentration of NH4-N in standing water compared to deep placed urea and NPK briquettes, with the highest NH4-N concentration on day 2 and then it decreased steadily until day 7. The NH4-N concentration was higher with higher rates of prilled urea application while the NH4-N concentration was very low in both urea and NPK briquette treated plots irrespective of N rates. This result indicates that N would be greatly lost via volatilization and/or surface run off when it is broadcast as prilled urea and such loss would be greatly reduced with deep placement of NPK briquettes. The same treatment (briquettes) produced significantly higher rice yield. Deep placement of briquettes with 30% less N rate demonstrated similar yield with broadcast prilled urea. Concerning water management, the AWD gave considerably higher rice yield compared to CF condition. There was a very low emission of N2O and NO throughout the growing season irrespective of fertilizer treatments. This study suggests that fertilizer deep placement could reduce nitrogen losses and increase rice yield.

Keywords：*Urea supergranules, Prilled urea, AWD, Continuos flooded, Rice grain yield,Nitrous oxide emission*

O78-5

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Preliminary Studies on Methane Mitigation in Rice Production Systems in Santa Catarina, Brazil

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According to the last national greenhouse gas emission inventory (MCT, 2010), most of Brazil´s flooded rice fields utilizes continuous flooding management. Santa Catarina state, Southern region, is responsable for 9.5% of the national rice production (IBGE, 2013). The most usual cropping system is the pre-germinated system, with many cropping areas established in organic soils, with a long period of irrigation. The objective of this study was to evaluate CH4 emission rates from paddy rice fields adopting pre-germinated system under two types of soils, and to verify the effect of crop management on CH4 emission.
Experiments were carried out at the Experimental Station of Itajai (Epagri) located at latitude 26o 57'03" and longitude 48o 45'42", in Santa Catarina state, under subtropical climate conditions throughout two consecutive cropping seasons. Two types of soils were studied - mineral and organic, where the mineral soil presented 33% of clay and 2.1% of organic matter, while the organic soil (peat) 28% of clay and 27% of organic matter
In the first season (2006/2007) sowing was performed on 27/Oct/2006, using the cultivar SCS 114 Andosan (density: 120 kg/ha). In the second season (2007/2008) the sowing was performed on 18/Oct/07, with cultivar Epagri 109 (120 kg/ha). In both seasons, N fertilizer topdressing applications totalized a dose of 140 kg urea/ha, divided in 2 applications.
In parallel, another experiment was carried out on the mineral soil area, aiming to compare CH4 emissions from pre-germinated and sowing on dry soil systems. Conventional tillage was used for the dry soil, with the incorporation of the stubble before the sowing (23/Nov/2007). In the pre-germinated system, the soil preparation was conducted similarly to the first season. The sowing proceeded in 29/Nov/2007 with the use of the cultivar Epagri 109 (120 kg/ha). The area in the pre-germinated system remained continuously flooded during the whole season, while the flooding was established only 20 days after the emergency of the rice in the area sowed on dry soil. The whole area remained flooded until 22 days before harvest, totalizing 95 and 117 days under flooding, for the area sowed on dry soil and pre-germinated, respectively.
Air samplings were carried out weekly in intervals of 5, 10, 15, 20, 25 min. by using aluminum-made chambers (60x60cm) (Sass et al., 1992). CH4 was quantified in a gas chromatograph HP6890 (Agilent, USA) equipped with FID at 280ºC, column megabore (0.53 mm x 30 m 15µm) Plot HP-Al/M, with loop of 0.5 cm3 maintained at 80°C attached to six-way valve.
In the 2006/2007 season daily average CH4 emissions registered 465.96 mg CH4 m-2 and 819.21 mg CH4 m-2 for mineral and organic soil, respectively. Cumulative emissions were estimated in 68.84 g CH4 m-2 and 138.21 g CH4 m-2 in the respective soils. In the season 2007/2008 daily average CH4 emissions registered 361.1 mg CH4 m-2 on mineral soil and 398.6 mg CH4 m-2 on organic soil, while cumulative emissions were estimated at 55.60 g CH4/m2 on mineral soil and 61.39 g CH4/m2 on organic soil. The pronounced difference in the values for organic may be associated with the soil preparation conducted in the 2006/2007 season, when all plant mass available was incorporated to the flooded soil just before the rice sowing. Otherwise, in the 2007/2008 season all the stubble was incorporated under drained soil conditions at least 60 days before rice sowing. When considered the crop management systems, cumulative emissions accounted for 61.05 g CH4/m2 on the pre-germinated system and 41.16 g CH4/m2 for sowing on dry soil, whose difference represents a reduction of 32.6% of CH4 emissions. Daily average CH4 emissions registered 482.6 mg CH4 m-2 on the pre-germinated system and 363.5 mg CH4 m-2 on dry soil. Beyond the positive impact in the CH4 emission, sowing in dry soil conditions reduces the consumption of water without compromising rice productivity.

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Keywords：*Pre-germinated system, CH4, Itajai, organic soil, mineral soil*

O79-1

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Bacterial Community Structures in Rhizosphere Microsites of Lolium Perenne Var. Nui Grown in Chilean Andisol as Revealed by Pyroseque

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The rhizosphere is a complex environment where diverse biotic and abiotic factors influence microbial community structures. Here, we examined the structure of bacterial communities in the rhizosphere of ryegrass in pasture systems on Chilean Andisols using high throughput pyrosequencing.The study further compared community structures associated with the root tips and mature root zones for plant grown in two different Andisol series that differed mainly in exchangeable Al. Results showed that the predominant taxa in the rhizosphere soils included Proteobacteria, Actinobacteria and Acidobacteria. No significant differences were observed with respect to root microsite location, whereas subtle differences in the abundance of Cyanobacteria and Firmicutes phyla were observed between the Freire and Piedras Negras soil series. Analysis of the community structures showed that dominant bacterial groups comprised only 5 to 10% of the total bacterial community. The remaining majority of bacteria were comprised of 79 genera that were present in low abundance, most of which have not been previously reported to be associated with the plant rhizosphere79 according to GenBank and SILVA databases. The results indicate that the vast majority of bacteria in Chilean Andisols and their functional traits are still largely unknown.

Keywords：*Andisols; Bacterial community; pyrosequencing; rhizosphere microsites*

O79-2

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Biogeochemical, Cultivation and Molecular Ecological Analyses of Geothermally-heated Soils on Kilauea Volcano, Hawaii

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A mosaic of formations ranging from very recent lava flows to millienal-aged ash deposits and lava comprises the diverse ecosystems of Kilauea Volcano (Hawai`i). Weathering and ecosystem developmentalso vary substantially from barren, new mineral surfaces to poorly colonized minimally weathered old lava flows to montane rain forests occupying young flows. We have used a variety of biogeochemical, cultivation and molecular ecological approaches, including metagenomic analyses, to characterize unique bacterial communities dominated by CO oxidizers. Approximately 80 years ago, a montane rain forest that had developed on 400-500 yr old lava flows was killed by the upward movement of a lava dike,which heated the forest soil to > 80 oC. Soil at the base of the remnant tree trunks is heated by steam, and contains a gas phase with elevated CO concentrations. Novel microbial biofilms dominated by Ktedonobacteria, Acidobacteria and Armatimonadetes colonize the surfaces of tree trunks. CO uptake assays by biofilms have revealed relatively high rates with optima between 50-60 oC; CO uptake by soils is also rapid, with even higher temperature optima. Results from isolates, 16S rRNA gene sequences and sequences of the large sub-unit gene for CO dehydrogenase (coxL) have indicated that members of the Ktedonobacteria dominate biofilm CO oxidation, while other novel thermophilic CO oxidizers dominate the soils. Metagenomic analyses show that genes for CO oxidation are relatively abundant, but also indicate that CO is not likely used as a carbon source, since rubisco genes are phylogenetically different and less abundant than those for CO. In addition, the biofilm contains few genes for nitrogenase and nitrogen fixation, which suggests that ammonia and nitrate might be provided by movement of water through the soil into the tree trunks.

O79-3

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Temperature Dependency of Soil Nitrogen Mineralization in an Andosol is Affected by Phosphate Availability

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Backgrounds and Objectives: One of characteristics of Andosol is its high organic matter contents, which is caused by retardation of organic matter decomposition due to formation of aluminum-humus complex. The free aluminum which causes organic matter accumulation also strongly fixes phosphate (P) in soil. Low P availability due to strong P fixation in Andosols may affect microbial activity in the soil and contribute to the accumulation of soil organic matter. Saito (1990) found that higher temperature dependency of soil nitrogen mineralization was observed in soils which are lower in P availability. We hypothesize that organic matter accumulation in Andosol may be partly caused by lowering of microbial activity with low P availability and that it may more clearly appear under lower temperature conditions. In this study, to clarify the effect of P on temperature dependency of soil nitrogen and carbon mineralization in an Andosol, we conducted a laboratory incubation experiment.

Materials and Methods: Surface soil was collected from uncultivated land in Morioka city, Iwate prefecture, the northeast area of Japan. The soil is allophanic cumulic Andosol. Some chemical properties of the soil were as follows: pH(H2O), 5.3; available P (Truog method), 16.3 mgP2O5/kg. We treated soil sample with P addition (corresponding to 5% or 20% of the phosphate absorption coefficient) as KH2PO4 or 4:1 mixture of fused magnesium phosphate and superphosphate, in combination with liming and without liming. The amount of nitrogen (N) mineralized and soil respiration rate were periodically measured during long-term incubation (86-120 days) under two or three temperature conditions (20, 25, and 30℃). The patterns of N mineralization were analyzed by fitting to the first order kinetics, which included that the temperature dependency was assumed to follow the Arrhenius Law. Then, we calculated N mineralization parameter (N0: N mineralization potential, k: reaction rate constant, and Ea: activation energy).

Results and Discussion: In non-limed soil, P addition increased N mineralization especially at 20℃. Parameters, N0 and k, were not affected by P addition, but Ea significantly dropped ($P < 0.05$) with 20% addition of KH2PO4, from 94.4 kJ/mol to 60.5 kJ/mol. In limed soil, P addition slightly increased N mineralization, but not affected soil N mineralization parameters. This indicates that, under non-limed conditions, increase in soil available P reduces the temperature dependency of soil N mineralization in the Andosol. Effect of the treatments on soil respiration rates did not necessarily agree with those on N mineralization. Liming increased soil respiration rate remarkably within the first 2 weeks of the incubation period. P addition clearly increased soil respiration rate for about 1 month in limed soil, regardless of temperature. In non-limed soil, on the other hand, P addition slightly increased soil respiration rate at 20℃, but not at 30℃.
In conclusion, temperature dependency of soil nitrogen mineralization in the Andosol is affected by phosphate availability, suggesting that lowering in mineralization with low P availability is more evident under lower temperature conditions. Furthermore, liming and P addition would have the combined effect on soil carbon respiration.

Keywords：*soil organic matter, nitrogen mineralization, soil respiration, phosphate, Andosol*

O79-4

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Fungal Translocation of Microelements during Fagus and Quercus Leaf Litter Decomposition in a Volcanic Soil Ecosystem

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Fungi are of pivotal importance for plant and microbial nutrition with primary roles in organic debris decomposition and biogeochemical recycling. Fungal mycelium in soil forms a web of apically extending branching tubes (hyphae) that transfer and redistribute nutrients and minerals over far wider spatial scales than would be possible in their absence. Many studies have been addressed to define the contribution of overall fungal activity to soil main functions and ecosystems maintenance, but little is still known on the mechanisms used by fungi to exploit leaf litter. The fungal ability to decompose leaf litter has been investigated mainly under laboratory conditions or by means of litterbag techniques. Fungal communities colonising leaf litter have been described by means of isolation and identification of single strains and more recently by means of molecular methods. What emerged is that decomposition in soil is dependent on many organisms that act synergistically. The degree of functional interaction between decomposers as yet has not been clearly shown; there may be several organisms that sequentially attack a given type of vegetal residue. Among the various organisms only few can hydrolyze the bulk of the debris (mainly cellulose and lignin), while the roles played by the others are not directly linked to hydrolysis of biopolymers. To further complicate the scenario, there is the evidence that in most natural habitats the spatial distribution of organic particles and minerals is patchy. Filamentous fungi have thread-like hyphae that are highly suited to growth across surfaces, through pores, and across air gaps. The ability of certain fungi to develop in such patchy environments is driven by their ability in translocation of biogenic elements through the hyphal web. It has been showed that fungi are capable of growing in low nutrient habitats because they can exploit the resources available in other parts of the mycelium. Some fungal groups have ability of sequestrating compounds from organic and inorganic substrates. A considerable number of fungi have been described as having the power to dissolve rocks and produce biogenic new minerals. In this study we used a combination of experimental techniques to compare fungal communities developing in two leaf litter environments, characterised by the same rock substrate (volcanic soil), but with different forest coverage (Quercus spp. and Fagus sylvatica L.). The data here showed are relevant to the changes in elemental composition of leaf litter after fungal development and to a comparison of the fungal communities in the two systems. Decomposing Quercus and Fagus leaves were analysed with a variable pressure SEM instrument (EVO50, Carl-Zeiss Electron Microscopy Group) equipped with a detector for electron backscattered diffraction (BSD). The system was used at a pressure that allowed the visualisation of unaltered fungal structures without the need for fixation and metallisation procedures. A chemical characterisation of the inorganic constituents of fungal structures colonising leaves' surfaces was performed by means of electronic dispersion spectroscopy (EDS), which allows for an X-ray area scanning of whatever is brought into focus in SEM images. Fungal structures (mainly mycelium, sclerotia and fruiting bodies) occurring on decomposing leaves and visible at a stereomicroscope were directly isolated with glass needles and cultured in Potato-Dextrose Agar (PDA) plus streptomycin sulphate (100 γ/ml of substrate) to evaluate the actively growing fraction of fungal diversity associated to decomposing leaves.
Most of the fungal structures documented on leaf litter proved to be capable of concentrating several important biogenic microelements (N, P, S, K, Mg and Ca), that are at a lower concentration or absent in the background substrate before fungal colonisation. Moreover it was documented the formation of oxalates directly on leaf surfaces as a result of the active translocation of calcium by the fungal mycelium. The compared ecosystems, although sharing several important variables (macroclimate, exposition, soil parental material) showed to support different fungal communities that have specific decomposition abilities towards the organic material. The initial elemental composition and some micro-morphological characteristics of leaves' surface could have a role in fungal colonisation and decomposition processes and explain some of the differences observed between Quercus and Fagus soil ecosystems.

Keywords：*Leaf litter, SEM-EDS, Microelements, traslocation, fungal, volcanic soil*

O79-5

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Unravelling the Influence of Plant Cover and Microbial Diversity on Ecosystem Function of Melanic Andosols

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The biological functions of soil are guaranteed by the activity of microbial communities which in turn are influenced by the interaction between the vegetation cover and the type of parental rock material. On a global scale the rates of litter decomposition are governed by climate. However in the context of a particular climatic region, the chemical composition of leaf litter and the activity of decomposers turn out to play a central role in the processes of nutrient cycling and soil formation. In order to characterize the microbial communities and understand their role in soil genesis, two volcanic model-soils developed under different vegetation, but undergoing the same climate and parent material, were considered in the present study. The compared soil profiles were sampled in the volcanic apparatus of Vico in Central Italy, on parent material made by phonolitic-tephritic with leucite lavas . They were both classified as Silandic Melanic Andosol (World Reference Base 2006) or Typic Melanudand (USDA ST, 2010). Both the investigated soils developed andic properties under udic soil moisture and mesic soil thermic regimes, with a short dry season, but under a different plant cover (beech and oak forests). The Andosols developed on this type of parent material showed an alteration with liberation of silica and aluminium. The latter contributed to the formation of allophanic compounds and umo-metallic chelates, both with high molecular weight, high complexity and stability. The formation of allophane could be associated to the formation of Al-organic complexes, which correlated inversely, in our case, to the overall content of Pirophospate Al. The described situation led to a pedo- environment with a high chemical fertility, but a low biological activity, with apparent difficulties of microbial communities in the mineralization of such complex organic compounds. This mechanism of fixation and stabilization of organic matter is responsible for the formation of melanic epipedon, but the water regime udic and the temperature low enough seemed necessary functional characters, in addition to the parent material, to create the conditions for achieving a biochemical balance. Within these general mechanisms developed, however, different biotic trends possibly due to the interaction of soil physical-chemical alteration with organic residues intakes of different quality, which selected the community of decomposers in an even more specific way.
The microbial communities and some of their functions were analysed according to the soil profile, using the different horizons as sampling scheme. We compared the two systems evaluating the abundance and richness of the microbial communities by quantitative PCR (qPCR), the structure and diversity of the microbial communities through two molecular approaches: T -RFLP (Terminal - Restriction Length Polymorphism) for the analysis of the diversity of Bacteria and Archaea, and DGGE (Denaturing Gradient Gel Electrophoresis) for the analysis of fungal diversity. In the soil under oak a marked difference between the A1 and A2 horizons in terms of total content of fungi, bacteria and archaea (biomass values obtained with the method qPCR) was found. The bacteria, in particular, decreased dramatically passing from the first to the underlying horizons. The archaea were present only in the first two horizons. It seemed that the leaves of oak allowed the establishment of a robust ecological succession, rich in species and capable of ensuring the "entrance" in the organic horizon (A2) of plant material already largely demolished. In contrast, in the profile under beech no marked differences between the first organic horizons were observed from the point of view of microbial taxonomic diversity. The biomass values decreased as expected along the profile but the ratio of fungi to bacteria increased with depth, indicating a gradient in which bacterial groups prevailed in the more superficial horizons whereas fungal species increased in diversity in the deeper layers, possibly because associated with the roots of plants. Two driving pedogenetic forces, the biological downwards, and the chemical upwards, could be revealed: i) a strong influence of leaf litter quality that led to a differentiation between the two soil profiles in terms of both microbial communities and quality of humic compounds that reached the organic horizons, and ii) an even stronger influence of the volcanic bedrock reactivity that, from the deeper horizons, chemically directs the profile's structure.

Keywords：*andosol, plant cover, microbial diversity, soil functions*

O79-6

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Early Microbial Succession in Recent Unvegetated Volcanic Deposits of Miyake-jima Island, Japan

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Newly emplaced substrates by volcanic eruption, such as lava, tephra, and volcanic ash, are habitats open to invasion by microorganisms and the microbial immigration might influence the formation of new soils and ecosystems. In this study, we analyzed early bacterial communities on 3.5-, 5.0-, 6.6-, 8.5-, and 9.5-year-old volcanic ash deposits in the island of Miyake (Miyake-jima), Japan by both culture-based methods and metagenomics. Volcanic deposit samples were collected at a fixed unvegetated site near the crater of Mt. Oyama, which erupted in 2000, ejecting large amounts of volcanic ash and gases. All collected samples were acidic (pH 3.0-3.6) and contained very low carbon and nitrogen. The samples had 10^8 (g dry weight)$^{-1}$ of total direct count and 10^6 to 10^7 (g dry weight)$^{-1}$ of culturable bacteria, in spite of very low-carbon environmental conditions. It was noteworthy that the volcanic deposits harbored high populations of autotrophic iron-oxidizers (about 106 most-probable-number counts [g dry weight]$^{-1}$). Interestingly, the deposit sample (age, 5.0 y) consumed an ambient level of CO_2 at a rate of 4.9 nmol CO_2 (g dry weight)$^{-1}$ h^{-1}, suggesting that autotrophic activity prevailed over heterotrophic activity in the deposit microbial community. The low heterotrophic activity was also supported from the result of ECO microplate assays (Biolog): the 6.6-year-old and 8.5-year-old samples did not utilize any organic substrates, while a reference soil in a lower mountainside forest utilized all the tested substrates.

In metagenomic analysis, bacterial and archaeal 16S rRNA gene (rDNA) sequences were retrieved from the dataset of 3.5-, 6.6-, and 9.5-year-old volcanic deposits. Archaeal 16S rDNA sequences were not found in 3.5- and 6.6-year-old deposits, but accounted for 1.3 and 6.5% of the total 16S rDNA sequences in 9.5-year-old deposit and the reference forest soil, respectively. The numbers of bacterial phylum were 13, 7, 17, and 16 phyla in 3.5-, 6.6-, 9.5-year-old deposits, and the reference soil samples, respectively, suggesting that bacterial diversity of volcanic deposits was comparable to that of the reference soil. In the bacterial communities of volcanic deposits, phylum *Proteobacteria* was the most abundant group, accounting for 52 to 77% of the sequences and the population seemed to increase with deposit age. The major members of *Proteobacteria* were iron-oxidizing bacteria, *Acidithiobacillus* in 3.5-year-old deposit and *Acidiferrobacter* in 6.6-year-old deposit, but their percentages decreased in 9.5-year-old deposit. *Nitrospirae* sequences were also abundant in 3.5-year-old deposit (22%), with the majority closely related to iron-oxidizing *Leptospirillum* groups. *Actinobacteria* was the third most abundant phylum, which mainly consisted of iron-oxidizing *Ferrimicrobium* and *Ferrithrix* and iron-reducing *Acidiferrimonas*.

Genes encoding energy-yielding, CO_2-fixing, and nitrogen cycling metabolisms were searched and their relative abundances were calculated using KEGG assigned sequences, which accounted for 24-31% of all predicted ORFs. As expected from the bacterial community analyses, gene sequences assigned to iron oxidation were found at significant levels in all volcanic deposit samples but not in the reference soil sample. As for other chemolithotrophic genes, both CO and hydrogen oxidations were expected to be prevailed in the volcanic deposit, while CO oxidation seemed to be dominant in the reference soil. When the relative abundance of a key enzyme gene in Calvin cycle was analyzed, the volcanic deposit samples contained higher percentages than the reference soil. Several key enzyme genes of reductive TCA cycle were also found but the levels were lower than the Calvin cycle gene. The detected iron-oxidizers in the volcanic deposits are known to be able to fix nitrogen. This was supported by high relative abundances of sequences of *nifH*, a key enzyme gene in nitrogen fixation, in the samples, most of which were assignable to the *nifH* gene sequences of *Acidithiobacillus* and *Leptospirillum*.

In conclusion, our results suggest that chemolithoautotrophic iron-oxidizing bacteria play a significant role in carbon and nitrogen fixation in the early ecosystem on volcanic deposits before the establishment of the first colonizer plants.

Keywords：*volcanic deposit, iron oxidation, metagenomics*

O80-1

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Oxygen Isotopes for Unravelling Phosphorus Transformations in the Soil/plant System: a Review

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Phosphorus (P) is a major nutrient for all living organisms. In some areas, agricultural production is strongly limited by the low soil P availability, while in other areas P inputs in excess to plant needs have resulted in extensive pollution of surface waters. A better understanding of the biological reactions controlling the fate of P in the terrestrial environment is needed. Besides classical approaches including routine analyses of soil available P and of plant P content, the determination of P chemical forms in soils and plants, and the use of P radioisotopes, researchers have started using the ratio of oxygen stable isotopes in phosphate (δ18O-PO4) to gain a better understanding of the P cycle. This paper will first present the theory behind the use of δ18O-PO4 and will provide a summary of the processes (sorption, desorption, solubilization, precipitation, uptake, enzymatic hydrolysis) controlling the oxygen isotope composition of phosphate in nature. Of particular importance is the role of various phospho-enzymes as they can exchange O between water and phosphate. The ubiquitous intracellular pyrophosphatase leads to a temperature dependent isotopic equilibrium between the oxygen of water and of phosphate, while phosphomonoesterase or phosphodiesterase on the contrary incorporate one or two O atoms from water in phosphate during the hydrolysis of monoester or diester P. Furthermore an isotopic fractionation can be observed during the incorporation of water in phosphate during the hydrolysis of ester P. In a second step the procedures for extracting and purifying P and for measuring δ18O-PO4 in soil and plant extracts will be presented. The challenge is to carry out the extraction and purification steps so as to assess the original oxygen isotope composition that is associated to P without any contamination from any external O bearing compounds. Most of the laboratories now precipitate P as Ag3PO4 which is then analyzed by pyrolysis and isotope ratio mass spectrometry. During the analysis, Ag3PO4 goes through a high-temperature reduction oven where O is converted quantitatively to CO, which is sent in a continuous flow to a mass spectrometer. In its third part the paper will present an inventory of the already published δ18O-PO4 signatures from different soil/plant compartments. In addition, selected studies conducted at different levels (from the single plant to the ecosystem level) will be presented to show how δ18O-PO4 results can be interpreted. These studies show that in most of the cases δ18O-PO4 can be used as a tool to assess biological activity but not as a tracer to quantify P fluxes. Nevertheless, under very specific conditions, δ18O-PO4 can be used to track sources and sinks at ecosystems level. Finally, this paper will show where future works should be conducted.

Keywords：*phosphorus, oxygen 18, biological processes*

O80-2

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

N-fixing Tree Species (Acacia Mangium) Introduced in Eucalyptus Forest Modify Soil Organic P and Low Molecular Weight Organic Acid Pools: a Case Study from Tropical Forest Ecosystem in Congo

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Productive eucalypt forests are generally planted in nutrient-poor soils such as sandy savannas. These trees are fast-growing woody species harvested every six-to-seven year intervals. Therefore, these eucalypt plantations often deplete soil macronutrients, such as N and P. In order to increase nitrogen (N) inputs in forest ecosystem, the N-fixing tree species acacia (Acacia mangium) was intercropped in eucalypt plantations in Congo. Increasing N availability in these sandy, nutrient-poor soils, could also change the bioavailability of organic P pool and low molecular weight organic acids (LMWOAs) via the modification of litter decomposition rate and the microbial activity, which release LMWOAs. Field measurements showed that the biological N fixation increased the productivity of eucalyptus trees in mixed-species plantations, indicating that N fixation was high in these environmental conditions. To investigate the effects of acacia on P cycling in these intercropped systems, we used first high performance ion chromatography to separate and quantify organic P and LMWOAs in soil from different types of plantation: pure stand of acacia, pure stand of eucalyptus and the mixture of the two species. Besides mineral anions, we were able to separate and to identify five organic P compounds (AMP, ATP, phytate, fructose bis-P, uridine-diP) and four LMWOAs (malate, malonate, oxalate, citrate). The results showed that AMP was the dominant form of organic P whatever the stands. However, its concentration decreased in the mixture compare to the pure stands. Phytate was present in all soil samples and was much higher in eucalypt than acacia stands, with intermediary values in the mixture. Oxalate and malate were the dominant LMWOAs, especially in eucalypt pure stands. We have also measured the mineralization of organic P compounds in bicarbonate-soil extracts using two recombinant fungal enzymes that are phytase (PhyA) from Aspergillus niger and an acid phosphatase (HcPhoA) from an ectomycorrhizal species Hebeloma cylindrosporum. The first results indicated that both enzymes were able to release inorganic P from organic P present in the soil extracts. To go further into the effect of LMWOAs on P bioavailability through enzyme activity, we will add variable amounts of identified organic anions to soil samples before running enzyme measurements. In conclusion, our first results show that the introduction of acacia modified both organic P forms and LMWOAs concentrations in pure and mixed stands and presumably P cycling.

Keywords：*N-fixing tree, Eucalypt plantations,Intercrop effects,Organic P, Organic acids, Ion chromatography,, Enzyme measurements*

O80-3

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Understanding Organic Phosphorus Speciation in Agricultural Soils: Correlation between P Types in Relation to Carbon (C), Nitrogen (N), and Organic Phosphorus (PO) Compounds

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Solution 31P NMR spectroscopy can be used to identify and quantify several different forms of phosphorus (P) present in soil. The relative amounts of these have been found to vary among soils, most likely due to factors including climate, land use, and soil type. However, few studies have investigated co-variation among these P types or stoichiometric correlation with the key elemental components of organic matter - carbon (C) and nitrogen (N), which could shed light on P pool structure and dynamics in agricultural soils. This study used twenty Australian agriculture chromosols of 0-10 cm soil depth to investigate the relationship between total soil C, N and P, and among the P types detected by NMR. Soils were extracted with NaOH-EDTA resulting in 50-60% recovery of P. Eight P species were quantified by NMR, with a large majority (>90%) in all soils identified as orthophosphate and high molecular weight humic P. The strongest correlations (r^2 =0.77-0.85, $p<0.001$) among P types were found among minor components: firstly between two inositol hexakisphosphate isomers (myo- and scyllo-) and secondly between phospholipids, and RNA (both detected as their alkaline hydrolysis products). No correlations were detected between orthophosphate and any organic P form. Total soil C and N were correlated with phospholipid and RNA P, but not the major P forms of orthophosphate and humic P. This suggests there is some influence of organic matter content on the organic P pool consisting of phospholipid and RNA (which can perhaps be equated to microbial P), but not on inositol P or the largest organic P pool in these soils – humic P. This is consistent with humic P having a high degree of stability and low turnover rate; in stable systems its concentration may ultimately come under stoichiometric control (i.e. be related to soil C, N and/or P contents), but under agricultural management regimes that involve substantial fertilizer P addition and result in substantial changes in organic matter content, this stoichiometry is not observed.

Keywords：*Carbon, Nitrogen, organic P, solution 31P NMR spectroscopy*

O80-4

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Abundance and Diversity of Phod Bacterial Communities as Influenced by Long-term Agricultural Management

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Changes in land management practices may have significant implications for soil microbial communities important in organic P turnover. Soil bacteria can increase plant P availability by excreting phosphatase enzymes which catalyze the hydrolysis of ester-phosphate bonds. Although enzyme assays provide important information about the ability of the soil to produce the specific enzyme, they are conducted under optimal conditions and may not be representative of actual activity at lower temperatures, with variable moisture, and in the presence of plant roots. Examining the diversity and abundance of alkaline phosphatase gene harbouring bacteria may provide valuable insight into alkaline phosphatase (ALP) production in soils. This study examined the effect of long-term management on soil P bioavailability, alkaline phosphatase activity (ALP), and abundance and diversity of ALP gene (phoD) harbouring bacteria.

In 2011 and 2012, soil samples (0-15cm) were collected from the wheat phase of the grain-forage rotation (flax-alfalfa-alfalfa-wheat) at the Glenlea Long-term Rotation in southern Manitoba, Canada. Management systems included no input organic (ORG), organic with composted manure (ORG+M), conventional (CON) and restored prairie (PRA). Composted cattle manure was applied to ORG+M in fall 2007 and 2011 only. Soil samples were analysed for $NaHCO_3$ extractable molybdate-reactive P (Olsen-P), total P and potential alkaline phosphatase (pH 11) activity. Soil DNA was extracted for quantification of the phoD gene using qPCR and bacterial community analysis by PCR-DGGE. Management system ($P< 0.001$) and sampling year ($P<0.001$) influenced Olsen-P values, with lowest concentrations in the ORG systems and highest in PRA in both years. The addition of manure did not result in differences in ORG+M Olsen-P values compared to ORG, although there were differences in total P after the second manure application. Alkaline phosphatase activity in July was highest in the ORG and ORG+M treatments, with correspondingly low levels of plant available P. There was a significant negative correlation between Olsen-P and ALP in 2011 (r^2=.68; P=.03) and 2012 (r^2=.51; P=.02), suggesting that ALP activity increased under P limiting conditions. The phoD gene abundance was also highest in ORG and ORG+M although differences were significant in 2011 only. A significant positive relationship was observed between bacterial phoD abundance and ALP activity (r^2= 0.71; P=0.009), although there was no correlation between phoD gene abundance and Olsen P or total P. Analyses of phoD bacterial DGGE profiles showed a higher number of species in CON compared to ORG and ORG+M. The sample profiles revealed a large number of bands for each management system with higher diversity observed in 2011 than 2012, but ordination by NMS did not result in a clear grouping according to system.

Soils were collected from the field site to further test the relationship between soil P, ALP activity and phoD gene abundance in a greenhouse experiment. For each soil, treatments of no P, composted cattle manure (3, 20 and 40 mg P kg^{-1} soil) and soluble P as KH_2PO_4 (15, 40, 80 and 160 mg P kg^{-1} soil) were applied to pots with 1 kg of soil and planted to ryegrass. ALP was higher and less variable in response to P amendments in ORG and ORG+M (5.63 and 5.46 μmol PNP g^{-1} hr^{-1}) than CON and PRA (4.68 and 4.67 μmol PNP g^{-1} hr^{-1}). The "priming" effect of high manure addition was less in ORG and ORG+M compared to CON and PRA. The addition of soluble P only suppressed ALP at 80 and 160 mg P kg^{-1} soil in the ORG and ORG+M soils. The abundance of total (DNA) and active (RNA) phoD genes is currently being investigated to examine the relationship to ALP, plant P availability and P uptake. Since the field study suggests the abundance of phoD genes was a better indicator of ALP activity than diversity, quantification of transcripts may provide even greater insight into ALP production by bacteria in response to P limitation and the rate and type of P fertilization.

Keywords：*bioavailable P, alkaline phosphomonoesterase, phoD abundance*

O80-5

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

The Accumulation of Inorganic and Organic P Forms in Fertilized Pasture Soils

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Phosphorus (P) fertilizers are essential for high pasture production in the high rainfall zone of eastern Australia. However, the fertilizer P use efficiency (PUE) in pasture systems is low and will need to significantly improve for agricultural and environmental reasons. The cause of low PUE in pastures is most often associated with the accumulation of P in fertilized soil as sparingly-available forms of orthophosphate and organic P. The processes associated with poor PUE can be elucidated from an understanding of the major soil P forms that accumulate under P fertilization in pasture soils. The aim of this study was to identify which soil P forms accumulate in a long-term P-fertilized, grazing experiment under permanent pasture.

The experiment was established in 1994 near Hall, Australian Capital Territory, Australia. The experiment was established on a Yellow Chromosol soil in a degraded grass/clover pasture managed at three levels of soil P fertility: (i) plots receiving no P fertilizer (control): (ii) plots receiving P fertilizer to maintain a soil P fertility of 10-12 mg Olsen-P kg-1 (P1): and (iii) plots receiving P fertilizer to maintain a soil P fertility of 20-25 mg Olsen-P kg-1 (P2). The experiment also included two stocking rates using yearling Merino wethers grazing at: (i) 9 sheep per hectare (SR09): or (ii) 18 sheep per hectare (SR18). Soil was collected from each experimental plot in the topsoil layer (0 – 10 cm) and prepared for soil analysis. Soil analyses included a Hedley fractionation procedure, laboratory X-ray fluorescence, and solution 31P nuclear magnetic resonance (NMR) spectroscopy on NaOH/EDTA extracts.

There was a linear relationship between cumulative P input and total soil P across all treatments. However, there was no significant difference in total soil P between stocking rate treatments. The accumulation of total soil P corresponded to 71 % of the applied P fertilizer in the topsoil layer over the duration of the experiment when averaged across all treatments. The ratio of total inorganic P to total organic P increased with increase in the cumulative P input. This effect was particularly evident in the high P input treatments for which total organic P had plateaued.

The largest increases in soil P were in the NaHCO3 and NaOH soluble fractions. Approximately 24 and 30 % of the applied fertilizer accumulated in these two fractions, respectively. The inorganic and organic P in the NaHCO3 soluble fraction increased by 162 and 65 %, respectively, relative to the control. For the NaOH soluble fraction, the inorganic and organic P concentration increased by 92 and 29 %, respectively.

The sums of the organic P Hedley fractions were strongly correlated to the organic P concentration in the NaOH-EDTA extract. The NaOH-EDTA extractant removed between 83 and 160 mg organic P kg-1, which accounted for between 23 and 33 % of total soil P. Solution 31P NMR spectroscopy revealed orthophosphate monoesters and orthophosphate diesters were the dominant ‘classes’ of soil organic P that increased with cumulative P input. The most dominant form of organic P for all soils was humic P, followed by lipid P (detected as α- and β-glycerophosphate), myo-inositol hexakisphosphate, scyllo-inositol hexakisphosphate, and nucleic acids. Humic P and lipid P were the only organic P forms in the orthophosphate monoester region to accumulate in pasture soils under increasing cumulative P input. However, the accumulation of these two organic P forms was quantitatively small (i.e. 18 and 3 mg P kg-1 over the duration of the experiment, respectively).

This study identified the major forms of inorganic and organic P compounds that accumulated under continuous inorganic P input in a pasture soil. The majority of the added P was incorporated into soil P fractions that were chemically different to the form it was added (i.e. Ca phosphate). Most of this accumulation was as inorganic phosphates associated with aluminum and iron. However, humic P, a large and stable form of organic P, also appeared to accumulate slowly.

Keywords：*Sequential fractionation, organic phosphorus sequestration, fertilizer PUE, solution P-31 NMR*

O81-1

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Tracing Palaeo-environmental and Land-use Changes in Polygenetic Soils of the Alpine Forelands (Germany) and the Northern Alps (Austria) - a Soil Micromorphological and Pedological Approach

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In Bernstorf/Germany (500 m a.s.l.) and Bartholomaeberg/Austria (1000-1800 m a.s.l.) the formation of polygenetic soils is closely related to past human influence. Our palaeo-environmental reconstruction suggests that they are a result of long-term land-use in which fire played an important role. Using soil micromorphology and pedological data traces of fire-induced clearances, erosional events, pasturing, abandonment and regeneration could be detected in the soil profiles. Palaeo soils and surfaces as well as different colluvial layers could be micromorphologically distinguished on the basis of their specific fabric, organic components, pedofeatures and anthropogenic constituents (microscopic charcoal particles). In Bartholomaeberg buried podzols merely occur in more stable relief positions such as depressions. There, characteristic horizon sequences are still preserved. The light-coloured eluvial horizon E overlies a reddish illuvial horizon Bs enriched in sesquioxids (Fe, Al). In slope position it is more difficult to distinguish relict soil horizons from their colluvial coverage due to similar colour and soil structure. With the use of thin sections analyses B-horizons could be identified by relict features of former illuviation. The groundmass is ferruginised in form of mottling including iron hydroxid nodules. In contrast, colluvial layers are rich in all kinds of organic residues, microscopic charcoal fragments and relatively unweathered rock fragments.

In Bernstorf our micromorphological analyses reveal that in buried remnants of palaeo soils as well as in colluvial layers clay coatings are present which imply past lessivation processes. Coupled with radiocarbon dated charcoal layers, palynological and archaeological records different phases of past environmental changes such as fire-induced forest clearances for pastures and settlement as well as forest regeneration can be detected for the Bronze and Iron Age. However, in Bartholomaeberg colluvisols under recent subalpine pastures do not evidence processes of podzolisation. On the contrary, in Bernstorf lessivation is replaced by podzolisation, because of planted spruce forest. These results might emphasize the important role of vegetational changes on soil properties during different epochs.

Keywords：*Alps, polygenetic soils, soil micromorphology, relict features, fire, human influence*

O81-2

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Paleohydrology and Ancient and Historical Paddysol

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One of pedogenic processes is human intervention to generate either anthrosol by mainly agriculture and technosol by various activities such as mining, crafting, and even industrial pollution. In particular, paddy soil is an interesting anthropogenic soil developed by creating artificial habitat for rice plant which is a semi-aquatic plant. Due to maintaining standstill water state, formation of paddysol is highly associated with hydrological conditions and irrigation schemes controlled by farmers and management techniques over time.

Soil Micromorphological investigation on various samples ranging from Bronze Age to modern paddy field from archaeological sites, Gulhwa and Pyunggeo and etc, provide a good research case to untangle complicated processes of natural hydrolysis related to environmental change such as groundwater level fluctuation and human management.
Various changes of geochemistry and soil micromorphological features are examined to distinguish mechanical disturbance by cultivation practice and both mechanical chemical changes occurred in paddysol from natural redoximorphic features expected in the water related environment. Paddy soil is subjected to long-term submergence conditions with frequent intentional drainage so that various processes of typical gleying under redoximorphic environment and even more intensive degradation such as ferrolysis generates physically distinctive pedofeatures such as silty clay concentration features with changes of Si and Al value. Such phenomenon is observed in the early historic paddy soil.

This paper presents findings of Korean ancient and historical paddy soil features and also attempts to make a comparison with various types of paddy sol developed under the different climatic conditions and irrigation techniques. In conjunction with changing local environment conditions and different degree of human management over time, how anthropogenic process play a role in creating anthrosol will be discussed.

Keywords：*Paleohydrology, paddy soil, anthrosol*

O81-3

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Soil Sequences in the Young Morainic Landscapes of North-eastern Poland

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To understand the soil-landscape relation it is necessary to study the spatial diversity of soil cover. This variability is partly predictable due to the substantial repeatability of soil units (Hall and Olson 1991). Depending on dominant soil-forming factor affecting the repeated soil patterns, different types of soil sequences can be distinguished. The influence of relief on the repeated variability of soil cover was first noticed by Milne (1935). He proposed the term 'catena' to describe a transect of soils that are related to the topography. Sommer and Schlichting (1997) distinguished several archetypes of catenas depending on the mobilization processes and hydrological regimes. The impact of climate on the variability of soil cover is described as climosequences (e.g. Stiles et al. 2003). Chronosequences are a suitable tool for investigating rates and directions of soil and landscape evolution (e.g. Sauer et al. 2012). A characteristic feature of the young morainic landscapes in Poland is remarkably heterogeneous soil cover. This pedological diversity in this area is a result of different natural and human-induced soil-forming processes. Since the end of the 10th century, this area has suffered a heavy soil erosion, aggravated by agriculture and deforestation. The strongest transformations occur in regard to arable soils developed on ground moraine deposits in hummocky moraine plateau landscapes. The degree of anthropogenic transformation is insufficiently detected. The aim of presented studies is to determine the typical sequences of soils developed within young morainic landscapes. In order to estimate the impact of agricultural activities the comparison of soil sequences located in the rural area with natural catenas under forests have been made. The field works were carried out in Brodnica Landscape Park. More than 300 augerholes were located in characteristic points of mezorelief and 40 sites were selected for soil pits. Four conceptual models of soil sequences (two representative of forests and two of agricultural areas) were created. The soils occurring in transects along the forested slopes formed hydro-toposequences. Topography is the dominant factor influencing spatial diversity of soils in forests sequences. This factor significantly modifies the hydrological conditions along slopes. Fully developed Luvisols without influence of ground water occupied crests, shoulders and back slope positions. Soils with clear signs of groundwater influence (Gleysols, Gleyic Chernozems and Gleyic Umbrisols) occurred in toe slopes and bottoms of depressions. In some cases high groundwater level within lowest topographic positions led to the formation of Histosols. The sequences representing the arable areas shows much greater soil diversity. An additional factor contributing to this variation is human-induced erosion. The summits of moraine hills covered pedons resulted from total erosion of original soil profile, classified as Regosols or Calcisol. These soils are subtly transformed by pedogenic processes. Total erosion of original soil horizons is evidenced by presence of significant quantity of calcium carbonates even at the surface horizons. In the top, convex sections of slopes dominated eroded Luvisols ABtp-Bt-Ck. Lack of eluvial horizons resulted from partial truncation of these soils. The Luvisols with preserved eluvial horizons mainly occur in the middle and lower sections of slopes. Immediately at the bases of slopes and in depressions, there are Colluvis Regosols of variable thickness of colluvium covering soils rich in organic matter - Gleyic Chernozems, Gleyic Umbrisols or Histosols. The presented study demonstrated a key role of accelerated erosion in shaping the present soil cover in young morainic landscapes of Poland.

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Keywords：*soil sequences, colluvial soils, young morainic landscape, human-induced erosion*

O81-4

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Microtomographic Studies of Loamy Soils: Problems and Prospects

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Macro and micro X-ray tomography is a relatively new and non-destructive method to study soil structure and its relationship to soil processes. Digital information obtained by tomographic studies can be directly utilized to analyze and model numerous soil properties on different length and time scales. Though the necessity and significant prospects of tomographic studies in soil science are evident, a number of methodological problems related to the specificity of soils as their object are still to be solved.

First and foremost, the mutli-scale nature of soil structural units should be taken into account. Aggregates of different scale orders usually differ significantly in their internal structure. Therefore, microtomographic data on small samples cannot be extrapolated over larger objects. In this context, in the work with soil samples, the choice of the necessary and sufficient resolution and sample size is of paramount importance.

An important problem is related to the polycomponent nature of soil bodies. Except for aggregates and pores, soils contain numerous pedofeatures (soil neo-formations) and inclusions that are of great diagnostic value. These are the accumulations of clay, organic matter, heavy metals, salts, plants residues, etc. There are also pedo- and litho-relicts and anthropogenic inclusions (artifacts). In contrast to pore space, many of these elements of the soil mass may be poorly distinguished in X-ray shadow projections. Special regimes of exposure and special techniques for image processing should be developed for enhancing contrast to view these features. Another problem is related to the surface position of soil horizons. Their direct contact with the atmosphere specifies the great temporal variability in the soil temperature and moisture. Thus, in addition to the spatial variability, temporal dynamics of the soil mass may affect the representativeness of the samples and the reliability of the results of interpretation of tomographic images.

In Russia, tomographic soil studies began in 2011 in the Laboratory of Soil Physics of the V.V. Dokuchaev Soil Science Institute of the Russian Academy of Agricultural Sciences. These studies are continued in close cooperation with the Geological Faculty of Moscow State University. In this contribution we mainly discuss structure of major genetic horizons of a clay loamy soddy-podzolic soil in the center of European Russia; differentiation of major structural characteristics in the soil profile, as well as the difference between these characteristics in the soil horizons and in the underlying parent material. The structure of plow horizons of a typical chernozem and the morphology of salt and Fe-Mn pedofeatures in different soils have been also studied in detail.

Further development of tomographic soil studies in the Dokuchaev Soil Science Institute is planned for solving various theoretical and applied problems. These studies are currently performed with due account for different hierarchical levels of the structural organization of soils:

1. Soil profile scale. The profiles of soil pore space have to be studied as vertical sequences of different forms of the soil pore space reflecting the structural state of soils and their separate morphological elements and in dependence on the soil genesis.
2. Soil horizon scale. The specificity of morphological and physical properties of the soil mass are studied in genetic soil horizons and at various interfaces existing in soils (lithological discontinuities, boundaries between organic (litter) and mineral soil layers, transitional horizons, etc.)
3. Soil aggregate scale. The morphological and physical properties of separate soil aggregates are examined, including intra-aggregate pore space in order to diagnose the soil structure, model soil aggregation processes, analyze shrink-swell processes, etc.

Keywords：*microtomography, soil structure, pore structure, hierarchy of soil morphology*

O81-5

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Modelling Pedogenesis in the Anthropocene

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The objective of this paper is to develop a framework for pedogenetic modelling in the Anthropocene, i.e., the present geological epoch during which humanity has become the main factor impacting the environment. We review the concepts of soil evolution as well as 15 existing quantitative models to determine the features of soil evolution modelling in an Anthropocene context. We emphasise soil-plant interactions by considering the importance of vegetation, both as a provisioning service and as a factor in soil evolution. Our review covers output variables, time scales, spatial representation, model structure, and control variables. Our synthesis in this work demonstrates that the modelling of pedogenesis in the Anthropocene requires the following specific features: (i) a description of the human impact on soil evolution, (ii) outputs related to ecosystem functions and services, (iii) the integration of a dual time scale (decade and cyclic shorter-term), (iv) multiple and interactive processes modelling, (v) the simulation of vegetation and its feedback on soils, and (vi) a representation of spatial heterogeneities, at least at the profile scale. No specific models of soil evolution in the Anthropocene have been developed thus far; however, certain required characteristics have been integrated into existing soil-plant models. Some others features will require further development, particularly a coherent and tested conceptual cornerstone that enables dual-time-scale modelling and is based on the resilience concept and energy metrics. We thus propose a general framework as a conceptual basis from which we can develop models of pedogenesis in the Anthropocene.

Keywords：*Soil evolution, Soil functioning, Resilience, Soil-plant interactions, Dual-time-scale, Decadal time scale, Energy metrics*

O82-1

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Globalsoilmap- the History, Vision and Way Forward

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GlobalSoilMap is being developed to provide primary soil data in a form that will meet the demands of a broad range of users including governments, natural resource managers, educational institutions, planners, and researchers. The online system will provide access to the best available soil and land resource information in a consistent format across the globe - the level of detail and reliability will depend on the survey coverage, field and environmental co-variate data available in each region. The purpose of the GlobalSoilMap project is to provide consistently produced soil property information at 100 m resolution to aid in solving some of the key environment and societal issues including food security, water security, global climate change, land degradation and carbon sequestration.

The GlobalSoilMap project consists of a global consortium of scientific institutions involved in soil survey and soil science. The GlobalSoilMap consortium was formed in 2006 by the International Union of Soil Sciences Working Group for Digital Soil Mapping. Soil Scientists from around the world and representatives from the user community along with potential donors were instrumental in setting up this project. Although the project has a consortium agreement and some formal structure for its governance, it is a bottom-up project whereby institutions across the globe can work on GlobalSoilMap products. Task groups have been organized to support the project that include: Methods, Training, End-user engagement, Specifications and Data/cyber infrastructure. Project standards and specifications have been produced and these are freely available.

This global soil science project has unique features including a definition of a product (e.g. a designed set of raster of soil properties, fixed depths, resolution, uncertainties) but there is autonomy for users and producers in the choice of methods to arrive at these products. Of course, the methods need to be documented, but they differ between different parts of the world because of differences in available data, technical expertise and preference for particular prediction methods.

In the past five years, we have seen that many groups in all parts of the world have started working towards GlobalSoilMap products with some countries producing data that follows the standards and specifications. The future challenge may be to stitch these different national and regional products together to arrive at a global cover of soil properties at 100 m resolution. We have also seen that groups started working on global products using existing information. These parallel approaches will require enhanced coordination, but the unique bottom-up characteristic of this project requires a distinct global coordination approach. A global top-down approach will not work given the sensitivity and restrictions of national soil information.

Keywords：*GlobalSoilMap, digital soil mapping, task groups, uncertainties*

O82-2

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Model Averaging for Combining Disaggregated Analogue Soil Maps with Those from Scorpan Kriging: Experience from the Dalrymple Shire, QLD, Australia

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Traditional soil maps are the legacy of a skilled group of individuals who invested much expertise, time and cost to produce them. In more recent times, digital soil mapping has matured to become more of the mainstream method for producing soil maps. Digital soil may offer important operational, technical and statistical advantages to analogue soil mapping. However, experience suggests that contemporary soil mapping projects will be the richer, and more informed by including analogue soil mapping within the digital soil mapping framework. Acknowledging other efforts to address this desire, we take an alternative route in this study by investigating model averaging as a possible combinatorial approach.

Investigating soil pH variability to 2m (at the regular depth intervals of 0-5cm, 5-15cm, 15-30cm, 30-60cm, 60-100cm, and 100-200cm) across the 68,000 km2 Dalrymple Shire, QLD, Australia, first, an existing analogue soil map was disaggregated from generalised mapping units to explicit soil class via the newly developed DSMART (disaggregation and harmonisation of soil map units through re-sampled classification trees) algorithm. To derive the soil pH map from this disaggregated product, the PROPR (for "digital soil property mapping using soil class probability rasters") algorithm was implemented. Secondly, using 1080 soil point data (previously collected from the area) and scorpan kriging methods, a soil pH digital map was produced also at the regularised depth intervals to 2m. For both types of digital soil maps, the mapping resolution was 30m.

For ensemble modelling, we investigated the use of common model averaging approaches: equal weights (EW), Bates-Granger or variance weighted (VW), Granger-Ramanathan (GRA), and Bayesian model averaging (BMA).

Neither the disaggregated soil map nor the scorpan kriging map was particularly accurate. Predictions from model averaging however did improve upon the accuracy, where at all depths, the combined predictions were an improvement to either of the contributing soil maps alone. Besides EW, the weightings attributed to the model averaging models tended to favour the scorpan kriging soil maps. While we did not determine a standout model averaging approach for this study, we would recommend the use of GRA for digital soil mapping applications for the first reason that its performance is equal to or better than the generally preferred BMA approach, yet is far simpler to implement. Secondly, for applying the model averaging predictions and estimating their uncertainties spatially, it would be far more efficient using GRA compared to the any of the other averaging approaches used in this study.

Keywords：*scorpan kriging, soil map disaggregation, model averaging*

O82-3

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Spatial Disaggregation using Random Toposequences

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Spatial disaggregation of legacy soil maps is an emerging facet of digital soil mapping research. Most spatial disaggregation methods attempt to downscale soil map unit information in order to map the soil class constituents of the map units individually. Spatial disaggregation techniques often rely on resampling the legacy soil map in order to build a dataset of samples with which to calibrate a predictive model. A matter of fundamental importance is determining how to allocate the samples to soil classes given we don't actually know what the true soil class at those locations are. Our DSMART algorithm (Odgers et al., 2014) allocates sampling points to soil classes at weighted-random using the reported within-map-unit proportions of the relevant soil classes as weights. This is a less arbitrary approach than using a simple random allocation or assigning the sample to the dominant soil class in the sample's map unit.

The data structure of the metadata supporting legacy soil maps is very diverse between jurisdictions and even over time in the same jurisdiction as methods or purposes change. Although it is not uncommon for the reports accompanying legacy soil maps to identify the soil class constituents of soil map units and an estimate of the proportion of the map unit which they are assumed to occupy, not all soil map reports contain the information in this format. On the other hand some soil map reports describe the typical toposequence found in each map unit as a list of soil classes and the slope units (crest, upper slope, lower slope and so-on) on which they are typically found.

As a result, we extended the DSMART algorithm's map resampling routine to enable it to sample along random toposequences (Odgers et al., 2008) within each map unit. In this approach samples are essentially allocated to the soil class assumed to occur on the slope unit at the sampling location. This approach is less arbitrary than the approaches described above because it takes position on slope into account and as such allocations should be more correct. The approach is demonstrated on a legacy soil map from New South Wales, Australia.

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Keywords：*digital soil mapping; spatial disaggregation; random toposequences; classification trees*

O82-4

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Pedogeomorphometry, Integrating Empirical and Mechanistic Models for Better Prediction of Soil over Space and Time

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Pedogeomorphomometry attempts to combine empirical digital soil mapping, and process-based soil dynamic modelling for a better representation of soil properties, processes and entities over space and time. While digital soil mapping has been successfully used to predict the spatial distribution of soil, estimates are based on empirical relationships that are in general non-transferrable and involve no underlying mechanisms. Furthermore, the change in dynamics of soil properties such as soil carbon over time requires us to consider the time dimension in our maps. On the other hand, mechanistic or process-based models have been used effectively to predict the state of change in soil properties (e.g. soil carbon) at points in the soil landscape. Digital soil maps which provide the spatial distribution of soil properties which are usually used as inputs to a mechanistic model to predict the future change of soil properties under different scenarios. However, we need to reverse this role and use our process-based understanding of a mechanistic model to help us make a better prediction of the spatial distribution of soil properties. This paper will therefore discuss pedogeomorphometry as an approach of dynamic spatiotemporal modelling of soil processes.

The mechanistic model simulates soil development in a 3 dimensional space to include the most significant soil formation processes, ranging from weathering to clay translocation, and combines this with the horizontal redistribution of soil particles through erosion and deposition. The model is spatially explicit and it represents the vertical variation in soil horizon depth as well as basic soil properties, i.e. texture and organic matter content.

The use process-based model in mapping accounts for the uncertainty in the processes that generated the data. Combining observations with the 3D models allows for a greater understanding of the process underlying the distribution of some spatiotemporal data.

Keywords：*soil mapping, clorpt, mechanistic model*

O82-5

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Modelling of Soil Carbon Variability and Trajectories across the Conterminous US

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Over the past decades a changing climate, land use shifts such as increased urbanization and decline in wetlands, intensification of management, and disturbances such as wildfires have had a tremendous impact on the spatial and temporal variation of soil carbon across the United States. How soil carbon interacts with such changing environmental forcings at the continental scale is still poorly understood. This motivated us to synthesize historical (~1925) to current soil organic carbon (SOC) trajectories and 750+ geospatial time-dependent environmental datasets for the U.S.. The following objectives were pursued: (1) Assess temporal trends in SOC stocks, (2) Investigate the relationships between SOC stocks and soil types, topography, ecology (ecoregions), and geology, and (3) Elucidate on the impact of environmental forcings – climate, water, land use/land cover, and humans – on SOC stocks. We present an integrated SOC assessment across a landscape about 9.8 million square kilometer in size which covers diverse climatic zones (from semiarid to wet tropical), a multiplicity of biomes, land uses, and management types that have generated a diverse mosaic in SOC from less than 10 Mg ha-1 to more than 3000 Mg ha-1 (0-100 cm soil profile). Climate variations (1979 – present) ranged from monthly averages of -12.2 °C to 32.9 °C with profound spatial and temporal variations. We assembled space-time sequences of environmental covariates from various sources: Spectral indices from remote sensing, such as the Moderate Resolution Imaging Spectroradiometer, MODIS; soil moisture data from the European Space Agency; gamma ray data from the U.S. Geological Survey; primary and secondary topographic attributes from the National Elevation Dataset; temperature and precipitation data from PRISM Climate Group, and many more. In addition SOC concentration and bulk density data were acquired from the National Cooperative Soil Survey Characterization Database (n = 258,094 horizons; ~1940 to current) and the Rapid Carbon Assessment Project (n = 144,833 horizons; 2010/2011). Various statistical and mixed statistical/geospatial methods were used to relate SOC and environmental covariates to investigate our objectives. The independent validation of SOC models included assessment of accuracy, bias, and model uncertainty. The characterization of SOC stocks along lithologic, pedogenic, topographic, biotic, and climatic trajectories provides new insight into causes and effects of soil carbon accretion.

Keywords: *soil organic carbon, space-time mapping, digital soil mapping, global climate and land use change*

O82-6

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Mapping the Functionality of Soils in Scotland using a Neural Network-based Digital Soil Mapping Approach

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A framework is demonstrated for automated mapping of soil parameters and functions in Scotland. This framework links georeferenced field observations with preprocessed spatial datasets of a number of environmental parameters, allowing rapid development of a dataset consisting of the original observations plus site characterisations. A neural network modelling approach is then used to develop and test a model with this information, which is then used to map the parameter or parameters of interest across Scotland at 100m resolution. We show that predictive accuracy varies between soil parameters, with certain parameters of interest (e.g. rooting depth, pH, LOI, CEC, profile depth, Ca, Mg) being well predicted and some others (e.g. size fraction parameters) being moderately well predicted. The framework relies on existing spatial datasets and can incorporate others as and when they become available. We discuss the effectiveness and flexibility of this neural network digital mapping approach in comparison with other methods

Taking the method a step further, we show that the initial mapping of soil parameters can be used to generate maps of soil functions, by one of two approaches: in the first, we use the parameter maps, linked with pedotransfer functions, to produce maps of three soil functions (carbon storage, primary production and water storage capacity). In the second approach, we first derive values for these same three functions at points where the relevant soil and environmental parameters are known, and then map the function values directly using the neural network mapping approach. The two approaches are compared, both in terms of their suitability for application under specific circumstances and the spatial distribution of their predictions. Finally, we describe mechanisms for mapping the importance of individual input parameters and for mapping the uncertainty in the map values generated. The framework has the potential to improve digital soil data for Scotland, and also for other parts of the world, in terms of spatial resolution and estimates of uncertainty. It can also be used for mapping 'higher-level' functionality of the soil with relevance to a number of ecosystem services.

Keywords：*Digital Soil Mapping, Neural networks, Soil functions, Scotland*

O82-7

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Operational Digital Soil Mapping at National Scale: Application of Random Forest to Spatial Prediction of Soil Particle-size Fractions

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There is a dearth of accurate and spatial soil information in most developing countries especially at the national scale where most developmental policies on land resource allocation, food security, environmental management and climate change mitigation are carried out. Therefore this study was aimed at predicting soil particle-size fractions (PSF) for Nigeria at the national scale. The predictive power of Random Forest (RF) in modelling PSFs was examined and compared with other popularly known prediction models like Classification and Regression Tree (CART) and Generalized Linear Models (GLM). Equal-area quadratic splines were fitted to Nigerian legacy soil profile data to estimate clay, sand and silt content at six standard soil depths (0-5, 5-15, 15-30, 30-60, 60-100, and 100-200cm) in line with the GlobalSoilMap project specification. This was done by first estimating the PSFs values at the standard depths using the spline functions, followed by additive log-ratio (ALR) transformation of the PSFs. The ALR PSFs were then predicted across the study area. Results showed a better prediction performance (based on 33% model validation) by RF compared to CART and GLM models. Although CART gave a better prediction at upper depth intervals relative to GLM, GLM out-performed it at lower depth intervals. Generally, prediction error increases with depths for the three models (e.g., R2 of 0.45-0.53; RMSE of 13.59-14.44 for clay at 0-5cm and R2 of 0.04-0.16; RMSE of 15.60-18.71 at 100-200cm). The inclusion of depth as predictor variable significantly improved the prediction accuracy of RF especially at lower depth intervals. While overall, RF predicted higher clay content in the eastern region compared to the western part of the country, CART and GLM predicted higher clay content in the north-western part. There is higher sand content in the western region compared to the eastern parts of Nigeria. Significantly the results could be used for national planning such as alternative agricultural production (grazing) systems vis-a-vis environmental sustainability.

Keywords：*Digital soil mapping, Environmental Sustainability, Particle-Size fractions, Random Forest*

O82-8

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Evaluating Total Carbon Stocks using Satellite Images in a Subtropical Wetland: the Everglades, Florida, US

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Wetland soils are able to exhibit both consumption and production of greenhouse gases and they play an important role in regulation of the global carbon (C) cycle. Yet it is challenging to accurately evaluate the actual amount of C storages in wetlands. The incorporation of satellite images into digital soil models has great potential to assess C dynamics in wetland soils. Our objectives were to (i) develop C stock prediction models utilizing satellite images and environmental ancillary data, (ii) identify the largest predictive environmental factors controlling the spatial distribution of soil C, and (iii) assess the amount of C stored in a prominent nutrient-enriched wetland. We collected a total of 108 soil cores at two soil depths (0 – 10 cm and 10 – 20 cm) in a C-rich ecosystem: Water Conservation Area-2A (WCA-2A), Florida, U.S. We used Random Forest (RF) to predict soil C stocks and identify environmental variables that control the spatial distribution of soil C stocks using field observations, environmental ancillary data (topography, hydrology, and geology), and spectral data derived from satellite images including SPOT (spatial resolution: 10 m), Landsat ETM+ (30 m), and MODIS (250 m). The RF models for both soil depths showed high performance to predict total C stocks with a R2 between 0.85 to 0.92 and a root mean squared error between 0.75 to 0.86 kg m-2. Highly ranked importance variables controlling the spatial distribution of soil C stocks in WCA-2A carried information relating to hydrology and/or vegetation. Results showed a low ranking of elevation in the prediction models suggesting that topographical variables are less important in controlling the distribution of C stocks in our study area, which is dominated by smooth/flat topography and macrophytes commonly found in subtropical wetlands in Florida. The RF models showed that WCA-2A stores about 1.96 and 2.24 mega tons of C in the 0 – 10 cm and 10 – 20 cm soils, respectively. The RF models in WCA-2A yielded about 9.7 kg m-2 soil C stocks in the top 20 cm and it was higher than 7.3 kg m-2 which is the median of estimated soil C stocks stored in all of the U.S. wetlands in the top 20 cm. Our results showed that WCA-2A stored a tremendous amount of C in soils and that the hydrologic regime was the most important factor. Results suggest that appropriate management of the wetland, such as water table position and inflow rate, is critical to maintain its potential ability to maintain and sequester C into soils. Sequentially reproducible assessment methods are necessary for measuring and monitoring the impacts of climate change in C storage capacity of the wetland and our methodology suits the need well and it will provide useful information to preserve the wetland's role as a C sink.

Keywords：*soil carbon stocks, wetlands, satellite image, random forest*

O82-9

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Spatial Distribution of Soil Organic Carbon in Southern Greenland Assessed following the Globalsoilmap.net Specifications

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Soil organic carbon (SOC) stocks in the Arctic are generally poorly constrained due to limited data and large soil variability. The current and anticipated future climatic changes in the region are furthermore demanding more detailed knowledge on soils organic carbon here. It is anticipated that soil temperature change in combination with land use change will drive changes in soil organic matter turnover which in turn will affect CO_2 and N_2O emissions. This is of paramount importance since large part of the sub-arctic areas are peatland (Helama et al., 2011). Recent studies have suggested that SOC stocks in arctic and subarctic ecosystems may be underestimated by a factor of two (Hugelius et al., 2013). This is mainly considered to be due to underestimated storage in cryoturbated permafrost soil and peatlands (Burnham & Sletten, 2010). As an example is the current understanding of SOC stocks and variation in southern Greenland based on a limited number of pedons and field data (e.g. Jacobsen & Eiby, 1997). A soil map of greenland was published recently (Jones et al, 2010) but sampling was designed for large scale maps only.
It remains thus to be re-assessed how large the SOC stocks are in southern Greenland, and as part of this, to assess how soils in general will respond to the predicted warming climate and anticipated expansion of agricultural cultivation in this region. We will present the basics for establishing methods for a soil resource database following the Globalsoilmap.net specifications (Minasny & McBratney, 2010) with special focus on SOC which can address the above questions.
A pilot study was established near Qaqortoq in Southern Greenland to study soil variability by Digital Soil Mapping applications (McBratney et al, 2003). One of several objectives was to map and predict the spatial distribution of SOCand its stock in the top soil layers. The study site was chosen to be representative for southern Greenland in a future, warmer climate where fields for winter fodder production dominate in suitable low elevation areas, whereas higher landscape positions have grazing land or is bare rocks. This insured the best unbiased representation of all geomorphologic units characterizing the area. Soil samples were collected in intervals from 0 to 15 cm depth at each 200 m grid intersection within a study area of approximately 6.5 km^2. The elevation was 0-400 m a.s.l. Permafrost is considered discontinuous and found above our max. height of sampling only. Samples were analyzed for SOC (g kg^{-3}), stone content and bulk density (g cm^{-3}).
A prediction soil organic C model based on SCORPAN' kriging was produced where the relationship between observed SOC content and SCORPAN variables was quantified with regression techniques. The maps generated at a grid size of 90x90 m for the entire study area. These maps of SOC content may serve as a first basis for a more detailed assessments of SOC stocks and variability in southern Greenland, and allow us to evaluate whether current estimates of SOC storage in this area are underestimated.

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Keywords: *Greenland, Globalsoilmap.net, Soil organic carbon*

O82-10

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Application of Spatial Simulated Annealing Method on a Soil Sampling Scheme in the Road Surrounding Region

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This study is conducted to clarify the impact of different sampling schemes on accurate interpretation of soil knowledge, such as the spatial variation of soil organic matter (SOM). Based on the spatial distribution of the road, the sampling schemes were formed. First, the simulated annealing was carried out for optimising the sampling layout patterns of SOM in the five different road surrounding regions among eastern part of Zhongxiang county. Second, based on surface analysis, the topographic factors were extracted from DEM data, including slope, aspect, plane curvature, profile curvature, topographic wetness index (TWI), stream power index (SPI) and sediment transport index (STI). After that, the topographic factors and optimised SOM samples were used for finding out the quantitative soil-landscape models, which would be used to forecast the SOM level. The models were developed by means of multiple linear regression (MLR) and multilayer perception (MLP) separately, and their accuracy was distinguished by MSE, NMSE, et al. The results reveal that exactly soil-landscape knowledge can elicit from optimised sampling scheme, and the predicted accuracy reaches the significant level and it is better than the accuracy of the original samples. According to the study, the low cost and high efficiency sampling pattern can be designed by taking advantage of the available information, such as the spatial distribution pattern of the road, historical samples and soil survey data. The study proposes a reasonable, theoretical and scientific means for displaying and surveying the spatial distribution pattern of soil organic matter in the whole region of Zhongxiang county.

Keywords：*soil-landscape model; spatial simulated annealing; multilayer perception; sampling optimization*

O83-1

[WG11] Soil Information Exchange Standards and Systems

Developing International Soil Information Exchange Standards

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Soil data and information should be useable both within the soils community and by other communities of practice, such as for global climate change and food security modelling. Soil researchers, practitioners and users of soil data need to recognise the inherent asset value of soil data and information and ensure it is appropriately managed and used. Information may be power, but such power can only be efficiently and effectively harnessed through appropriate life-cycle management of data and the application of well governed soil information standards.

A number of initiatives have been developing soil data and information exchange standards at local, national and regional levels. These include activities under the auspices of the ISO, European INSPIRE, eSoter, GlobalSoilMap, the UN FAO Global Soil Partnership, German GS-Soil and the Australian Collaborative Land Evaluation Program, to name but a few. The IUSS Working Group on Soil Information Standards (WGSIS) was established in 2010, in recognition of the need for the international soil community to provide leadership, coordination and cooperative governance of soil data exchange standards. The IUSS WGSIS has since held a number of meetings to develop a terms of reference, work plan and web presence, and to progress coordination and alignment of relevant soil information standards initiatives. The WGSIS recognises the global need for soil information model harmonization at a high level to allow exchange and collation of consistent data, whilst respecting the needs for specific extension or constraint of models to facilitate country, agency or project specific outcomes. This paper presents the WGSIS's latest concept and progress in developing an integrated hierarchy of international standards which will support soil data and information exchange between countries, regions, national institutions, agencies and a wide variety of users.

Keywords：*data standards, information models*

O83-2

[WG11] Soil Information Exchange Standards and Systems

Iso and Inspire for Digital Soil Data Exchange- Extensions, Improvements and Potential Feedbacks between Similar Standards

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With the International Standard ISO 28258 – Soil Quality – Digital Exchange of Soil-Related Data and the Data specifications Soil (DS SO) of the Infrastructure for Spatial Information in Europe (INSPIRE), two in their basic ideas similar application schemas based on GML and Observations & Measurements (OM) have been developed during the last years. While DS SO is embedded in a legally based data infrastructure covering 34 themes of environmental importance, ISO 28258 stands alone.

Both standards cover somewhat different purposes. ISO 28258 more aims at exchange of both raw or even to-be-obtained data and quality-assured, product-like soil data, while DS SO will essentially be used for the latter kind of data only. Therefore DS SO also includes further data products, e.g. spatial datasets holding information derived from soil (and possibly other) data, and covers not only vector, but also raster datasets. ISO 28258, in contrast, can even be used to send analytical requirements to a laboratory.

The basic objects described are nonetheless similarly defined, e.g. typical objects of soil science like soil profiles and horizons. The difference between both application schemas is in naming and – more substantial – in different relations between the objects. Nonetheless comprise both application schemas mere meta-models that have to be customized when soil data shall be exchanged. DS SO uses extensible codelists for attribute parameters that shall be managed in registries. In ISO 28258, this aspect is, although intended, not well defined. Both aspire interoperability of data on the object level, and leave interoperability of semantics – on the attribute parameter level – less defined. In DS SO, this will probably be handled by controlled codelist extensions in a central INSPIRE codelist registry.

For ISO 28258, no central institution could take over this task. Semantic interoperability could nonetheless possibly be reached by a well-maintained vocabulary or thesaurus. This should explicitly be included in an improved edition, in which several technical shortcomings had to be addressed anyhow.

Keywords：*Soil data exchange; INSPIRE; ISO 28258; Application schema*

O83-3

[WG11] Soil Information Exchange Standards and Systems

European Soil Data Centre: a Spatial Data Infrastructure for Research and Policy Making in Europe

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In the context of the European Union's Soil Thematic Strategy, policy makers require easy access to soil data and information of various types and scales to assess the state of soils at European level. To satisfy this need, the European Commission and the European Environment Agency decided to establish the European Soil Data Centre (ESDAC), located at the European Commission's Joint Research Centre. The ESDAC is one of ten environmental data centres that have been established in support of policy development, implementation and monitoring by the European Commission's Directorate General for Environment.

The ESDAC, located at http://esdac.jrc.ec.europa.eu, has become the focal point for soil data and information at European Union level by hosting a series of soil products and web-based tools that allow access to the data. The ESDAC infrastructure provides the main input datasets for (land-relevant) research at European level and assist policy making by providing information, maps, aggregated data and indicators. The European Soil database (covering large part of Eurasia and Mediterranean) is the main source of information together with datasets on soil threats: soil organic carbon (Stocks, Content), soil erosion, soil compaction, salinization, landslides and contaminated sites. The ESDAC authentication system has delivered more than 2,100 data licenses in 2013 (35% increase compared to 2012) for the 25 available datasets.

The ESDAC supports an increasing number of customers from the European Commission and Member States and even from outside Europe (18%). Data have been requested from users coming from more than 110 countries in the World. ESDAC user base includes more than 4,000 scientists following the soil-relevant activities at European level.
They range from policy makers, public organizations and local authorities, and public administrations to research institutes, technical institutions, universities and schools, modeling groups, research projects and citizens. Most of the data requests (around 67%) is done for research purposes (Modeling, Research projects, PhDs, manuscripts, etc). ESDAC data and information are highly relevant for the development, implementation and assessment of a number of EU policy areas: agriculture, soil protection, bio-energy, climate change, food security, nature protection, biodiversity, development policy, health, protection of citizens, research and sustainable development.

ESDAC contributes to open access to science and data in Europe (as set for the HORIZON 2020). The ESDAC is as "open" as legally possible, meaning that if data and information resident in the ESDAC can legally be published, the system will do. Even when a product is protected for access by only privileged users, efforts will be made in order to present its metadata to the user.

Keywords：*Data Centre, ESDAC, policy making, research project, data managemebnt, harmonisation*

O83-4

[WG11] Soil Information Exchange Standards and Systems

Best Practice Guidelines for Soil Data Harmonization

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Web-GIS has immensely improved the accessibility of digital soil information. However, the data content is usually focussed on a regional or national context, and cannot be generalised further: soil data very often do not fit geometrically and conceptually at administrative borders. Soil data do not communicate with each other in a user friendly way, and larger data bases still require an immense manual input by data collectors and technicians.

Experiences from harmonization in the field, and data documentation and harmonization plentifully exist. Yet, data providers fear harmonization because it requires either the adaption of own data collection concepts, or the very difficult task to harmonize after the data were collected.

Recently, a recent European project about the assessment and strategic development of geodata services (GS Soil) has collected experiences from an extensive review through the literature. Harmonization methods were applied and extended in 9 test cases. The test cases cover a broad range of data types and levels of resolution throughout Europe. The final results are now available as a best practice documentation; it will be discussed in the frame of global data base building and global earth observation.

Keywords：*soil data harmonization*

O83-5

[WG11] Soil Information Exchange Standards and Systems

Towards an Ontology-based Soil Information System

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Environmental information is critical to the sustainable use and management of the world's resources. Soils are a fundamental part of the environmental information requirement. They underpin agricultural sustainability and food production, climate change and carbon sequestration, biodiversity conservation and the provision of ecosystem services, human health and infrastructure development [1]. Appropriate soil data and information are crucial to support evidence based policy, planning and resource management decisions [2].

For data to be useful, one basic requirement is that they be interpretable. Sufficient information should be provided to allow data to be unambiguously interpreted and used. Examples of such information include the location at which the soil was sampled, the property that was measured, the unit of measure, and quality assurance and quality control information. Furthermore, data should be easily integrated with other data sources, which is typically required in an application. For example, simulation of crop production may require, besides soil data, also weather, crop and fertilizer data.

To meet these requirements, we intend to develop an ontology-based soil information system. Central to our approach will be the use of a soil ontology, which captures the essential semantics of soil data to better facilitate data discovery and integration. Ontologies provide a formal representation for defining concepts and relationships within a domain of interest, which can be used to draw logical conclusions without human intervention. For example, suppose that the texture of the soil is determined by its particle-size characteristics (e.g. plasticity index), and such knowledge has been captured by the ontology. Then, given a sample, the system can use the ontology (through a reasoner) to automatically classify whether the soil is sand, clay or silt. As ontologies represent a shared understanding of a domain, they inherently facilitate integration and exchange of data. Moreover, by building on Semantic Web technologies, e.g. the Resource Description Framework (RDF, http://www.w3.org/TR/rdf-primer/) and the Web Ontology Language (OWL, http://www.w3.org/TR/owl-features/), and following Linked Data principles, data can be published on the Web, linked and integrated with other data sources.

We have developed an initial soil ontology. The ontology includes some generic concepts describing observations and measurements, e.g. Site, Position, Property, and Unit, and some domain-specific concepts describing soil information, e.g. SoilOrder, SoilTexture, SoilLayer, and SoilProperty. We model SoilProperty as a type of Property, and define three types of SoilProperty, SoilGerneral Property, SoilPhysicalProperty, and SoilChemicalProperty. An example of SoilGeneralProperty is SoilLayerDepth. SoilPhysicalPropery can be BulkDensity, DrainedUpperLimit, or CropLowerLimit with respect to a particular Crop, and SoilChemicalProperty can be pH, Nitrogen, or Sulphur. The ontology also defines relationships among concepts, e.g. hasPosition, and restrictions on relationships, e.g. a Site has exactly one Position. In the future, we plan to align the ontology with the OZSoilML feature model which is currently being developed through ACLEP (http://www.clw.csiro.au/aclep), as well as with existing modelling efforts on observations and measurements (e.g. OGC O&M model). As a proof of concept of the use of the ontology, we are going to map APSoil data(http://www.apsim.info/Products/APSoil.aspx) onto the ontology, make data available in RDF format on the Web, and link it to other data sources.

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O84-1

[C3.2-1] B: Soil Erosion and Degradation on Agriculture Land

Soil Erosion at European Level: a Step Forward data Harmonization and Collection with the Contribution of a European Network

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In 2010, the European Soil Data Centre (ESDAC) of the European Commission conducted a data collection exercise on soil organic carbon and soil erosion from national institutions in Europe, using the European Environment Information and Observation Network for soil (EIONET-SOIL). The objective of this data collection was to present the official status of the countries as Member States often 'disagree' with the pan-European modelling results (PESERA, RUSLE, MESALES).

ESDAC requested participating institutes (the National Reference Centres for Soil) to provide their best data on actual soil erosion (as tonnes per hectare per year) in a grid of 1km resolution.

Even if the EIONET network has 38 countries (28 Member states of the European Union plus candidate countries), soil erosion data have been received from 14 countries. Among the submitting countries, only 8 countries (Austria, Belgium, Bulgaria, Germany, Italy, Netherlands, Poland and Slovakia) have provided almost complete data (covering more than 50% of the country) according to the specifications set in the data request protocol. The rest 6 countries (France, Denmark, the former Yugoslav Republic of Macedonia, Ireland Norway and Estonia) have provided data that could not serve for a nationwide comparison.

This data collection was the first attempt to perform such an exercise at European level envisaging the application of a future Soil Framework Directive where data coming from Member States will be collected, checked, harmonized, stored and made available through the European Soil Data Centre. The metadata (model used, land uses, period, input factors) accompanied the data proved of extreme importance for the correct interpretation of the data. The current findings could have greater value if large countries (Romania, Sweden, Finland, United Kingdom) or countries with potentially large soil loss (Spain, Greece, Portugal) would have contributed to the data collection. The main reason for the limited participation was that national institutes were not legally obliged to provide the requested data.

The EIONET-SOIL erosion data come from application of the Universal Soil Loss Equation – USLE (Wischmeier and Smith, 1978), and its more recent version (RUSLE) revised by Renard et al. (1997). The average erosion rate is 2.32 t/ha/y for the whole area of the eight countries which submitted data. The highest average erosion rates were reported for Italy(6.60 t/ha/y) and the lowest rates by the Netherlands (0.25t/ha/y).

The EIONET-SOIL erosion data were compared to the PESERA dataset (the only available harmonised pan-European dataset) and showed a certain under-estimation of erosion rates on behalf of PESERA. The mean EIONET-SOIL erosion values are higher than mean PESERA values in all slope classes between 2 and 10 degrees while in flat areas (0-1 degrees of slope) the difference (EIONET-SOIL minus PESERA) is lower than the overall difference in the country. Regarding land cover, mean EIONET-SOIL erosion values are larger than the mean PESERA estimates except for arable lands. The EIONET-SOIL and PESERA differences are attributed to: different mapping procedures, influence of slope and vegetation in USLE and PESERA models, different input factors and scale issues.

This study has shown the potential of the EIONET-SOIL erosion data for the application and, in a later phase, calibration and verification of the USLE model at European scale. The data collection exercise will be repeated by ESDAC to better contribute to the State of Environment Report (SOER) in the year 2015.

Keywords：*Erosion rates, RUSLE, EIONET, data collection, Europe*

O84-2

[C3.2-1] B: Soil Erosion and Degradation on Agriculture Land

Natural Regeneration of Soil Physical Conditions following the Establishment of Permanent Pasture on a Structurally Degraded Soil

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The objective of this study was to measure changes in soil physical conditions following the establishment of permanent pasture (perennial ryegrass/White Clover) on a structurally degraded soil as a result of continuing cropping. An area of an arable cropping farm, near Lincoln, on Immature Pallic soils (Dystric Haplustept) was converted to irrigated grazed dairy farming in 2009. The physical regeneration of the topsoil was monitored over a 4 year period using a visual structure evaluation method as well as more widely used physical measurements of soil degradation (e.g. soil bulk density, macroporosity, water infiltration rates, and earthworm numbers).

The visual assessment of soil structure was obtained using the method of Peerlkamp. Using this method the topsoil was assessed to be in poor condition (<4) and showed no significant improvement during the 4 years following conversion to dairying. Values remained consistently low (2.9 to 3.5) during the observation period indicating that the soils under the previous cropping/cultivation period were structurally degraded and appear to have remained in a degraded/structureless massive state when put under a grazed pasture system.

Although no visual improvement in soil structure was observed, there was a significant increase in macroporosity (3.56 to 9.97 %) and a concurrent decrease in soil bulk density (1.47 to 1.25 g cm^{-3}) from year 1 to year 4 following dairy conversion. Earthworm numbers increased from the first year ($187/m^2$) and remained in the range of about 700 to $1000/m^2$ in years 2, 3 & 4. Water infiltration rates remained unchanged, at moderate rates, during the observation period and are consistent with poorly structured silt loam soils. Soil macroporosity, although significantly increased, was still less than the critical value of 10% and these low values coincided with the moderate infiltration rates.

In conclusion, although the visual structure assessment of Peerlkamp is, in effect, an estimate of structural grade and visual porosity, the ability of this method to detect changes in bulk density and macroporosity when the soil is in poor condition and structureless massive is limited. Soil structure can remain unchanged/massive in appearance even though other improvements in soil physical conditions can occur.

Keywords：*Structure, degraded soil, Peerlkamp, macroporosity, bulk density, infiltration, earthworms*

O84-3

[C3.2-1] B: Soil Erosion and Degradation on Agriculture Land

Impact of Enrichment Planting Activity on Soil Physico-chemical Properties of Degraded Forestland

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Forest replanting activities were considered the best way to restore the degraded forestland to its initial state. Enrichment planting, a mix species planting technique is believed to be able to restore the degraded forest soil fertility. However, the study on the impact of enrichment planting on degraded forestland still lacking. Hence, a study was carried out at the enrichment planting and secondary forest plots of Compartment 13, Tapah Hill Forest Reserve, Perak, Malaysia, to evaluate on soil physico-chemical properties, clay mineralogical composition and soil quality index (SQI) for both plots. Results showed that enrichment planting sites had significantly higher ($p<0.05$) clay fraction, bulk density, porosity, acidity in acid suspension, total carbon, total nitrogen, organic matter and exchangeable magnesium compared to those of secondary forest at 0-15 cm depth. However, exchangeable potassium was lower ($p<0.05$) and exchangeable aluminium was higher ($p<0.05$) for enrichment planting at 15-30 cm depths. Kaolinite and gibbsite were the most dominant clay mineral present in the soils at both plots which indicate that both plots have highly weathered soils. Moisture content, organic matter and exchangeable magnesium show the strongest contributing factors to soil fertility for both plots. Soil Quality Index (SQI) for enrichment planting was higher compared to that of the secondary forest for soils at 0-15 cm depth, while the SQI for both plots at 15-30 cm depth was identical. Rehabilitation activity such as enrichment planting after 42 years of planting improves soil fertility by which the soil properties at particular degraded area can be nurtured back to its original state through appropriate rehabilitation efforts.

Keywords：*soil physico-chemical properties, forest rehabilitation, enrichment planting technique, soil quality index*

O84-4

[C3.2-1] B: Soil Erosion and Degradation on Agriculture Land

Application of Soil Survey to Assess Non-point Source of Elements Contamination to Surface Water in Agriculture Watersheds

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Nutrients and other water soluble chemicals can be transported from agricultural land by runoff to surface waters. The USDA-NRCS technique utilizes existing climatic, hydrologic, soil survey and vegetation database to estimate the loss of elements by runoff from agricultural land. The technique applies runoff model to estimate water loss from agricultural watersheds. The interaction between runoff water and dissolved elements in root-zone soil is used to estimate element losses from soil. In previous studies, the technique has been applied successfully to estimate phosphorus and nitrate-N losses from agricultural watersheds. In this report, it was used to estimate 8 heavy metals and 4 alkaline earth elements (AEEs) loss by runoff from soils in Wagon Train (WT) watershed, Nebraska. Elements are released from a thin layer of surface soil that interacts with rainfall and runoff water.

For the watershed, the predicted annual loss of water by runoff (4.32 million m3) was in good agreement with the observed annual inflow for WT reservoir (4.25 million m3). Significant losses by runoff were predicted for Si (112 Mg/yr), Al (98.3 Mg/yr), and Fe (53.2 Mg/yr). Relatively lower amounts were predicted for Cu, Zn, Ni, Pb, and Cd where losses were 202, 147, 82.7, 5.44, and 2.37 kg/yr, respectively. With respect to AEEs, significant losses by runoff were predicted for Ca (67.5 kg/ha/yr) and Mg (19.9 kg/ha/yr). Lower values were predicted for Ba and Sr where losses were 172 and 47.8 g/ha/yr, respectively.

The observed average Al, Fe, Si, Ni, and Zn concentrations in the streamwater was much lower than those predicted in runoff generated from soils in the entire watershed. The biological uptake of elements by weeds, algae, and aquatic plants might explain the low elements concentration in the streamwater. Further, high pH in the streamwater could precipitate oxide, hydroxide, and carbonate forms of elements. On the other hand, the predicted Cd, Cu, and Pb concentrations in runoff from the watershed agreed with those observed in the streamwater. With respect to AEEs, calcium concentrations in the streamwater ranged between 46.3 and 77.4 mg/L with an average of 61.4 mg/L. Magnesium concentrations ranged between 14.3 and 24.4 mg/L with an average of 18.6 mg/L. Barium and Sr had much lower concentrations, averaging 273 and 360 μg/L, respectively. The predicted annual Ca and Mg concentrations in runoff from the watershed were 63.2 and 18.6 mg/L, respectively. Meanwhile, the corresponding Ba and Sr concentrations were 274 and 45 μg/L, respectively. The predicted Ca, Mg, and Ba concentrations in runoff agreed with those observed in streamwater. The high Sr concentration in streamwater could be attributed to a subsurface seepage discharging directly into streams in the watershed.

We used the average annual element concentrations in the streamwater to estimate annual loadings. The estimated annual loading was relatively high at 2,291 and 285 kg for Si, and Cu, respectively, whereas it ranged between 27 and 52 kg for Al, Fe, Ni, and Zn. The estimated annual loading was small at 5.78 and 1.94 kg for Pb and Cd, respectively. For the AEEs , the estimated annual loading was about 273, and 80 Mg for Ca, and Mg, respectively, whereas it was 695 kg for Ba and 193 kg for Sr. These values were slightly higher (about 4%) than those predicted for element losses by runoff from soils.

Keywords：*NRCS Technique, Runoff, Heavy metals, Alkaline Earth Elements*

O84-5

[C3.2-1] B: Soil Erosion and Degradation on Agriculture Land

The Soil Erosion Risk Map of the Sicilian Region (1:250,000 Scale)

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Assessing the risk areas of soil erosion by water at the regional level is relevant for current and future land planning of environmental actions to combat land degradation. The gravity of the risk is not only depending on the rate of soil erosion by water, but also on other factors, primarily soil depth and rock weatherability. The map of the soil erosion risk in the Sicilian region, expressed in terms of years to a complete loss of the fertile soil cover, is here presented as a methodological model. The degree of risk was not only estimated in function of the rate of soil erosion by water, but also of the depth of the fertile part of the profile, and of the weatherability degree of the underlying bedrock.

Keywords：*Risk assessment, soil thematic strategy, geomorphology, geology, soil formation rate, Sicily*

O84-6

[C3.2-1] B: Soil Erosion and Degradation on Agriculture Land

A Sound Measurement of Splash Detachment Rates for Erosion and Eluviation Modelling

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Splash is well recognised as a key process of interrill erosion and soil surface degradation. Splash has more recently been pointed out as a mechanism of colloid mobilisation suggesting the role of this process in controlling colloid-facilitated transfer and lessivage. Measured splash detachment rates are used to parameterise interrill erodibility in soil erosion and landscape evolution models as well as eluviation in pedogenesis models. However, the available measurements of splash detachment rate are biased and experiment-specific. Firstly, splash detachment is often considered as a single process whereas, depending on the measurement conditions (e.g. soil aggregation, surface water content, rainfall kinetic energy), raindrop impact on soil can trigger different physical mechanisms. Secondly, the interaction between the measurement device and the redistribution pattern of splashed particles produces bias that are generally not taken into account when interpreting the experimental data. Thirdly, the size selectivity is mostly disregarded whereas several authors have already pointed to its preeminence. The objectives of this communication are thus 1) to propose a measurement framework that is physically and experimentally sound to determine splash detachment rate, 2) to quantify reliable detachment rates for different soils and size fractions, 3) to analyse the way splash detachment is represented and parametrised in different soil erosion and pedogenesis models, and 4) to suggest a new approach to model splash detachment.

The experimental framework we designed enabled to: 1) distinguish the consequences on soil aggregates of aggregate breakdown, and transport by splash; 2) propose an invertible mathematical model for a non-biased interpretation of the measurements. This model was obtained from a numerically integrated point-equation by first conducting a sensitivity analysis to determine the significant parameters and then finding a simplified form by meta-modeling.

Two laboratory devices were set up to sample the soil fragments produced by aggregate breakdown and transported by splash, respectively. Each device has a central circular 18-cm2 source. Sieved air-dried soil (3-to-5-mm size fraction) was exposed to simulated rainfall at 29 mm.h-1 and with a time specific kinetic energy of 250 J.m-2.h-1. Those conditions are representative of a storm on a dry seedbed. Three cultivated soil surface materials, with various sensitivities to erosion, were tested: a silt loam, a clay loam and a silty clay loam. The size distributions (16 size fractions from 0.05 to > 2000 μm) of the broken down and splashed soil fragments were determined by combining sieving and laser diffraction. These size measurements were performed in ethanol in order to preserve aggregation.

The results show that the splash rate depends mainly on the size fraction of the aggregates available at the soil surface. The rates are higher for the middle-sized fractions (50 to 1000 μm) and, contrarily to what is generally thought, splash of colloidal-sized soil fragments is not significant. The physical mechanism generating colloidal-sized soil fragments under rainfall impact is breakdown and it occurs only on aggregated soils. In the literature, splash detachment refers to various physical processes: in soil erosion and landscape models, it encompasses both aggregate breakdown and splash sensu stricto, and, in eluviation and colloidal-particles transport models, it actually relates to aggregate breakdown only. Thus splash detachment in soil erosion and landscape models should be parametrised by combining aggregate stability tests (representative of aggregate breakdown) and splash cup measurements. Eluvation and colloidal-particles transport models should be parametrised by aggregate stability tests only.

Keywords: *aggregate breakdown, soil erosion model, pedogenesis model*

O85-1

[C3.3-4] B: Soil Management Strategy for Enhancing Crop Yields

Industrialization Progress and Application of Slow & Controlled Release Fertilizers in China

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Abstract：The economic loss and environmental hazards resulted from application of large amounts of fertilizers and low nutrient use efficiency (NUE) has been increasingly emphasized. How to considerably improve nutrient use efficiency and to give full play to the contribution of fertilizers is one of the most important problems in the development of sustainable agriculture. The new idea and more effective way to solve the problem have been exploited by practical use of slow and controlled release fertilizers (SRFs and CRFs). The coating materials, manufacturing technology, processing equipments, controlled-release mechanism, product standard and application of CRFs were systematically studied in the series national projects undertaken by Shandong Agricultural University and Shandong Kingenta Ecological Engineering Company. Four automatic industrialized manufacturing processing lines for the production of CRFs using four different coating materials and coating processing technologies were established and over 100 patents for the technicology and products of CRFs have been authorized. Twelve series and over hundred species of CRFs have been produced for the total production capacity of 1,500,000 tons per year. These species have specific nutrient release patterns, and continually release their nutrients in the designed release rate and duration, and the release peaks could be observed, so that the controlled nutrient release could be achieved and the nutrient release synchronized to the plants' needs. Meanwhile, the nutrient elements would exert their highest utilization efficiency for the crop production. Based on the effects of nutrient release factors and controlled release mechanism, fast testing methods of nutrient release rate and release longevity were created, and the national standard of "Slow Release Fertilizer"and industry standard of "Controlled Release Fertilizer" was established and carried into execution in Sep. 1, 2009, and July. 1, 2012, respectively. The results of the experiments, demonstrations and extensions on over 30 kinds of crops in 26 provinces all over China for several years have indicated that the nutrient use efficiency of CRFs increased from 30% to over 50% as compared to the conventional fertilizers. As a result, the crop yield still increased even though the amount of applied nutrients of CRFs decreased by one third or one half, and the qualities of the crop and food products were also improved. In addition, the nitrogen volatilization and leaching losses were considerably reduced by application of CRFs. Especially, in the economic developed region with excess application of fertilizers, the increasingly severe non-point pollution situation would be considerably reduced by using CRFs, which would be propitious to the farmland ecological construction and environment protection, and would have momentous benefits for the ecology and environment.

Keywords：*Slow & Controlled release fertilizers; Industrialization Progress; Nutrient release patterns; , Standard of SRFs & CRFs; Nutrient use efficiency; Agricultural production increment evaluation*

O85-2

[C3.3-4] B: Soil Management Strategy for Enhancing Crop Yields

Utility of Soil Analysis Database of Routine Laboratory to Monitor and Describe the Evolution of the Fertility of Costa Rican Soils

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Soil analysis continues as one of the most efficient tools to make reliable diagnosis of soil fertility status. The objective of this work is to show the utility of collecting and analyzing the records of a routine soil analysis laboratory. Through a systematic arrangement of data and with a simple frequency analysis, routine lab soil databases can become a powerful tool to evaluate the current status of the soil chemical properties, and also to visualize the changes experienced in soil nutrient dynamics over time. In 1986, with the information available from the main soil laboratory in Costa Rica at that time, the first author structured a soil database consisting of 13,000 records. Data were grouped according to the smaller territorial divisions that were available ('canton' in this case), and, for each element reported in the analysis, the percentage of samples that had values below the critical level was quantified, both for 'canton' and country level. This work allowed the identification of the main national and regional constraints in terms of fertility. Moreover, in that moment, the presentation of fertility maps provided a new tool to understand the nutritional status of Costa Rican soils. In 2012, both authors made another study with the same methodology of the previous work with a more robust database (23,000 records) from the Laboratory of Soil and Plant of the University of Costa Rica (LSF/CIA-UCR), with soil samples of 2006-2010 period. In addition to the updating of the soil fertility status in Costa Rica, this second study permitted to point out the main changes in the chemical properties of agricultural soils that have occurred in 25 years. Changes in land use, increments in area under more intensive cropping systems, and the introduction of practices that were not so frequent before, appear as the agronomic key factors that could explain the changes that have occurred in the chemical soils properties with the passing of time. The changes also demonstrate the dynamism in which the soil fertility is involved under cultivation conditions. The most important changes detected were: reduction of P, Ca and Mg problems, and increase of acidity and Zn problems. Although P is still the most problematic nutrient in the country, there was a decrease in the frequency of low P levels. From 74% of samples with less than 10 mgL-1 (Olsen modified extractant) in 1986, this value has dropped currently to 58%. Probably, areas of soils derived from volcanic ash with high fixation capacity have been strongly fertilized with P in order to supply the high nutritional demands of horticultural crops. Also, the increase of agricultural frontier includes many crops with high P fertilization as ornamentals, palm, and fruits plantations. The first study showed that in Costa Rica, the problems of low levels of bases (mainly Ca and Mg) were more relevant than acidity problems. These conclusions have conducted to intensified research in liming practices, especially with dolomitic materials, and on the quality of products used as amendments. At the present time, the frequency of soils with low levels of Ca and Mg has decreased (from 35% to 25% approximately) but, the problem of acidity has increased significantly. While in 1986 43% of the samples had pH values below the critical level (5.5), currently, this value has grown until 53%. It seems evident that despite more amounts of liming materials are used, these are not sufficient to counteract on the acidifying effect caused by the intensive use of ammonia nitrogen fertilizers. Zn still is the microelement that most commonly appears limiting the production. Nowadays, 30% of the samples showed less than 2 mgL-1 of Zn (Olsen modified extractant), while in 1986 this value was 25%. The use of new more marginal cropping areas naturally deficient in Zn and the common practice of foliar correction of Zn deficiencies have contributed to exacerbate such problem in the soil. From the above mentioned data, it is concluded that a study like this gives support to the implementation of new soil fertility management practices in the country and helps to clarify lines of future research.

Keywords：*Data Management, soil analysis, chemical variables, Costa Rica soils fertility*

O85-3

[C3.3-4] B: Soil Management Strategy for Enhancing Crop Yields

Changes in Soil Fertility under Slash and Burn Systems with Different Land Use Systems in the Peruvian Amazon

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Land resource in the Amazon is very high, occupying about 482 million of hectares as reported by Cochrane and Sanchez (1982). Most soils are Oxisols (46%) with 220 million hectares and 141 (29%) millions of hectares are Ultisols. Ultisols are located in upland and poorly-drained soil landscapes. The main chemical soil constraints of crop production in the Amazon are soil acidity; with high aluminum saturation on the top 50 cm, P deficiency, micronutrient deficiency, and low ECEC (Effective cation exchange capacity). Ninety percent of the soils of the Amazon have topsoil P levels less than 8 mg/kg and if one assumes a critical level of 10 mg/kg, these soil will not support crops without additions of P.(Alegre and Arevalo 2009). Since the use of external inputs such as lime, fertilizer and herbicides are beyond their reach; farmers use the slash and burn system. The objectives of the study are to analyze the initial soil fertility status under different long term land use systems in the Peruvian Amazon, and to find options to maintain sustainable agriculture. The study is part of a long term study of dynamics of soil physical, chemical and biological properties of long term land use sytems (LUS) in the Peruvian Amazon with UNALM-VLIR Project. The study is being performed in the upper Amazon of Peru. The average annual temperature is 26.3 °C. Total annual rainfall is 2200 mm. Soils belong to the Yurimaguas series (Typic Paleudults, fine loamy siliceous, isoperthermic). Ten LUS were selected; most of them without fertilization management, to compare the soil fertility status, the untouched primary forest was the control. The other 9 LUS were : 1) Secondary forests 2) and 3) multistrata agroforestry sytems with Cedrelinga catenaiformis and with Centrosema macrocarpum cover crop in two sites with 10% clay and 4% clay, 4) Brazilian nut (Bertholletia excelsa) with coffee (Coffea arabica) ,5) peach palm (Bactris gasipaes) for hearth of palm production with very low N fertilization 6) peach palm fruit production 7) Oil palm ((Elaeis guineensis) production with Kudzu (Pueraria phaseoloides) cover crop , 8) degraded native pasture and 9) improved pasture with Brachiaria brizantha and Centrosema macrocarpum) and was fertilized only once with lime, P and K. The initial soil sampling was performed at two depts. 0-15cm and 15-30 cm. For this presentation we are going to discuss only the following soil properties: bulk density that we used to convert it to soil nutrients reserves in kg/ha, pH, Al saturation, available P and K, ECEC, Exchangeable Ca, and Mg and concentrations of humines, humic acids and fulvic acids. All soils under the different LUS were extremely acid (pH less than 5) with ranges in Al saturation from 12 to 60% being the highest for the primary forest and the lowest for the fertilized improved pasture. There were not significant differences for available P reserves and the range at 0-15 cm depth was from 5.6 to 8.7 kg/ha which is very low. Reserves of K were higher (151 kg/ha) only in the improved pasture and was significantly different than the other LUS. For exchangeable Ca reserves, the Improved pasture that was fertilized had the highest content (1040 kg/ha) and the lowest was for the originally soil of primary forest (192 kg/ha).Potassium reserves was higher only in the improved pastures with 208 kg/ha. Degraded pasture presented the lowest content of humic acid and there were no differences between the other LUS. For fulvic acid the highest concentrations were for primary forest (0.36%) and peach palm (0.39%). In general all LUS will require P fertilization for a sustainable agriculture.

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Keywords : *Amazon soil , shiting cultivation,degradation , agroforestry*

O85-4

[C3.3-4] B: Soil Management Strategy for Enhancing Crop Yields

Assessment of Nutrient Flows and Balances in Smallholder Cereal-legume-livestock Farms in the Dry Savannas of West Africa

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The integration of crops and livestock is an effective means of harnessing and recycling nutrients in manure and crop residues to improve crop yields. However, the productivity of cereal-legume-livestock systems in West Africa is constrained by the alarming rate of nutrient depletion and the inadequacy of the crop residues generated. Resource flow mapping and nutrient balance assessment were carried out in 15 cereal-legume-livestock farms along the savannas of West Africa to identify hot spots for nutrient losses and quantify N and P balances. The study was conducted at Cheyohi, in the northern guinea savanna of Ghana, Sarauniya in the sudan savanna of Nigeria and Garin Labo in the Sahel savanna of Niger. The nutrient inflows monitored were mineral fertilizers use, manure application, biological N fixation and atmospheric deposition. The nutrient outflows assessed were crop produce harvesting, crop residue removal, leaching and gaseous loss. Crop residue removal and leaching were found to be dominant nutrient flows for nutrient losses. The total removal of crop residues led to nutrient mining of 35 - 45 kg ha-1 of N, 4.1 - 5.7 kg ha-1 of P and 66 - 76 kg ha-1 of K annually. Leaching losses were 20.2 - 20.8 kg ha-1 for N and 4.0 -7.0 kg ha-1 of K annually. Nitrogen balances ranged from -7 to -22 kg ha-1 with the application of the recommended N rate and -34 to -82 kg ha-1 in the absence of fertilizer use. The application of the recommended rate of P fertilizer led to the P accumulation in the order of 3.3 to 15.7 kg ha-1. However, without the use of P fertilizer, P depleted at rate of 2.4 to 7.9 kg ha-1 annually.

By relating N stock to N balance it was found that farmers using mineral fertilizers at the recommended rate could maintain crop yields at current level for 20 – 133 years but only 7 – 15 year in the absence of mineral fertilizer use.

Keywords：*resource flow, nutrient flow, nutrient balance, nutrient stock*

O85-5

[C3.3-4] B: Soil Management Strategy for Enhancing Crop Yields

Decadal Changes of Spatial Distributions of Soil Properties in a Japanese Paddy Field and Their Relationship with Field Management, Rice Yield and Soil Color

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Introduction: In Japan, small fields have been joined into larger ones during these several decades to cope with the decreasing number of producers. Statistics in 2006 indicate that 61% of the paddy fields have an area of 0.3 ha and 8% of them have an area greater than 1.0 ha. This land consolidation has contributed to labor-saving and cost-effective production. But it has also caused large within-field heterogeneity of rice growth conditions especially soil properties. In one of such fields, we investigated decadal changes of spatial distributions of soil properties and their relationship with field management and rice yield. We also evaluated the extent to which the analysis of soil color can be useful for estimating soil properties.

Materials and methods: The field was an experimental field of Kyoto University located at Takatsuki City, Osaka Prefecture, Japan. It was subjected to land consolidation during 1960s, heterogeneous application of cow dung manure in the late 1970s, land leveling in 1986, 1987 and 2003, and uniform application of horse dung manure for these years. Surface soils were collected throughout from the field in 2002 and 2012, and their physicochemical properties were analyzed. Additional analyses were carried out for relative altitude in 1986, 1999 and 2012, soil hardness in 2012, and the yield of transplanted rice in 1999, 2012 and 2013.

Results and conclusions: In the field examined, the distributions of field attributes including soil properties reflected the history of field management. The heterogeneous distributions of relative altitude and subsoil hardness were partly explained by a passage of agricultural machinery, whereas the heterogeneous distribution of soil organic matter was explained by both past and recent applications of manure. In general, the measured soil properties were maintained during these ten years. The pattern of spatial distribution did not change significantly for many of the properties such as total N, available P and acid oxalate extractable Fe, suggesting that land leveling carried out in 2003 barely influenced the distribution of such stable properties. Rice yield was influenced potentially by organic matter-related soil properties. Under field conditions, however, the factors affecting rice yield were complex, because subsoil hardness and relative altitude may have masked the influence of soil chemical properties. The yield of 2012 measured at unfertilized plots was lower when subsoil is harder and the relative altitude is higher. The yields of 1999 and 2013 suggested that basal fertilizer application was effective to stabilize and increase the yield.

The soil samples were further subjected to the analysis of color with a soil color reader (SPAD-503). Two grams of air-dried, finely-ground samples were packed firmly in a plastic cell, and their colors appeared on a window of the cell were measured. A CIE 1976 (L*, a*, b*) color space was used for color description. The method applied could detect subtle changes of soil color parameters within the field. The values of the coefficient of variation for total C, total N and acid oxalate extractable Fe were around 15%, whereas those for the L*, a* and b* values were 1.5%, 4.2%, 4.4%, respectively. The L* value (lightness) was negatively correlated with the content of total C and total N (R^2 = 0.18** and 0.26**, respectively), whereas the b* value (yellowness) was positively correlated with the content of acid oxalate extractable Fe (R^2 = 0.59**). This indicates that the analysis of the spatial distribution of soil color parameters was effective to estimate the spatial distribution of organic matter and active Fe in soil at a field scale.

Our results suggest that land leveling and basal fertilizer application are a most practical method for sustaining rice yield at a high level in a paddy field. The site-specific topdressing of fertilizer according to heterogeneous rice growth may also be useful to offset the influence of other uncontrollable factors, when seemed necessary. In addition, the analysis of soil color parameters using a soil color reader would be useful for estimating within-field heterogeneity of organic matter and active Fe without using chemicals and thereby for deciding the amount of manure application to minimize heterogeneous distribution of soil organic matter in a field. These findings provide basic information for precision agriculture in consolidated paddy fields in Japan and other countries in monsoon Asia.

Keywords：*Field management history, Relative altitude, Rice yield, Soil chemistry, Soil color, Soil hardness*

O86-1

[C3.4-1] Design and Performance of Cover Systems for Landfills and Contaminated Sites

Water Balance and Soil Physical Properties of a Temporary Landfill Cover in Northwest Germany

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The project 'Landfill Rastorf' determines the water balance, soil development and deals with the optimization of recultivation layers in a cost-effective temporary landfill surface cover in Rastorf, Northwest Germany. Since February 2008, TDR and FDR sensors constantly monitored the soil water dynamics resulting from surface water infiltration into the temporary top sealing. The measurements take place in 20, 50, 80 and 100 cm in three slope positions: top, middle and bottom with three replications per depth for matrix potential and temperature and two replications are installed for soil moisture. Furthermore, undisturbed soil material was used to determine further soil physical characteristics and the shrinkage behavior in the individual layers. In the hydrological year 2013, the matric potential courses showed greater drying periods from May to August with measurements of -800 to -1000 hPa in the upper 20 cm. At a depth of 50 cm, the matric potential even decreased on -400 to -600 hPa. In the sealing layer (≥ 70 cm), the critical matric potential of -250 to -500 hPa has never been achieved. Currently, the low shrinkage potential (COLE) in the three layers (loamy sands) was demonstrated by the potential change in volume of 7-13% in the dry state. The consistency of the mineral layers with bulk densities of 1.7-1.9 g cm-3 can be classified as very hard. The Ks values and saturated water contents in all layers are completely at a low level. By comparison with the shrinkage behavior, the analysis showed that critical crack initiation in the sealing layer has not yet been inserted. Moreover, an external rewetting via the installed drainage pipes as prevention against cracking in case of a too intense drying throughout the year has not yet been neccesary. Taking account of soil science researches, landfill cover systems without critical crack initiation could be permanently established.

Keywords：*temporary capping, matric potential, shrinkage behavior*

O86-2

[C3.4-1] Design and Performance of Cover Systems for Landfills and Contaminated Sites

Cover Systems and Contaminated Land Remediation Strategies in England

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This paper explores and presents an account of the development and use of cover systems used in the reclamation of contaminated land in England, derived from the author's experiences over the past 35 years. Landfills are excluded since these sites are considered to present their own particular contamination/environmental problems and necessitate special engineering requirements. The sites of concern in this account encompass land contaminated through historical land use, primarily of an industrial nature, concentrating on both problem sites which been reclaimed under a statutory duty due to significant environmental risks to current use and also the redevelopment of potentially contaminated land, so called "brownfield sites".

The paper begins with an overview of the history and development of English legislation governing contaminated land, from describing the circumstances as stood in the 1970's, through the inception of primary and secondary legislation in Part 2A of the Environmental Protection Act 1990 and the Contaminated Land Regulations 2000, with subsequent amendments, and how matters stand in 2014. Differences between mandatory reclamation under Part 2A and that instigated through the planning system are briefly discussed.

Risk assessment is based on the source-pathway-receptor concept. Where land is to be redeveloped for beneficial use, be it housing, industry or amenity, the fundamental role of a cover system is to create a physical barrier which effectively separates contamination (i.e. the source) from the receptor by blocking or removing the pathway or reducing exposure. By reference to both published technical guidance and case studies, the suitability and applicability of cover systems is discussed within this context, considering what actually constitutes a cover system, the technical aspects of what materials might be employed, how to design a system and calculate depths, engineering aspects, how to validate cover systems and post reclamation/development monitoring and aftercare, differentiating between systems designed and employed to protect human health and those for use to protect controlled waters. Particular mention is given to capillary break layer systems, quality control for growing media and imported materials and barriers/membranes.

The commonest current use of cover systems is on residential housing land, either remediated under Part 2A or during the normal course of re-development where, in both scenarios, safe gardens need to be established. The commonest contaminant of concern in most every case is benzo-a-pyrene, BaP (regarded by the author as England's "public enemy No. 1). Two Part 2A case studies are described and also general housing redevelopment case studies, highlighting the present inadequacies of risk assessment for BaP whereby the soil cover system might well have been avoided.

Whilst a computer model was developed and published in 2004 to aid the design of soil cover systems, this has not found widespread use: in many situations a nominal minimum depth of 300mm is the simple recommendation for establishing grass/turf, increasing to 600mm-1000mm where shrubs and trees are to be stablished. Issues concerning validation including guidance issued by one English public body and also post-installation monitoring are also discussed, highlighting the fact that the latter aspect very rarely occurs.

The paper concludes with an appraisal of how cover systems have been used and their likely or perceived effectiveness, together with what might be required to improve future use through better design, validation and validation.

Keywords：*contaminated land; cover systems; remediation; England;*

O86-3

[C3.4-1] Design and Performance of Cover Systems for Landfills and Contaminated Sites

Managing Water Flow through Rock Covers on Mine Sites

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Mining activity produces waste material including waste rock and tailings. These waste materials may pose a risk to the environment when they get into contact with the elements, especially water. Consequently contaminants may be mobilised and pollute the environment. Separating the waste material by encapsulation and avoiding contact with water is one of the main strategies on mine sites. However, many mining environments, particularly metalliferous mines in semi-arid environments, lack suitable material for the construction of covers, such as weathered, clay-enriched materials. Benign waste rock is used as a cost-effective alternative, therefore. If the coarse or blocky component dominates the particle size distribution, preferential pathways may be a consequence leading to large volumes of water being transported to deeper depths in the cover or into the hazardous waste. Especially under climatic conditions with high intensity or amounts of rainfall, the functionality of such a cover is compromised. An additional barrier is required in such circumstance to avoid throughflow of water.

The paper explains the risk of preferential flow and illustrates possibilities for determination and quantification of a bi-modal pore characteristic. To prevent deep drainage as a result of preferential flow, a hydrological barrier has to be introduced to manage the flow. Using a test site, the principle of such a barrier is presented. The barrier is constructed from chemically amended tailings, which itself is a waste material. A pathway is shown how laboratory tests, hydrological modelling and field tests can be used to design a functional cover. Results are presented, which highlight the performance of such a cover design.

Keywords：*cover, waste rock, hydrological barrier, preferential flow*

O86-4

[C3.4-1] Design and Performance of Cover Systems for Landfills and Contaminated Sites

Hydrophysical Properties of Clays Likely to be used for Landfill Liner Construction

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Landfilling of solid wastes is still an important way of their utilization in many countries. Landfills pose a serious threat to soil and groundwater as well as to the atmosphere. In order to prevent them from pollution of the environment landfills have to be isolated by barriers, known as liners, utilizing various technical solutions based on natural and geosynthetic materials. Mineral liners, properly constructed and compacted, sealing the bottom, slopes, and top of the landfills are one of the most popular manners of landfills isolation. The mineral liners are usually constructed of compacted clay soils in order to obtain the required low saturated hydraulic conductivity. In EU these limits are $1x10^{-9}$ m $s^{-1}$for landfills of hazardous and municipal wastes and $1x10^{-7}$ m s^{-1} for landfills of inert wastes. The value of hydraulic conductivity of saturated soils is directly affected not only by the compaction degree but also by the conditions of soil compaction, especially the molding water content.

This paper is focused on the determination of the effects of molding water content of two selected clay soils on their saturated hydraulic conductivity and shrinkage potential. The selected clayey materials were sampled from open pits located in Bychawa and Lazek Garncarski, (South East Poland). Particle size composition of the materials under consideration showed the content of 12% sand, 46% silt, and 42% clay for Bychawa material and 5% sand, 51% silt and 44% clay for Lazek Garncarski material. Range of our studies covered the in situ and laboratory measurements of bulk density and saturated hydraulic conductivity for variable molding water contents. The following ranges of molding water contents were applied in our studies: 13%-27% (by weight) for the material sampled in Bychawa and 14%- 25% for the material sampled in Lazek Garncarski. Saturated hydraulic conductivity under field conditions was measured by BAT probe, (GeoNordic) while the hydraulic conductivity of the compacted clay soils was tested by Humboldt Mfg. Co. permeameters (with falling water head) according to ASTM D5856. Thereafter the measurements of shrinkage potential were performed.

It was found that saturated hydraulic conductivity decreased and the shrinkage potential strongly increased with the increase of molding water content. The observed saturated hydraulic conductivity for variable molding water contents decreased from $1.19x10^{-8}$ m s^{-1} to $3.09x10^{-11}$ m s^{-1} for Bychawa material and from $3.8x10^{-8}$ m s^{-1} to 2.09 $x10^{-11}$ m s^{-1} for the material sampled in Lazek Garncarski. The field values of saturated hydraulic conductivities ($2.75x10^{-10}$ m s^{-1} for Bychawa material and $1.37x10^{-10}$ m s^{-1} for Lazek Garncarski material) were within the interval of the values obtained in the laboratory measurements. The bulk densities of the materials compacted at various molding water contents were in the range of 1.68 Mg m^{-3} to 2.02 Mg m^{-3} for Bychawa material and in the range from 1.82 Mg m^{-3} to 2.08 Mg m^{-3} for the material from Lazek Garncarski.

It was concluded that compaction of clay liners should be performed at moisture contents below the Proctor optimum in order to reduce possibility of shrinkage and thus of formation of cracks, which would destroy the result of compaction.

Acknowledgement: The study was financed by Polish NCN research project 7550/B/T02/2011/40 (N N523 755040)

Keywords：*clay materials, clay liners, saturated hydraulic conductivity, landfills, shrinkage, soil compaction*

O87-1

[WG8] Proximal Soil Sensing

Practicality of using Proximal Soil Sensing in Agriculture and Natural Resources Management

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Proximal soils sensing (PSS) is a growing area of research and development with a number of potential applications to improve crop production and enhance other natural resources management practices. This paper provides an overview of the current state-of-the-art in PSS; it also includes an extended discussion of the potentially acceptable methods that practitioners around the world would be more likely to adopt. The analysis considers the balance between the efforts needed to provide a soil mapping service using an integrated sensor approach, and the payback the information generated could provide to the ultimate beneficiaries of these technologies. Existing and potential PSS solutions are evaluated not only in terms of their capability to predict specific soil attributes or reveal spatial soil heterogeneity, but also in terms of the way in which this knowledge could improve soil water, nitrogen and carbon management and other important processes. A number of service providers around the world have been offering mapping services using PSS, proximal crop sensing and remote sensing tools. Depending on the sensor deployment and data interpretation methodology, these new services can help to increase crop production revenues as well as partially reduce non-point source environmental pollution. By relating the theoretical aspects of different PSS platforms with their potential benefits, this paper lists the applications with the most probable net profitability and defines areas of research and development where new PSS-based land use improvement technologies should be explored.

Keywords：*proximal soil sensing, precision agriculture, soil heterogeneity, technology adoption*

O87-2

[WG8] Proximal Soil Sensing

Identification of Morphological Soil Horizons In-situ using Visible Near Infrared Spectroscopy

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Designation of soil horizons is one of the oldest and most widespread classification technique in soil science, but even so it is not absent from a fair degree of subjectivism. Some features like form and abundance of redoximorphic features, percentage of roots or even the designation of clear or diffuse horizon boundaries require expert knowledge. We have developed a new methodology based on the use of Visible and Near Infrared spectroscopy (Vis-NIR) and fuzzy clustering techniques to objectively identify soil horizons in the field and then create objective stratified soil property predictive models.

We used two catchment scale data sets and an External parameter orthogonalization (EPO) projection matrix (Geeves, 1994; Minasny et al., 2011) to eliminate the moisture effect of the in-situ samples; Dataset A and B belonged to the Hunter Wine Country Private Irrigation District (HWPID) NSW Australia and the EPO matrix was calculated based on 391 samples collected from agricultural areas from southern NSW (Geeves, 1994; Minasny et al., 2011). Dataset A (Laboratory dataset) consist of 59 soil cores varying between 100 to 130 cm depth, The cores were divided into 2cm segments, air dried, ground to 2m and Vis NIR scanned (3 replicates each scan).This resulted in 3190 separate soil samples for the dataset. Dataset B (In-situ data set) consisted of 4 soil pits that were Vis-NIR scanned on the site every 5 cm on two vertical lines separated by 1 m on each pit (5 replicates each scan), resulting in a 156 separated soil observations dataset. Both data sets were morphologically described (CSIRO, 2009).

The methodology involves two steps. First, Vis-NIR spectra of both in-situ and laboratory processed and analysed samples were filtered and then EPO transformed and second, a fuzzy clustering of the Principal Components on each laboratory and in-situ sample was performed. This facilitates prediction of soil properties in-situ using stratified predictive models that are more aligned with the traditional morphological soil horizons.

As result of the fuzzy classification in Dataset A we were able to detect horizon boundaries with 2 cm accuracy. The clustering algorithm split the Dataset A into three classes with 29.3, 36.1 and 34.5% of total observations for each cluster respectively. 55.8% of the samples contained in cluster 1 (A horizons) were A1, A2 or A2e horizons. 67.7% of the samples contained in cluster 2 (B horizons) were B2 or B2w horizons, 61.7% of the samples contained in cluster 3 (C horizons) were B3 or C horizons. In Dataset B we were able to detect horizon boundaries with 5 cm accuracy. The clustering algorithm split the dataset B into three classes with 32.1, 30.1 and 37.8% of total observations for each cluster respectively. 74% of the samples contained in cluster 1, were A1, A2 or A2e horizons. 85.1% of the samples contained in cluster 2, were B2 or B2w horizons, 42.3% of the samples contained in cluster 3, were B3 or C horizons.

After clustering, 100% of samples of Dataset B-cluster 1 were on the Dataset A-cluster1 convex hull. The same percentage was obtained on cluster 2 and 93.2% was obtained in cluster 3.

We were able to detect horizon limits in the field without expert knowledge and to stratify different soil samples based on their horizon type using Vis-NIR spectra. Future research will involve discrimination techniques to assign the type of horizon and its associated properties to unidentified samples using Vis-NIR spectra.

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Keywords：*Proximal sensing, Spectroscopy, Soil Horizons, Pedology, Pedometrics*

O87-3

[WG8] Proximal Soil Sensing

Soil Visible Near-infrared Spectroscopy: Lessons from the Field

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A major recent development in the field of pedometrics is the utilisation of visible near-infrared spectroscopy (VNIR) to rapidly collect more soil data and predict soil chemistry, in particular soil organic carbon (SOC). While the spectra collection often occurs in the lab, on air or oven-dried, sieved soil samples, the portable nature of the equipment also allows soil spectra to be collected in the field. In this paper, we investigate some of the associated benefits of in-situ field spectroscopy, in particular the depth resolution at which soil information can be produced.

Soil spectral data were collected from a drystock farm located in the Manawatu region of New Zealand. The farm is divided in two distinct parts: flat land on the floodplains of the Manawatu River and adjacent dissected hill country, with slopes typically greater than 15 degrees. The elevation increases from 50m on the floodplains to 360m on the summit.

A digital elevation model obtained from LiDAR was used to derive a suite of terrain attributes: slope, aspect, annual global solar radiation, topographic wetness index, SAGA wetness index and geomorphological features. Associated with the parent material map and national climatic data layers (rainfall and monthly water balance), these soil covariates were used to select 50 soil sampling positions, using conditioned Latin Hypercube stratified sampling.

Intact, fresh soil cores were extracted from the 50 sampling positions and scanned with a VNIR spectrometer at field conditions, at 1-cm intervals along the length of the field moist core to 30 cm. The ASD FieldSpec 3 collects spectra in the range 350 to 2500 nm. The cores were then subsampled at 5 cm intervals to 10 cm and then at 10 cm intervals to 30 cm soil depth. The subsamples were then air dried, mixed and 2 mm sieved, before being scanned by the VNIR spectrometer for a second time, this time in an air-dry state.

The collected spectra were used to predict the SOC volumetric content [kg/m3] under the two conditions (fresh, field condition and sieved, air-dried, lab conditions). The field spectra are collected at a 1-cm depth resolution whereas the lab spectra are collected at the depth resolution of the subsample (either 5 or 10cm thick). The 1-cm field spectra were aggregated to match the subsample intervals of the air-dry samples analysed using lab SOC measurements. Two partial least square regression (PLSR) models were then trained, the first one using the aggregated field spectra, and a second one using air-dry spectra. The PLSR model trained on aggregated field spectra was then applied to the original 1-cm depth resolution field spectra to predict SOC along the core.

The results are twofold. First, using field moist spectra gave a more accurate prediction model than using air-dry spectra. Direct collection of soil spectra from intact soil in the field captures features that are normally destroyed by conventional lab analysis soil processing methods. Some of these soil features (such as ped surfaces and surface roughness) are related to SOC content, which can explain why better results are achieved using field condition spectra. Collecting VNIR spectra at field condition also eliminates the cost and time required with sample preparation at the lab (air-drying and sieving).

Additionally, the ability to predict at 1-cm intervals provides new data, previously unobtainable by conventional methods of assessing soil chemistry, to explore and study SOC variations along the soil profile. Depth variations are commonly modelled using mathematical tools, such as negative exponential functions or spline interpolators. Field VNIR spectroscopy provides a new method to more directly model SOC variation with depth. From a pedology point of view, showing the variation of soil attributes with depth in an almost continuous way at a marginal cost would also allow to better understand the effects of pedological processes such as alluvial deposit or hill slope processes. From a management perspective, the method can be used to assess mitigation strategies aiming to increase SOC stocks (e.g. introduction of deeper rooting grass species for deeper allocation of SOC; introduction of deep burrowing earthworms for deeper allocation of SOC).

Keywords：*Vis-NIR spectroscopy, In-situ spectroscopy, carbon stocks, pedology*

O87-4

[WG8] Proximal Soil Sensing

Electromagnetic Conductivity Imaging (emci) of Soil using a DUALEM-421 and Inversion Modelling Software (EM4Soil)

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One of the most popular geophysical methods currently being used to provide information about the spatial variation of soil properties is electromagnetic (EM) induction. This is because EM instruments are easy to set-up, use and mobilise. In addition, the measured apparent electrical conductivity (sigma-a-mSm-1) has been shown to be useful in mapping soil (e.g. clay) and hydrological (e.g. water holding capacity) properties. In this research, we describe how a next-generation EM instrument (i.e. DUALEM-421) and an inversion algorithm (EM4Soil) can be used to generate a two-dimensional model of the electrical conductivity (sigma-mSm-1). The algorithm was evaluated using DUALEM-421 sigma-a acquired across an irrigated agricultural field, in an extensive Quaternary alluvial clay plain northwest of Moree (NSW-Australia). In addition, we conduct inversions of various combinations of DUALEM-421 data to compare the results. We compare the inverted models of sigma with measured soil properties such as clay and electrical conductivity of a saturated soil paste extract (ECp–mSm-1). In general, sigma is shown to compare favourably with ECp. In terms of identifying an optimal set of sigma-a data, we found that inversion of all available data (r2 = 0.68) provided the best correlation with ECp closely followed by inversion of DUALEM-41 (0.65).

Keywords：*DUALEM-421, inversion, EM*

O87-5

[WG8] Proximal Soil Sensing

In Situ Evaluation of a Visnir Penetrometer for Soil Characterization

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Generating high-resolution soil maps using standard soil sampling and analysis techniques is typically cost prohibitive. Visible and Near-Infrared (VisNIR) spectroscopy is an established method for rapidly and inexpensively estimating soil properties when applied to dried and sieved samples in a laboratory setting. However, this approach still requires samples to be extracted, transported and processed using standard methods. To reduce soil mapping costs further, and allow more spatially dense sampling, it would be ideal to interrogate soils in situ with a field-portable VisNIR spectrometer and fore-optic. The goal of this study was to test a VisNIR penetrometer capable of simultaneously collecting soil spectra and insertion force, in situ. Our design is compatible with field-deployable spectrometers that employ signal delivery via fiber optics (e.g. ASD Agrispec) and hydraulic push-type soil coring systems for insertion (e.g. Giddings). To evaluate VisNIR penetrometer performance, we interrogated soil profiles at 4 fields (36 locations per field) within the Palouse area of eastern WA and northern ID (USA), and at 6 diverse fields (10 locations per field) in the northwest pacific corner of the USA (western Washington, southern Idaho and Oregon). Calibration soil cores were extracted adjacent to each VisNIR interrogation location. In the laboratory, we scanned intact cores at the corresponding depth of in situ interrogations using both the VisNIR penetrometer and Analytical Spectral Devices (ASD, Boulder, CO, USA) contact probe fore-optic. Afterwards, sample cores were cut and 3 cm slices of soil centered on depth of in situ and intact cores interrogation were dried, crushed and sieved (2 mm mash). Ground samples were then scanned by VisNIR penetrometer and ASD contact probe fore-optic. Predictive models of soil clay content were developed by spectra collected in situ, on intact cores and on ground samples, using partial least squares regression (PLSR) with core-out cross-validation used to assess predictive accuracy. From initial results, we achieved semi quantitative level of accuracy from in situ predictive model of soil clay content (SEP = 5.1 g kg-1). Comparable level of accuracy was observed in intact cores (SEP = 5.2 g kg-1) and ground samples (SEP 5.1 g kg-1) predictive models. Furthermore, we obtained equivalent results from contact probe fore-optic, either with intact core (SEP = 5.6 g kg-1) or ground samples (SEP = 5.1 g kg-1) interrogation. These preliminary findings suggest that our penetrometer-mounted fore-optic provides data comparable to widely-used commercial fore-optics, and can be used to generate detailed soil maps.

Keywords：*Proximal soil sensing, VisNIR spectroscopy, penetrometer, clay content*

O88-1

[C2.2-3] B: Behavior and Fate of Pollutants Entering the Soil Environment

Thallium Adsorption-desorption Quantity-intensity Relationships in Different Soils

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Thallium (Tl) is a non-essential toxic element that is widely distributed in our environment at trace levels. It is found in sulfide ores of heavy metals such as lead, zinc, and copper and in coal. Thallium concentrations in surface soils are generally ranged from 0.1 to 0.2 mg kg-1 worldwide. Thallium is designated as one of priority metallic pollutants by the United States Environmental Protection Agency. Plant available forms of heavy metal fraction in the soil are various such as water-soluble, exchangeable, reducible, and oxidizable. The different forms of heavy metals are released to soil solution by chemical reaction and interaction of soil-water systems. In this interaction, mechanism of adsorption and desorption of heavy metals occurred. Based on the sorption mechanism, the measurement of quantity (Q) and intensity (I) factors is important to predict plant growth condition. Therefore, the objectives of this study were to investigate Tl sorption quantity-intensity(Q/I) relationships in artificially Tl contaminated soils and to examine the relations between Tl uptake by different plants including barley, soybean, cucumber, and sunflower and Tl concentration extracted by different single chemical extractants such as 1.0M NH4Cl, 1.0M (NH4)2SO4, 1.0M KCl, 1.0M KNO3, 0.005M DTPA solutions. The quantity factor was defined as the amount of Tl adsorbed on the solid phase of soils or the content of Tl extracted by 1.0M (NH4)2SO4 solution and the equilibrium concentration of Tl in the corresponding soil solution such as water or 0.01 M CaCl2 solution was the intensity factor. The Tl adsorption Q/I relationships were examined in different soil-water and soil-0.01M CaCl2 solution systems using three different soils, acidic sandy clay loam Soil A, neutral sandy caly loam Soil B, and alkaline loam Soil C. Adsorption of Tl in the soil-water/0.01M CaCl2 solution systems were remarkably affected by soil pH. Values of Tl buffering capacity (BC=ΔQ/ΔI) in the different soil-water systems were highest (45.60) in the alkaline Soil C and lowest (18.64) in the acidic Soil A. In the soil-0.01M CaCl2 solution systems, BC values were highest (14.03) in the neutral Soil B and lowest (3.36) in the acidic Soil A. The single chemical extractants containing NH4+ and K+ ions had relatively higher extractability for Tl from the soils. Also, the Tl content extracted by 1.0M (NH4)2SO4 solution was significantly correlated with Tl uptake by the plants (R2 = 0.939 ~ 0.995). In addition, the Tl desorption Q/I relationship was determined by 1.0M (NH4)2SO4 extractable Tl content as the Q factor and water or 0.01M CaCl2 extractable Tl concentration as the I factor, which was presented by BC values. The BC values were highest in the neutral Soil B, which were 67.49 and 12.80 with different I factors determined by water or 0.01M CaCl2 solution, respectively.

Keywords: *thallium, adsorption, desorption, plant uptake, quantity-intensity, buffering capacity*

O88-2

[C2.2-3] B: Behavior and Fate of Pollutants Entering the Soil Environment

Assessment of Cadmium Contaminated Soil using Sulfur Oxidizing Bacteria: Batch Tests

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A sulfur-oxidizing bacteria (SOB)-based biosensor was successfully applied in the assessment of toxicity of Cd2+-contaminated soil in batch tests. Both pH and electrical conductivity (EC) changed according to the SOB activity. An evaluation of the effects of SOB attached sulfur particles amounts (15-55 g) on SOB activity detected a substantial shift at 25 g, which was then selected for the Cd2+ tests. EC and sulfate were found to be highly correlated; increasing the amount of soil (0.1-5.0 g) in the reactors caused a decrease in the rate of EC change and sulfate production. A 40-94% decrease in SOB activity was seen in the presence of cadmium contaminated soil. Data from this study of a SOB system indicate that the utilization of these bacteria, accompanied by a relatively simple and low-cost monitoring system, yields an efficient method for detecting soil toxicity and may have multiple applications for the evaluation of soil suitability for various uses.

Keywords：*SOB biosensor, cadmium contaminated soil, toxicity assessment*

O88-3

[C2.2-3] B: Behavior and Fate of Pollutants Entering the Soil Environment

Methods for Visualising Active Microbial Toluene and Benzene Degraders in in Situ Microcosms

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In order to investigate the microbial contaminant degradation activity at field sites, in situ microcosms (BACTRAPs) were inserted into the soil or sediment. The detection of isotopic enrichment in the biomarkers after colonisation of the carrier materials provided the proof of in situ microbial activity. Data on the spatial distribution of active microbes can, however, not be obtained with this approach. Methods for visualising certain groups of microbes, such as fluorescence in situ hybridisation (FISH), do not provide data about activity and often require an extraction of microbes from solid samples prior to analysis. In order to link microbial activity to the distribution of contaminant degraders, we combined the recently improved in situ microcosm approach (DP-BACTRAP) with nano-scale secondary ion mass spectrometry (NanoSIMS) analysis on samples from contaminated aquifers and constructed wetlands.

A stepwise approach using various types of activated carbon carrier materials was tested for the feasibility of the general method. First, DP-BACTRAPs containing commercially available activated carbon beads were loaded with ^{13}C-toluene and exposed in the BTEX-plume of an anoxic aquifer at the site of a former hydrogenation plant at Zeitz (Germany). These samples were embedded into resin and polished, in order to prevent contamination of the NanoSIMS instrument with dust of the activated carbon. The inner surface was barely colonised but most of the microbial biomass was moderately enriched in ^{13}C. However, the preparation technique used prevented direct visualisation of single cells.

Having demonstrated the general applicability of the approach, the second step was to use special, not commercially available, activated carbon materials embedded within a Nomex matrix for the BACTRAPs, thus allowing NanoSIMS measurement without embedding. In this experiment, the traps were loaded with ^{13}C-benzene and incubated in the gravel bed of a mostly oxic constructed wetland for the treatment of groundwater contaminated with benzene. Moreover, these were subjected to a FISH protocol, which led to deposition of fluorine-containing dyes. The microbes were visualised by both fluorescence microscopy and scanning electron microscopy. Analysis by means of NanoSIMS showed that, contrary to the aquifer samples, the carrier was highly colonised, but only a small fraction of microbes was enriched in ^{13}C and therefore was actively degrading the benzene in the wetlands. We could identify and even localise bacterial biomass in 3-dimensional structures on the basis of elevated ^{31}P and ^{19}F signals for the biomass. With the methods presented, we successfully visualised toluene- and benzene-degrading microbes on solid materials with high surface area by means of NanoSIMS, and we could show that NanoSIMS analysis of unembedded samples with a topography much more complex than usually applied is feasible.

Keywords：*: NanoSIMS, 13C, microbial activity, in situ microcosms, DP-BACTRAPs, benzene, toluene*

O88-4

[C2.2-3] B: Behavior and Fate of Pollutants Entering the Soil Environment

Characterising the Functional Relationships of Stable Forms of Organic Carbon in Micro- and Nano-aggregates of Soils with a Focus on High pH Soils

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Soil organic carbon (SOC) is the largest reservoir of organic carbon (OC) on the Earth's surface and understanding factors controlling SOC stability is critical to quantify changes in the SOC balance and developing novel methods to enhance C sequestration. Alkaline soils (pH>8) cover one third of the world's land area, a large part of which are used for agricultural production. Soil alkalinity affects chemical fertility, in particular, the ability to provide nutrients to plants. While the interest in research on the dynamics and fate of SOC in acidic forest soils and slightly acidic arable soils has increased, little work has been undertaken on assessing the chemistry of SOC in alkaline soils. Despite the wide distribution of alkaline soils and the recognition that their properties limit plant productivity, detailed studies on the chemistry and agronomy of alkaline soils are rare and published data on effects of high pH on SOC cycling are inconsistent. Consequently, limitations to SOC accumulation in alkaline soils are poorly understood. We used C (1s) near-edge x-ray absorption fine structure (NEXAFS) and synchrotron-based Fourier transform infrared (FTIR) spectroscopy to investigate the C speciation in soil and dissolved fractions of alkaline soils. In another series of experiments we defined threshold pH values for OC solubility and buffering capacity of alkaline soils. Together, this information is not only useful in terms of understanding the mechanisms responsible for SOC retention/dissolution but also in terms of nutrient bioavailability, as this is strongly related to SOC speciation. In this presentation, analyses of SOM chemistry in relation to its speciation and stability and implications for sequestration and nutrient cycling will be discussed.

Keywords：*organic carbon, pH, soft X-ray absorption, synchrotron, FTIR*

O88-5

[C2.2-3] B: Behavior and Fate of Pollutants Entering the Soil Environment

A Study of Korean Growing Media's Characteristics

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In Korea, Commercial growing media have been produced since the early 1990s.
Currently around 30 manufacturers produce 250 million dollar worth soil mixtures of rice, vegetables and plants seed-raising. The bed soil market of Korea is composed of 70% rice seedbeds products and 30% horticultural ones. These products are mixed with abouts 20 raw materials, such as cocopeat coir, peat moss, diatomite, vermiculite, zeolite, perlite etcs.

Most of the raw materials, such as cocopeat coir, peatmoss, zeolite, perlite, vermiculite for Korean top-soils are importing from India, Sri Lanka, China, Europe, Canada etcs. The diatomite, loess, local soil, by-products of crops are used domestically supplied.

Korean growing media's characteristics are 1) cocopeat coir is the main component 2) contains fertilizer 3) for germination and raising seedling for vegetables and plants 4) for rice seedbeds. Since the government understood the importance of the topsoil, Korean government began regulating the quality (density and gravity, pH, EC, total contents of fertilizers etcs) of commercial bed soils from Jan. of 2013.

Keywords：*Growth culture media. Artificial soils. Rice seedbed media. Horticulture growth media. Bedsoil.*

O89-1

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Congruent Development of Microbial Communities, Organic Matter and Surface Properties in Artificial Soils with Different Mineral Composition and Charcoal Presence

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An interdisciplinary approach was used to gain understanding of the interplay between physical, chemical and microbiological processes in soil. Artificial soils with different mineral composition and charcoal presence were designed to study the establishment of microbial communities, their functionality and the resulting development of organic matter (OM). The artificial soils were composed to create a simplified soil-like material with well-defined composition and initial conditions and contained different mixtures of the minerals illite, montmorillonite, ferrihydrite and boehmite, and charcoal. Sand and silt-sized quartz were used to provide texture, the mixtures were inoculated with an extract from a natural arable soil, and sterilized manure was added as a substrate. The mixtures were incubated in the dark at 20°C and constant water content, and sampled after 3, 6, 12 and 18 months incubation. The samples were then analysed for microbial abundance and diversity, functionality, as determined by respiration and enzyme activity, OM composition, physical structure and surface properties.

The mixtures quickly developed into soil-like systems with an established microbial community, macroaggregation and developing organo-mineral associations. All artificial soils had similar CO2 respiration rates, and OM composition and particle size distribution developed similarly for all compositions. The mixtures were all generally hydrophilic, with decreasing contact angles over time for most compositions. However, no clear changes in specific surface area with time were detected. The presence of a clay mineral was important for the formation of macroaggregates, and clay mineral presence led to a higher amount of non-hydrolysable nitrogen, indicating interactions of OM with clay mineral surfaces. Furthermore, the calorific value of the thermolabile and thermostabile fraction of the OM depended on artificial soil composition, indicating interactions of OM with the materials present.

Within these systems, the microbial community established could be differentiated based on charcoal presence and clay mineral composition, as determined with DGGE and pyrosequencing. With incubation time, the influence of charcoal decreased, whereas that of ferrihydrite and boehmite increased, possibly due to increasing coverage of the charcoal surface with OM and changes in

nutrient dynamics of the system. Further study of the microbial communities in separate habitats, as distinguished by particle size fractionation, showed that the microbial community in the coarse fractions was controlled by the large particulate OM particles present, which served as a substrate, whereas microbial communities could be separated by (clay) mineral composition in the finer particle size fractions. Characterization of the microbial community with TRFLP after 3 and 12 months showed that microbial communities became more heterogeneous with incubation time. However, further incubation with additional substrate after 12 months led to an approach of the community composition to that which was present after 3 months, which points to an effect of substrate limitation on the microbial community with incubation time. These shifts in microbial community structure were also reflected when analysing their functional traits. Diversity and abundance of alkane degraders were significantly reduced when soils were compared after 3 and 12 months of maturation independent from their parental material. However, after substrate addition microbial communities in soils after 12 month maturation were able to induce gene expression of the alkB genes (coding for the alkane monooxygenase) much faster compared to the younger soils, mainly in artificial soils where charcoal had been added. This was further supported by the enzyme activity, which shifted from r to K-strategy type patterns between 6 to 12 months of incubation. Enzyme production was also significantly affected by artificial soil composition, especially in the first 6 months of incubation. This indicates that the functionality of the microbial community was at least partly controlled by the minerals present, either due to direct interactions of microbes with mineral surfaces, or due to a control on nutrient availability by sorption to mineral surfaces.

Overall, the artificial soils used in this study provide a new approach to gain a mechanistic understanding of the interaction between microbiological, chemical and physical processes in well-defined soil-like systems. Furthermore, the combination of a range of interdisciplinary methods illustrates how microbial communities interacted with, and were affected by, the OM, mineral and charcoal surfaces present in their habitats.

Keywords：*organic matter quality, clay mineral, incubation, surface interactions, organo-mineral association, particle size fractionation, enzyme activity, microbial community structure, soil formation*

O89-2

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Soil Humic Aicd Complexation with Protein

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Humic substances (HS), including humic acids (HA) and fulvic acids (FA), are important components of soil systems. The reaction between enzymes and soluble humic matter has been attributed to co-polymerisation, adsorption and encapsulation of enzymes into the inner structure of humic matter. The importance of electrostatic and hydrophobic interactions between humic acids and proteins concluded that parameters like mixing ratio of HA and protein, pH and ionic strength determined the extent of HA-protein complexation and aggregation of the complexes. Complexation of oppositely charged HS and protein is a form of 'complex coacervation' or 'associative phase separation', a well-known liquid-liquid phase separation driven by the association of two oppositely charged macromolecules. HS form strong complexes with oppositely charged proteins, which will lead to changes in the enzyme activity. The effect of soil HS on the activity and stability of two enzymes was investigated as a function of pH, ionic strength and mass ratio HS/enzyme. Humic acid (JGHA) and fulvic acid (JGFA) are negatively charged, lysozyme is net positive at pH values below 10.4 and urease is net positive below pH 5.2 or net negative above pH 5.2. The enzyme activities in the HS-enzyme complexes were suppressed when the enzymes were oppositely charged to the HS. The largest activity suppression was observed around the mass ratio HS/enzyme where the HS-protein complex was at its isoelectric point (IEP). At the IEP strong aggregation of the complexes led to encapsulation of the enzyme. The ionic strength was important; an increase decreased complex formation, but increased aggregation. Due to the larger hydrophobicity of JGHA than JGFA, the reduction in enzyme activity was stronger for JGHA. The enzyme stability decreased also maximally at mass ratio around the IEP of the complex when HS and protein were oppositely charged. When urease and HS were both negatively charged no complexes were formed, but the presence of JGHA or JGFA improved the activity and stability of the enzyme.

Keywords：*humic acid, protein, interaction, activity, stability, structure*

O89-3

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Nanoparticles of FE_2O_3 and Zno and Microbial Interactions in Rice Rhizosphere

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When engineered nanoparticles (e.g., ZnO or Fe2O3) carrying mineral nutrients enter into soil ecosystem, they may undergo biological transformations. Little is known about their effects on rice growth, or if transformed whether they could supply plant nutrients (Zn, Fe) to rice crop during their growth. In a series of replicated laboratory, hydroponics and greenhouse studies we assessed the effect of different levels of nanoparticles on root characteristics, release of phyto-siderophores, movement of nanoparticles to root and uptake of Fe and Zn from Fe2O3 and ZnO nanoparticles. We also assessed the interaction of siderophores [desferrioxamine B (DFOB)] with nanoparticles, and the effect nanoparticles on soil organisms and their activity in the rice rhizosphere.

It has been observed from the hydroponics study that with increasing concentrations of Fe2O3 and ZnO nanoparticles (30, 60, 100 ppm), the growth of rice roots was reduced. Similarly, the release of phyto-siderophores from roots was reduced with increasing concentration of nanoparticles from 30 to 100 ppm, indicating toxicity effect at higher concentration. Using transmission electron microscopy (TEM), it has been further observed that at higher concentrations Fe and Zn nanoparticles were accumulated in root cells, showing that these nanoparticles were transported from roots to shoots via xylem and caused cell damages.

The results on siderophores [desferrioxmine – B (DFO-B)] applications showed significant Fe release from nanoparticles of Fe2O3, which revealed that there is disintegration (dissolution) of these nanoparticles by siderophores, thus plant can use the targeted nutrient if the concentration is at safe level.

There were variable observations on population of microbial groups and enzyme activities in soils. Negative effect of nanoparticles is evident in case of bacteria, but this effect seems specific to type of nanoparticles and type of microbial groups. For example, bacterial population was lower in soils treated with nanoparticles of ZnO than Fe2O3. With respect to enzyme activities also there have been both positive and negative effects of nanoparticles. Nanoparticles of Fe2O3 showed lower urease activity, whereas ZnO showed higher values. Except urease activity, effect of ZnO found to be negative on several other enzyme activities in soil.

It is concluded from several experiments that manufactured nanoparticles of ZnO or Fe2O3 can release Zn and Fe in the rhizosphere. Siderphores in soil plays an important role to destabilize and release of Zn and Fe. At higher concentration of nanopartilces, it may be unfavorable to rice plants and soil organisms.

Keywords：*Nanoparticles, siderophores, soil microbes, soil enzymes, rice, rhizosphere,*

O89-4

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Effect of Phenanthrene and Hexadecane on the Release and Transport of Mobile Organic Matter in Soil - a Two Layer Column Study

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Biogeochemical interfaces (BGIs) in soils are “hot spots” of microbial communities and turnover of organic substances. We hypothesize that the model compounds and additional carbon sources phenanthrene (PHE) and hexadecane (HEX) influence microbial communities, which in turn may affect the release of mobile organic matter (MOM), including biocolloids, and may impact the properties of BGIs in matured soils. We explored the release of PHE and HEX using an experimental approach employing two-layer columns (10x12 cm) (Weigand et al. 2002) filled with matured soil originating from a Luvisol (Scheyern, Germany; Ah, 5-20 cm). The upper layer (2 cm) served as source layer (SL) and was either spiked with PHE (0.2 mg g-1) or HEX (2.0 mg g-1). The lower layer, further called “reception layer” (RL, 10 cm) only contained the Luvisol soil material. The experiment was carried out under unsaturated flow conditions with two replicates per treatment and two control columns as reference. Columns were irrigated with artificial rain water for one month (1-1.5 pore volume day-1) with several flow interrupts (FI) of different durations (1-52 days) to allow reactions at BGIs. Physicochemical and chemical parameters (pH, EC, turbidity, TOC/DOC, anions/cations, PHE, HEX and their metabolites) and the microbial community composition were analysed in effluent samples and in soil slices with different distances to the SL obtained at end of the flow period.

The release of MOM from the columns was in general controlled by non-equilibrium. Total organic carbon (TOC) and dissolved organic carbon (DOC) differed by a factor of 1.2 after the flow interrupts. During flow, no TOC/DOC-difference was observed. PHE had only a slight effect on MOM release, which was observed after the first longer FI of 26 days. Columns spiked with HEX showed a similar behavior. Turbidity and hydrodynamic diameter, two parameters that relate to suspended particles and colloids, were unaffected in the PHE treated columns. Yet, HEX substantially increased these parameters.

In all effluent fractions of the PHE experiment, diverse and heterogeneous bacterial communities were found. This proves the assumption that microorganisms are mobile and can be relocated in soil under studied flow conditions, like observed in recent field studies (Dibbern et al. accepted). By denaturing gradient gel electrophoresis (DGGE), depth distribution of the bacterial communities associated with the immobile solid phase indicated high similarities among different depth layers and treatments. Abundances of genes involved in the anaerobic and aerobic degradation of PHE, as well as a few bacterial populations in DGGE fingerprints were shown to be depending on the distance to SL in PHE-spiked columns.

Chemical analysis of PHE at the solid phase showed a slight displacement of the model substance at the boundary SL to RL and the concentration decreased downstream across the entire column. Small contact angles (6.6 ± 5.2 °) were determined in all Luvisol materials indicating good and rapid wettability of the surfaces. Slightly higher contact angles (17.5 ± 3.7 °) were observed in lowest RL slice of the PHE spiked Luvisol.

Our results suggest that microorganisms and even “communities” can be mobilized and transported passively to downstream compartments under unsaturated flow conditions. First indications point to the fact that the additional carbon source will impact not only the activity of microbial taxa, but also the mobilization and transport of these microorganisms. That, in turn, will help to understand the processes that result in the inhabitation of pristine surfaces, thereby resulting in the formation of new biogeochemical interfaces.

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Keywords：*Biogeochemical interfaces, mobile organic matter, biocolloids, column experiment*

O89-5

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Microbial Utilization of Free Versus Sorbed Pyruvate Investigated by Positon-specific 13C and 14C Labeling and 13C-Plfa Analysis

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Sorption of charged or partially charged low molecular weight organic substances (LMWOS) to surfaces like clays and sesquioxides in soil delays microbial uptake of LMWOS and therefore their mineralization to CO2 as well as other chemical transformations. We used position-specific labeling, a tool of isotope applications novel to soil sciences, to compare the transformation mechanisms of sorbed and non-sorbed pyruvate in soil. As a precursor for acetyl-CoA, pyruvate is produced in nearly all metabolic pathways, anabolic and catabolic alike and therefore is a model representative for the pool of LMWOS.

To assess transformations of sorbed pyruvate, we combined position-specifically and uniformly 13C and 14C labeled pyruvate tracer solution with a loamy haplic luvisol that had previously been sterilized by γ-radiation. After shaking the mixtures, the supernatant was removed, as was all non-sorbed pyruvate by repeated shaking with millipore water. The labeled soil was added to non-sterilized soil from the same site. To compare the effect of sorption, soil labeled with the same position-specifically labeled tracers without previous sorption was prepared and incubated as well. We captured the respired CO2 and determined its 14C-activity at increasing time steps. The incorporation of 14C into microbial biomass was determined by CFE, and utilization of individual C positions by distinct microbial groups was evaluated by 13C-PLFA analysis.

Microbial uptake and transformation of the sorbed pyruvate was 5 times slower compared to non-sorbed pyruvate. To compare the fate of individual C atoms independent of their concentration and pool size in soil, we introduced the divergence index (DI). The DI reveals the convergent or divergent behaviour of C from individual molecule positions during microbial utilization. The DI revealed, that pyruvates C-1 position was mainly oxidized to CO2, while its C-2 and C-3 were preferentially incorporated in microbial biomass and PLFAs. This indicates that sorption by the COOH group does not protect this group from preferential oxidation. Microbial metabolism is determinative for the preferential oxidation of individual molecule positions. Uptake into the PLFA of gram negatives was highest for both the sorbed and non-sorbed treatment, showing that this group is not only highly competitive regarding the uptake of free LMWOS (like root exsudates) but are also able to desorb and utilize sorbed LMWOS.

The use of position-specific labeling revealed mechanisms and kinetics of microbial utilization of sorbed and non-sorbed pyruvate, as well as interactions between microbial groups, soils and LMWOS. None of these findings could have been achieved without the use of position-specific tracers, therefore this method will improve our understanding of stabilization processes and soil C fluxes.

Keywords : *Soil-SOM-interaction, Microbial transformation, Metabolic tracing*

O90-1

[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Proposed Soil Taxonomy Changes for Gelisols and Other Soils with Gelic Materials

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Soils in cold regions comprise approximately 9 % of the ice-free area of the earth and are an important sink of approximately 316 billion tons of soil organic carbon (Eswaran et al., 2000). These soils are impacted by climate change and anthropogenic pressures such as mineral exploration and extraction.

In 1993, the Gelisol order was proposed in Soil Taxonomy, the U.S. soil classification system, to address permafrost-affected soils. This resulted from joint international investigations and efforts by pedologists and geocryologists. Gelisols were added as the 12th soil order with the release of Keys to Soil Taxonomy, 8th Edition in 1998. They are defined as soils that have (1) permafrost within 100 cm of the soil surface; or or (2) gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface. They are classified as Cryosols in the both the World Reference base and the Canadian System of Soil Classification, and Cryozem in the Russian soil classification system.

Soil Taxonomy is intended as a guide for categorizing soils and developing soil interpretations in soil surveys. It is designed to accommodate new data for modification, for the system to evolve and remain relevant. The conceptualization of Gelisols as mapped soils and an environmental component is centered on definitions, observed natural conditions, and predicted responses to climate change. Refinements to Gelisols and other soils with gelic materials have been introduced in the iterations of Keys to Soil Taxonomy (12th Edition due out in 2014), but the current classification is not perfect and definitely not static. Based on observations and published studies, more modifications and additions should be considered to augment the current taxonomy (Ping, 2013; Bockheim, 2013; Smith, 2013). Some of these were highlighted during the 2013 Ultra-Continental WRB Field Workshop in Central Yakutia, Russia.

Central Yakutia is the only cold region of the world with low precipitation (ca. 200 mm/yr) and extreme seasonal temperature differences; monthly air temperatures range from 18.5°C (July) to -44.5°C (January). Absolute maximum and minimum air temperatures are 38°C and -71°C, respectively. The mean annual air temperature in Central Yakutia has increased from -11.2°C four decades ago to -8.8°C today. As a consequence, the active-layer has increased from around 1 m to more than 3 m and has been accompanied by substantial thermokarst.

Workshop participants examined 16 pedons and viewed permafrost, ice cores, and other cryogenic structures and permafrost affected soil properties that are shared in common between Central Yakutia and other high elevation and circumpolar regions. However, Yukutia also includes some unique characteristics such as saline and sodic soils that are uncommon in other permafrost affected regions. The dominant soil-forming processes in the Central Yakutia region are weak cryoturbation, gleization, weak podzolization, weak ferrugination, humus accumulation, and strong solodization, salinization, and calcification. The pedons were classified using WRB and Soil Taxonomy.

Some of the main findings from the field tour that have implications for Soil Taxonomy include the need to: (i) quantify cryoturbation; (ii) revise the Gelisol order to include Aqui- and Aridi- suborders and additional great groups and suborders; (iii) include more Geli-suborders and great groups in Soil Taxonomy; (iv) improve the soil temperature and soil moisture regimes to accommodate soils outside North America; (v) stress that permafrost depths (1 or 2 m) should be taken or adjusted to end-of-season conditions, i.e., mid-September in the Northern Hemisphere and early April in the Southern Hemisphere; (vi) specify amount of gelic materials to meet Gelisols and Turbic subgroups in various orders, i.e., trace amount, “significant” amount, or a set threshold.

Keywords：*Soil Taxonomy, Gelisols, gelic materials, permafrost*

O90-2

[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Soils with High Activity Clay and High CEC in Acre State, Amazon Region

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The tropical soils are mostly associated to the presence of low activity clays, characterized by the prevalence of kaolinite and goethite/hematite minerals and the low cation exchange capacity (CEC). Although this is valid for the majority of soils in the Cerrado region and the bulk of Amazon soils, in the Acre State - in Northwestern Amazonia, soils with high activity clay and high CEC were characterized during a field trip in 2010 for soil classification and correlation organized as part of the project for validating the Brazilian Soil Classification System (SiBCS). The soils are originated from the Solimoes Formation parent materials. Many authors relate the deposition of these sediments to the influence of Andean tectonics on the Miocene incursions, and the occurrence of an internal sea in the region, as well as climatic variations alternating arid and humid conditions. The climate is classified as Am type, hot and humid equatorial, with mean annual temperature from 24.5 (lowest) to 32 (highest) °C. Due to the high rainfall and temperatures it was expected to find soils with deep and strongly weathered mantles. However soils with 2:1 expansible clays were found in Acre, as well as accumulations of carbonates, phosphates, and minerals such as feldspars and plagioclases in the sand and silt fractions. High CEC was a common characteristic, either associated to high Al (extractable with KCl) or high Ca and magnesium levels, and in some profiles both, i.e., Al, and Ca and Mg. Soils classified as Vertisols, Cambisols and Alisols, plus some identified as Luvisols were found in this field trip, and also reported previously by other authors. The formation of these soils is relatively recent, where many of the soil attributes are inherited from the parent materials and formed in pedogenetical environments different from other areas in Amazon. Thus, even in the Amazon region, to state that soils formed in tropical environments are dominantly Ferralsols and Acrisols might be oversimplifying, and this should be avoided in developing a global soil classification.

Keywords：*Polygenetic soils, paleoclima, national soil classification*

O90-3

[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

The Method of Development and Structure of the Modernized Hungarian Soil Sclassification System

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The current Hungarian Soil Classification System (HSCS) was elaborated during the 1960s, based on the genetic principles of Dokuchaev. It was developed before sufficient data and modern data processing tools were available and served different purposes than current users need or apply it for. The central unit is the soil type, grouping soils that were believed to have developed under similar soil forming factors and processes. The major soil types are the highest category that group soils based on climatic, geographical and genetic bases. Subtypes and varieties are distinguished according to the assumed dominance of soil forming processes and observable/measurable morphogenetic properties. Stefanovits (1963) defined the 23 soil-forming processes that have a dominant impact on the differentiation of the 39 soil types of the system.

After 6 decades the modernization of system became essential, to serve broad variety of users (from farmers, trough modelers to decision makers) and allow international correlation. In the modernization process the units of the system were reviewed and analyzed with numerical approaches. The originally defined processes were linked to common diagnostic elements (horizons, material, and properties) of the USDA Soil Taxonomy (ST) and the World Reference Base for Soil Resources (WRB) and adopted for Hungarian conditions.

The taxonomic relationship of the classification units were studied with distance methods. Based on the results the number of soil types was rationalized. In the new grouping 15 soil types were differentiated ((Peat soils (Histolsols), Anthropogenic soils (Anthrosols), Shallow rocky soils (Leptosols), Lithogenic soils (Leptosols), Solonetz soils, Solonchak soils, Swelling clay soils (Vertisols), Groundwater influenced soil (Gleysols), Carbonate soils (Calcisols), Steppe soils (mollic soils), Clay accumulation soils (Luvisols), Sediment soils (Fluvisols and Colluvic Regosols), Sandy soils (Arenosols), Undeveloped other soils (Regosols).

A computer assisted key was developed and tested on 12000 profiles. The key handles legacy data, hence correlation of the units of the earlier system to the modernized one is possible on the “type” level.

The lower lever units were developed by the application of specific clustering algorithms.

The paper will demonstrate the applied methods and the resulted structure and elements of the modernized system.

The definitions and criteria are significantly simpler than the corresponding ones in ST or the WRB but the correlation is possible with simple algorithms, hence fitting data to harmonized data bases is possible.

Keywords：*Hungarian Soil Classification, numeric approaches, harmonization*

O90-4

[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Developing a Simplified Guide to Soil Taxonomy

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The U.S. Soil Taxonomy has been developed over a span of more than 60 years. This dynamic system has been amended and improved to add newly found soils and soil properties around the world into a common system. The U.S. National Cooperative Soil Survey (NCSS) consisting of National, State, local, and private soil scientists have helped build the system. There have been 10 international committees assembled to improve Soil Taxonomy since 1975. Soil taxonomy is the official classification system for soils in the U.S. and is currently used in several countries as the primary or secondary classification system. Soil Taxonomy has always been intended as a universally accepted system of soil classification. Soil taxonomy is a detailed system with a complex hierarchy that can be very intimidating to learn. Beginning soil scientists, students and soil practitioners often find it difficult to use. An ad hoc NCSS advisory working group was formed to develop a simplified guide to using Soil Taxonomy. The simplified guide can be used to classify a soil to the great group level of soil taxonomy and will not require an advanced understanding of soil science, extensive field experience, or laboratory data in order to use and appreciate Soil Taxonomy. This collaborative effort targets the needs of beginning soil science and agricultural studies students, natural resource specialists with minimal soils experience, and other professionals who use NCSS products and reports. The guide consists of several sections paralleling the Keys to Soil Taxonomy. It is enhanced with the use of illustrations, horizon and profile photos, maps, and flow diagrams. The description of soil orders is expanded to explain central concepts of the taxa, includes maps of occurrence, explains class criteria in simplified terms, and includes a summary description for characteristics of the great groups. The section on diagnostic surface and subsurface horizons and features is enhanced in a similar manner. The guide conveys the classes and criteria of soil taxonomy through a more prosaic narrative and there is extensive use of hyperlinks for quick reference. The guide lends itself readily to web access and use on smartphones and tablets for use in the field.

Keywords：*Soil Taxonomy*

O90-5

[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Explore the Secrecy in the Distribution of Red and Yellow Soil on the Earth

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In 1986 we presented a paper (oral) at the 13th World Congress of Soil Science: 'The Contribution of Forest and Catastrophic High Temperature to the Formation of Yellow Red Earths'. During the last 30 years, more evidences have been discovered to support the conclusions proposed in that paper about the formation and distributions of red and yellow soils. In addition to the analysis on the distributions of red and yellow soil, some discussions on oxisol are also given in this paper.

We questioned the hypnosis on the soil distribution proposed by a scholar in Russia, which stated that red soil, yellow soil and laterite usually presented in the subtropical and tropical areas, the formation of red soil were the results of allitic weathering, and the decrease of silica to alumina ratio were due to the weathering. However, in fact, red soil, yellow soil and laterite can be found widely distributed in temperate zone, frigid temperate zone and highlands. Our experiments also revealed that the silica to alumina ratio has been increased, not decreased, from the soil samples lasted for more than 15 years. It would be hard to explain, based on the theory of allitic weathering, the wide distribution of red calcareous soil in the limestone areas. Furthermore, the red soil layer underneath the yellow soil layer can be found to a great extent in the loess high plateau in northern China, which is one of the evidences to support the theory that yellow soil can be evolved from red soil.

More evidences are discovered in supporting the theory: the formation of red soil is due to extreme high temperature, and the formation of yellow soil is due to the biological evolvement from red soil. Soil profile with three layers, black, yellow and red, can be found everywhere in the world (please refer to our papers on the 15th and 18th WCSS for more information). We also discovered that the red soil layer underneath a reservoir does not evolve into yellow soil and stays as red soil layer; however a yellow soil layer can be found to evolve underneath the rice fields planted on top of red earth hills. And we believe the formation of the yellow soil layer underneath the rice fields is due to the presence of plant root system and microbiological substances. These evidences further support the conclusion that we proposed that the development of red soil is due to high temperature and the development of yellow soil is due to biological substances (microbiological substance and plant root system).

Oxisol, a widely used higher level category substance, and named latosol in China, were thought to be evolved from high degree of weathering in the tropical areas. Based on some brief survey done in Hawaii, it is found that oxisol could be part of the magma spurt from the volcano eruptions or derived from weathering of basalt. The same kind of soil can be found in the stratum from the Quaternary period in the eastern part of China (it is named ferric magnesium in China rather than oxisol.) The same kind of soil can be found in many countries, such as Greek, Australia and Canada. It would be hard to classify that the weathering process in Hawaii to be in high degree, so that it would be hard to conclude that oxisol is formed due to high degree of weathering.

It is important to understand the formation of red and yellow soils and their distributions. Otherwise the data analyzed from the advanced instruments, such as Mossbauer spectrum analysis and X-ray analysis, could not provide clear and systematic results. It would hard to use the criteria analyzed, such as secondary clay mineral type, in the classifications of red and yellow soils, if the basis on the formation of the red and yellow soils is not quite clear.

Keywords：*red soil, yellow soil, soil formation, soil biological yellowlization*

O91-1

[DS5] Soil Health: Key to Food Security

Environmental Geochemistry and Health, with Special Reference to Food Contaminants

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Food safety is currently one of the major public health issues in the world, especially in the developing countries. There is an important link between soils, health and food safety. Soils provide balanced essential nutrients for plants, and animals, and eventually for humans. If soils contain deficiencies or surpluses of nutrients may affect for those that live and depend on the soil. Over exploitation and misuse of soils has led to contamination. Repeating the episodes happened in the 18th, 19th and 20th centuriesin developed countries, much damage has done to the soils in developing countries, at a much faster rate, due to rapid industrialization. Such damage to soils further leads to soil, water and air pollution, and a variety of problems including release of toxins and carcinogens. Under such circumstances, soils will become a sink or even a source of pollutants, threatening the ability of soils to meet safety standards, and jeopardize food production. Among all contaminants, heavy metals and persistent organic chemicals are of particular concern. Common health problems such as cancers (arsenic, asbestos, dioxins), neurological damage and lower IQ (lead, arsenic, mercury), kidney disease (lead, mercury, cadmium), and skeletal and bone diseases (lead, fluoride, cadmium) are serious issues in developing countries. There seems to be data gap concerning emerging chemicals of concern (e.g. such as flame retardants and phthalates) and pharmaceutical products. Soils possess different functions such as adsorption of nutrients, filtering, leaching, flow control, storage and amelioration, which are vital in planning food security. It is therefore essential to understand soil properties and functions, for better management of contaminants and would-be soil pollutants in the soils system with respect to food safety.It is also important to understand contaminant pathways (from soil to human body); and various factors in determining how much of a contaminant is available to the human body, and for transport in the vicinity. This presentation will highlight some major issues concerning how contaminants are entered into food, which include uptake of contaminants by plants, effects of agricultural practices on soil contaminant contents, through application of fertilizers, sludge and agrochemicals, and industrial emission as a source of contaminants in food. Contamination in food during food processing and food fortification is also discussed. Cases studies related to our region will be cited.

O91-2

[DS5] Soil Health: Key to Food Security

Heavy Metal Contamination of Soils: a Global Challenge to Food Security

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Heavy metals contamination of agricultural soils and the environment has become a global challenge for food security and human and animal health. Heavy metal, with specific gravity greater than 5.0 g cm-3, include Fe, Mn, Cu, Zn, Cd, Pb, Hg, Cr, Ni, Mo, Co, and As (a metalloid but similar to heavy metals in chemical properties and environmental behavior) are hazardous to biota and human and animal health. Heavy metal pollution has a combined worldwide economic impact estimated to be in excess of US $10 billion per year. In China, approximately 12 million tons of grain is contaminated by heavy metals every year due to soil pollution, resulting in economic losses exceeding US$3.2 billion. Heavy metal pollution impacts soil quality, reduces crop production, impairs health of terrestrial and aquatic ecosystems, reduces drinking water and food quality, and poses an increasing threat to human health and societal stability worldwide. Both geological processes and anthropogenic activities contribute to heavy metal pollution. Joint efforts of government, scientists, and community are needed in monitoring, assessing and controlling heavy metal pollution of agricultural soils and the environment. Science and technology development is critical for prevention of heavy metal pollution and remediation of contaminated soils and water bodies, whereas governmental regulation, establishment of global standards, and public awareness are essential to minimize its impacts on food security and human health.

Keywords：*Agriculture, food security, heavy metals, human health, soil quality*

O91-3

[DS5] Soil Health: Key to Food Security

Soil at the Nexus of Food Security, Climate, and Sustainability

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Food production needs to double to meet a global population of 9 billion. Meeting future food needs puts stress on soil resources and requires new ways of plant production and managing soils. Climate poses another challenge in meeting food security. Food security, water availability and quality, and climate change are some of the greatest challenges facing our society. Meeting these challenges must be balanced with the sustainability of soil. This will require changing soil and water management practices, increasing nutrient and water use efficiencies, in addition to developing more productive crop genotypes and improved crop management strategies. Clearly, stress on soil resources through land use change could become entangled with food security. Plant production systems should be guided by two principles, productivity and resource efficiency, to protect soil resources and ecosystems. To achieve these two principles and have any success of meeting the growing food demands, plant-soil systems must intensify and diversify. Intensification of the plant production system should consider multiple crops, reduction in tillage intensity, and increase nutrient and water use efficiency. Diversification should consider annual and perennial plants and multiple uses across the landscape. To meet food demands while maintaining soils will require novel thinking.

Keywords：*soil Food security, sustainability*

O91-4

[DS5] Soil Health: Key to Food Security

Soil the Next Step Nexus for Global Existential Environmental Challenges

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There are a number of large environmental challenges that have been identified as affecting sustainable development, including Food Security, Water Security, Energy Security, Climate Change Abatement, Biodiversity Protection, and Ecosystem Service Delivery. It is clear that soil underpins these challenges by providing a set of functions, which include; (1) biomass production, (2) storing, filtering and transformation of nutrients, substances and water, (3) biodiversity pool, (4) physical and cultural environments, (5) source of raw materials, (6) acting as a carbon pool, and (7) archiving and geological and cultural heritage. Aligning the seven scientifically established soil functions affecting each of the global challenges clearly demonstrates that soil is the nexus when investigating them. The quantity, quality and accessibility of food is affected by the having a fertile soil with enough water to produce biomass, and is not contaminated. Soil provides for clean stored water contributing to water security, and by doing so, maintains the soil's ability to produce food and protect biodiversity. The ability to produce plants also provides for energy production, and although this is not always synergistic with food production, is essential for energy security. The sequestering of carbon and nutrients in soil supports the reductions of greenhouse gasses affecting climate change and soil is the habitat for the largest gene pool and diversity of species. Overall, soil also provides for a wide set of ecosystem services and can be considered as a stock that can be evaluated in terms of its natural capital. Degrading the soil through erosion, fertility loss, salinity, acidification, soil carbon decline and compaction have been shown to have adverse effects. It is clear that to account for soil as a contributor to all these challenges, soil needs to be considered through its biophysical attributes as well as, its inevitable economic, social and policy aspects, making it the nexus for these global challenges.

O91-5

[DS5] Soil Health: Key to Food Security

Movement of Heavy Metals from Soil to Human Food Chain and Risk Assessment

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Heavy metals, such as cadmium (Cd), copper (Cu), lead (Pb), chromium (Cr) and mercury (Hg), are important environmental pollutants, particularly in areas with high anthropogenic pressure. Their pollution in soils can result in severe problems to all organisms, and heavy metal bioaccumulation in the food chain can pose a threat to human health. Heavy metals enter human body mainly through two pathways: inhalation and ingestion, with ingestion being the major exposure of heavy metals to human population. Heavy metal intake by humans through food chain has been reported in many countries. For soil-plant-food chain system, heavy metal toxicity risk assessment is based on soil threshold that does not exceed food hygiene standards, and is highly dependent on the movement of heavy metals from soils to the edible parts of the crops. In this paper, recent progresses of research on the movement of some important heavy metals (including Cd, Cr, Pb, Hg, and Cu) from soils to crop edible parts (human food chain) are reviewed. The movement of heavy metals from soils to edible parts of crop plants is highly dependent on kind of metals, soil type, crop species or cultivars, and microbial interactions. Cadmium is among the most mobile in food chain of all the heavy metals. Soil properties such as soil pH, organic matter content, and clay mineral are the major factors regulating metal bioavailbility and accumullation in food chain. In addition, the interactions of soil-plant root-microbes play an important role in regulating heavy metal movement from soil to the edible parts of crops. Some endo-microbes have been found to increase metal movement and accumulation in crop by several times. Agronomic practices, such as fertilization, water management and crop rotation, influence bioavailability and crop accumulation of heavy metals, thus affecting the thresholds of assessing dietary toxicity of heavy metals in the food chain. The processes and factors regulating the movement of heavy metals from soil to human food chain in vegetables and food crops for soil health assessment are discussed in details.

Keywords：*heavy metal pollution; human food chain, risk assessment, soil health.*

O91-6

[DS5] Soil Health: Key to Food Security

Improving Soil Productivity in Dryland Agroecosystems of India by using Organic Amendments

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Rainfed dry lands meet about 60% of the food and nutritional needs of the World's population and are backbone of the marginal or subsistence farmers. Out of 1.53 billon ha of total cultivated area in the World, rainfed dry lands constitute 1.13 billion ha or ~74%. Droughts are characteristic of dry lands and can be defined as periods (1 - 2 years) where the rainfall is below the long-term average. Frequent weather aberrations, degraded soils, low biomass and carrying capacity of the system are common features of these regions. Largest area of drylands exists in the countries of Africa and Asia, where population density is much higher and food insecurity is a serious concern.

Poor soil health is one of the important productivity constraints after severe scarcity of water in these agro ecosystems. Low soil organic carbon (SOC) particularly in tropical dry lands, multi-nutrient deficiencies, low biological activity, prone to salinization etc are major contributors to declining soil health and crop productivity in these regions. Cultivated soils of rainfed regions in Asia are severely depleted of their SOC content (<5 g kg-1 soil). Therefore, important strategy is to improve soil productivity by enhancing SOC pool as it is a strong determinant of the nutrient dynamics and overall soil functions. However, improving the SOC pool in dry lands is a challenge due to prevailing higher temperatures which result in rapid decomposition of added organic matter. Indiscriminate removal of crop residues including root portion and residue burning as a mean of clean cultivation is widely practiced in drylands of India. Most of the residues of maize(Zea mays), cotton(Gossipium hirsutum) and rice(Oryza sativa) in northern parts of Indian sub-continent are burnt in situ. Serious efforts are required for creating awareness about its demerits and implementing policy against field burning of crop residues in India and elsewhere.

A wider range of organic amendments have been tested in long term experiments in drylands of India, to assess the impacts of such practices on SOC concentration and pool, soil health and overall crop productivity. In Alfisols of Anantapur (Andhra Pradesh), application of groundnut(Arachis hypogea) shells and farm yard manure(FYM) at the rate of 4 -5 Mg ha-1 improved SOC concentration of the surfatce layer from 3 to 6 g kg-1 soil after 20 years of groundnut monocropping under arid conditions. The increase in SOC concentration improved water retention in soil (available water by 2%) along with increases in availability of limiting nutrients and overall soil quality improved groundnut productivity from 0.78 to 1.03 Mg ha-1. In Vertisols at Solapur (Maharashtra), 22 years of regular addition of sorghum residue, FYM and green manuring with Leucaena leucocephala improved the profile SOC stock up to 68.5 Mg ha-1 with overall carbon build-up by 40 %. The corresponding sorghum productivity was 1.2 Mg ha-1, significantly higher than that under farmers practice. The declining trends in productivity of finger millet even with recommended doses of NPK fertilizers have been reversed and improved over 35 years by using a combination of FYM and chemical fertilizers. Regular addition or organic amendments improved the concentration of major plant nutrients while also improving the plant available water retention capacity anmd soil tilth. Similar gains in productivity by using organic amendments have been recorded for soybean (Glycine max)-chickpea(Cicer arietinum) system on Vertisols in central India, upland rice on Inceptisols in Varanasi in northern India, cereal-legume rotation on Entisols of at SK Nagar in Rajasthan. Regular addition of organic amendments to soil over 20-35 year period resulted in a higher sustainable yield index (SYI) over unfertilized control and sole application of either of the chemical fertilizers tested. Increase in productivity of several rainfed crops ranged from as low as 13 to 170 kg ha-1 for every Mg ha-1 SOC stock in the root zone. Thus, there is a strong need to identify and implement suitable enabling mechanisms and policy interventions at national level to facilitate the large scale field implementation of such addition of organic amendments in conjunction with the use of inorganic fertilizer nutrients for narrowing the large yield gap and improving soil quality, and advancing food security in India.

Keywords：*Soil health, Soil organic matter, Organic amendments, Crop residue, Green leaf manuring, , Crop productivity, Dryland agriculture*

O91-7

[DS5] Soil Health: Key to Food Security

Phosphorus Recovery and Reuse from Waste Streams

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Phosphorus (P) is an important macro-nutrient required by higher plants for growth and development. Phosphate rock is the main raw material for P fertilizers and the global rock phosphate production stands at 191,000 x 103 t in the year 2011 (Jaisinski, 2012). Phosphate rock is a scarce and finite resource only available for the next 50- 100 years (Cordell et al., 2009). In Pre industrial era, farm and domestic waste materials produced were returned back to the farm so that the nutrients were recycled and represented sustainable agriculture.

Increasing population and the need for ensuring food security resulted in Green revolution and characterised by improved high yielding varieties with better fertilizer response, irrigation facilitates and more area brought under cultivation. On-farm wastes were replaced by industrial manufactured and subsidised fertilizers and were applied almost every year to increase the yield. Farmers avoided recycling of farm waste and other wastes, and the valuable nutrients ended in non-agricultural land, thereby resulting in permanent loss (Allsopp, 2012).

Mined rock phosphate is the main source for all P fertilizers and its reserve is available only with handful of countries. Increasing demand and price of P fertilizer and dwindling quality phosphate rock are indication of P peak. Unlike oil peak, which can be tackled by the use of alternate energy sources, P peak is difficult to manage as there is no alternative for P in living systems (Cordell et al., 2009). FAO predicts that the World population in 2050 estimated to be 9 billion people and there is a tough task ahead for Agriculture and Fertilizer industry to ensure food availability including meat based food stuffs. Only 15-20% of applied P is used by the crops and animals, the remaining amounts of P are wasted into various waste streams (Roy et al., 2006). The P present in these waste streams pose a threat to environment by way of nutrient enrichment resulting in various ecological problems.

The world livestock population of 65 billion produce huge quantities of manures and the traditional approaches to using waste streams including manures, farm effluents and bio solids as a nutrient source are not currently economically viable due to the sheer volume required to obtain adequate nutrient levels. Optimum use of these waste streams as a source of nutrients and water requires knowledge of their composition not only in relation to beneficial uses but also to environmental implications. These waste streams can be very well utilized for recovery and reuse of P for a sustainable future. Annually, large quantities of waste streams that are rich in nutrients such as N and P are produced in each country. For example, the quantity of P present in these waste streams produced in the US (t/annum): poultry manure-610,000; sheep manure-5,000; cattle manure-154,000; pig manure-54,000; and in Biosolids-127,000 (Thangarajan et al., 2013).

The P present in waste streams can be recovered by various processes that include: (a) Precipitation as calcium and magnesium phosphate. The industrial by product such as lime, fly ash can be used for precipitation. (b) Nucleation of P present in the waste streams using nano materials. (c) Dissolved P in waste stream can be adsorbed and recovered using suitable adsorbent which are having high affinity to phosphate ions. Alum, red mud, slag can be used as adsorbents. Ion exchangers such as resins are generally used in waste water treatment plant to reduce P concentration in effluent. (d) Thermo-chemical combustion techniques involve incineration of municipal bio solids followed by a wet extraction and recovery of P from ashes. (e) Enhanced biological phosphorus removal (EBPR) and denitrifying P removal are the two methods of biological P removal techniques.

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Keywords：*Phosphorus, nutrients, recovery, waste stream, reuse.*

O91-8

[DS5] Soil Health: Key to Food Security

EXPO2015 Milan and Feeding Knowledge Programme: the Nexus between Land, Water, Climate Change, Biodiversity, Energy and Food Security in the Mediterranean

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Feeding Knowledge (FK) programme has been developed in the frame of 2015 Milan Universal Exposition. The theme 'Feeding the Planet, Energy for Life' chosen for the EXPO2015 is related to nutrition, food security, safety and quality embraced by the common goal to achieve sustainable development that allows everyone on the planet to have access to healthy, safe and sufficient food at all times. Five priority areas have been identified in the context of the FK programme. They include: (1) Sustainable management of natural resources, (2) Quantitative & Qualitative enhancement of crop products, (3) Socio-Economic Dynamics and Global Markets, (4) Sustainable development of small rural communities in marginal areas, (5) Food consumption patterns: diet, environment, society, economy and health. The programme is first focused on the Euro-Mediterranean region including South-East European countries and Turkey. After 2015, programme activities will progressively involve other regions of the world. Registration to the programme is available at https://www.feedingknowledge.net/.

The Mediterranean is undergoing tremendous political, economic, social and environmental changes and many challenges lie ahead but fears are that food security may be the next major “trouble”. The region is best described for its limited natural resources especially land and water, its rich biodiversity and by high population growth rates in the Middle East North Africa (MENA) region . Paradoxically, shortages of suitable land for crop production and water for irrigation or urban use are much severe in the MENA. Climate change effects are already taking their toll as the region is becoming drier and hotter imposing considerable negative consequences on crop production, biodiversity loss, reduction of ecosystems services and overall compromised environmental sustainability. On the other side, the MENA region posses considerable fossil fuel reserves and large potential for renewable energy production from wind and solar, even though these last sources are yet in the early stages of development and it is not clear what impact could have on food security.

One thing is sure: the MENA countries, even by the most optimistic scenarios, not only today, but also on the medium and long term periods can’t meet the goal of being food self sufficient via their own agricultural production and hence food-safe. They will continue to rely on food imports compensated largely from the fossil fuel exports and tourism revenues as long as these sources would be available. Widespread land degradation and desertification but especially the inefficient and inequitable use of water, lie at the roots of many problems the region is facing, and yet, effective solutions remain elusive.

The nexus between land, water, climate change, biodiversity, and energy and its relationship with food security in the Mediterranean indicate that natural resource degradation often receive a “back seat” position in the Governmental agendas. It can be reversed however, if it is caught up early and there is a political will to stop it. Research results show that there are many options available for its recovery through sustainable land and water management, biodiversity conservation, efficient use of energy sources and mitigation/adaptation actions to climate change.

Keywords：*EXPO2015, Mediterranean, food security, natural resources, climate change, biodiversity*

P1-1

[IDS1] Folk Soil Knowledge for Soil Taxonomy and Assessment

Characterization and Classification of Soils in Mexicali Valley, Baja California, Mexico

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The soils in the Mexicali Valley, at Nortwest of Mexico, are classified in Six Soil Series, according to its mechanical composition, and in order of importance by surface are: Gila, light- textured phase (142,940 ha), Gila, heavy-textured phase (104,920 ha), Imperial (45,800 ha), Holtville (13,290 ha), Meloland (1,020 ha) and Superstition (430 ha) (Soil Survey of the Yuma-Wellton Area, Arizona-California, 1933, SRH, 1966). Subsequently these soils were classified as Chromic Vertisol, Calcaric Regosol and Calcaric Fluvisol, according to the classification system of the FAO (1998). However, due to changes in classification systems in current use, including other criteria, the classification may be feasible to complete or update. The study was conducted in order to conduct a preliminary study to describe and classify the predominant soils in the Valley of Mexicali, Baja California, Mexico. Nine profiles of soil were conducted and described (Soil Survey Manual, 1993), located in a transversal transect, north-center-south and west-central-east of the Valley of Mexicali, Baja California, Mexico, (32º 00'- 32º 36' N and 114º 45"- 115º45' W). Soil samples were taken and carried out physical and chemical analysis (Van Reeuwijk, 1995), and the classification of soils was done, according to World Reference Data Base for Soil Resources (WRB) and Soil Taxonomy (Soil Survey Staff, 2006). Gila Series, light- textured phase and heavy-textured phase, which are the most representative of the soils in the Mexicali Valley, according to the classification traditionally used in the region (SRH, 1966) are now called just Gila Series. In the currently classification system the Gila series is no longer considered the denomination heavy phase or light phase, among others, but the predominant particle size is indicated by other nomenclature to family level (Soil Survey Staff , 2006). According to the World Reference Base (1998), the soils were classified as Fluvisols, Cambisols and Vertisols, wich are Haplic or Fluvic type, being typical of soils formed of fluvic material, related to the rivers origin. According to Taxonomic Classification, the soils were classified as Entisols, Vertisols and Aridisols, the Entisols are soils of recent formation, which were subdivided into Fluvents by deposition of alluvial material, and developed under an aridic humidity regime (torrid). The Vertisols are formed by a high clay content (> 30%) in the surface layer, were subdivided into Torrerts by cracking when they are not irrigated, and chromic to present a value chroma (color purity) > 3. The Aridisols develop under a regime of aridic soil moisture, were subdivided into Aquicambids because when these are not irrigated have aquic conditions for some time during the year, and are Fluventic to present an irregular decrease in organic carbon with depth. The profile located in Ejido Nuevo Leon, at 32 ° 20'29 'N and 115 ° 11'81' W, and an altitude of 3.048 m, traditionally classified Gila Series, heavy-textured phase, correspond to Vertisol. In this profile were identified three horizons Ap, AC1, AC2 at 0-12, 12-70 and 70-140 cm, respectively. The descriptions of majority of these horizons indicate a dark brown color (7.5 to 10 YR 4/3) in wet, clay texture (> 60%), pH (7.61 to 8.31), between others. In contrast, the profile conducted in Colonia Polvora, at 32º 29´97" N y 115º 12´71" O, and an altitude of 6.096 msnm, a typical Gila Series, light-textured phase, was classified as Aridisol. This profile presented seven horizons A1, A2, B21, B22, 2C1, 3C2, 4C3 at 0-1, 1-9, 9-26, 26-46, 46-77, 77-110, and 110-230, respectively. In general, the main characteristics for these horizons presented a dark brown color (7.5YR 3/2 to 4/4) in wet, silt loam, pH (6.9 to 8.18). Gila Series, light- textured phase and heavy-textured phase, which are the most representative of the soils in the Mexicali Valley, are now called Gila Series, omitted the name of heavy-textured phase or light-textured phase. The soils were classified as Fluvisols, Cambisols and Vertisols, according to World Reference Base (1998) and as Entisols, Vertisols Aridisols, according to the Taxonomic Classification. Class Taxonomic mainly reflects the recent alluvial origin and weathering of material, aridic moisture regime, high clay content and low organic carbon content in the soils.

Keywords：*Vertisol, Aridisol, Entisols, Gila Series*

P1-2

[IDS1] Folk Soil Knowledge for Soil Taxonomy and Assessment

Relationship between Phytophysiognomy and Classes of Wetland Soil of Northern Pantanal Mato Grosso - Brazil

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The soils of the North Pantanal of Mato Grosso have great diversity of soil types, as Planosols, Cambissols Fluvic, Neosols, Gleysol, Luvisols and Vertisols (Couto et al., 2002), and has as main characteristic the occurrence of sandy soils, if not in the whole profile, at least in the superficial portion. And these soils may be related to the distribution of different vegetation types found in the Pantanal. The objective of this study was to determine the relationship of the different vegetation types and classes of soils observed in the Northern Pantanal. The study was conducted at Private Reserve of the Social Service of Commerce (RPPN SESC Pantanal) that is located in the city Barão of Melgaço, Mato Grosso, Brazil, and its surroundings. The study was conducted in different vegetation types, was collected and described one profile of soil for each area. After morphology description of the profiles were taken one sample per horizon, and sent for laboratory analysis according to Embrapa (1997). The profiles described were classified according to the Brazilian Soil Classification System. To evaluate the relationship between soil classes as an indicator of the presence of phytophysiognomy within the northern Pantanal, contingency tables were assembled. Observing the variation of soils, can be ordering Cambarazal (Vochysia divergens Pohl) studied can be ordered along a gradient based on flooding of claim Junk et al. (2006) that the flood pulse - annual fluctuation of water level - is the driving force of ecological processes in floodplains and along a gradient of geomorphic features from the lower areas of the landscape that are subject to severe seasonal flooding up higher parts of the landscape but they are free of flood, except in years of exceptional floods. The cambarazal identified in areas subject to severe seasonal flooding were under the Gleysols. Already found in the gently rolling relief were under the Plinthosol, subject to temporary flooding, for being soils from poor drainage, corroborating with Couto and Oliveira (2008). In parts, the highest in the landscape that is free of flood, except in years of flooding exceptional Cambara were observed under the Neossols corroborating with Couto and Oliveira (2008). The “Landis” act as water drainage channels, being, however, characterized by a forest formation of Calophyllum brasiliense Camb. (Nogueira et al. 1989). In the northern Pantanal were the Landis observed on the same soil types as predominant phytophysiognomy around it, differing only by the small variation of the local relief, condition is that according to Couto et al. (2002) have large effects in ecological terms, because the position at a given location, the elevation gradient, determines its period of flooding and drought. In the higher parts of the landscape that are free of flood, except in years of flooding exceptional Landis were observed under the Neossols Quartzarenic and connect the higher ground to the lowest in the landscape, acting as channels of water runoff during flood. On gently rolling relief conditions were under the Plinthosol, and for be poorly drained serve as drainage channels, with deposition of shallow and temporary sediment. The “Fields mounds” second Eiten (1983, 1994b) can be described as being a savanna types characterized by the presence of trees grouped in small elevations of land and surrounded by a grassy field, in the case of a type phytophysiognomy savanna. The origin of these formations is discussed in the literature where some studies attribute this rise to the action of termites (biological hypothesis), and other studies attribute the formation process of the outcome of the process of erosion by water (abiotic hypothesis). Fields mounds were identified in areas subject to severe seasonal flooding and waterlogging under temporary Planosol Háplic, Planosol Nátric, and the gently rolling relief conditions were under Plinthosol Argilúvic. In the higher parts of the landscape that are free of flood, except in years of flooding exceptional mounds fields were observed under Neossols Quartzarenic. This work evidenced the existence of the relationship of the types of vegetation type with soil classes identified in the Northern Pantanal.

Keywords：*Fields mounds, flooding, vegetation*

P1-3

[IDS1] Folk Soil Knowledge for Soil Taxonomy and Assessment

Use of Sig Tools in the Treatment of Data and Study of the Relationship between Soil, Geology and Geomorphology in the Basin of the Ribeirao Jardim, Distrito Federal, Brazil

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The gathering of information related to the spatial distribution of regions on the surface of the Earth, is an activity of paramount importance in advanced societies (Burrough, 1986). The task of organizing, maintaining and updating a database of charts format, further complicated and costly due to the large number of people involved in the process, have a significant probability of errors. Another limiting factor was the difficulty of crossing and analyze information on paper, reducing the workability of the material. In this situation arise Geographic Information Systems (GIS) in order to reduce the costs of production and maintain of maps while still allowing interpolation and manipulation of data from various sources such as planialtimetric maps, geomorphological, geological, remote sensing products and others allowing to combine information and make the most diverse types of environmental analyzes, making it a valuable tool in the characterization of natural resources, particularly soil (Camara e Medeiros, 1998). The rocks can be considered as the most important source material of the soil. It is from the action of weathering agents, such as climate and organisms that decompose rock (Embrapa, 2004). The soil presents own morphology, in-depth study of some of these features allow important inferences about their training and their behavior in relation to agricultural use as the capacity to sustainably produce, suitability for agricultural practices, propensity to erosion, salinization, desertification among other (Santos, 2005). That said, the aim of this study was the observation and subsequent establishment of relations between soil types, topography and source material, the basin of the Jardim River, Distrito Federal, using remote sensing products processed in GIS tools. Initially was done bibliographic survey of primary data and secondary data from watershed Ribeirao Jardim, such as soil maps, geologic map, geomorphological maps, thematic maps hydrography, contours, elevation points, mosaic of scenes 2215 and 2216 ALOS sensor AVNIR, 2012. Then the care and handling of data through GIS was conducted and the preliminary relationships were established between the source material, geomorphology and formed soil classes, with checks in the field. With the obtained data watershed Ribeirao Alto Rio Jardim was considered representative of relations between soils, geology and geomorphology observed in the basin of Jardim River therefore chosen for more detailed these relationships forming the current landscape studies. Once selected, the watershed Ribeirao Alto Rio Jardim was bounded by software ArcGIS 10 , using thematic maps of hydrographic and contours of the Distrito Federal (CODEPLAN/SICAD, 1991). For better interpretation of regional soils, origin material and relief, the area of the watershed study was expanded in 2km (two kilometers) using the Buffer tool. Later was generated Digital Terrain Model (DTM) using the Top to Raster tool and than was classified in three classes defined in altimetry <980 m, 980-1100 m, and> 1100 m, thus generating the map of Geomorphologic Units of watershed Ribeirao Alto Rio Jardim. Through the DTM was made Map of slope of the watershed Ribeirao Alto Rio Jardim, using the Slope tool. This map was reclassified into six slope classes generating the Map of Slope of Ribeirao Alto Rio Jardim. Through the obtained data and observations in the field and at the laboratory it was possible to identify significant points of sampling for subsequent morphological analysis and texture. These studies lead to a greater understanding of the behavior of region soils, aiming at the sustainable use and conservation of soils.

Keywords：*Ribeirao Alto Rio Jardim, Geographic Information Systems, Geoprocessing, Soil, Pedomorphogeology relations*

P1-4

[IDS1] Folk Soil Knowledge for Soil Taxonomy and Assessment

Farmer's Knowledge of Land and Classes of Corn of Michoacan, Mexico

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Farmers recognize locally to their lands and they are named according to their characteristics and production. This knowledge is also known as Ethnopedology. There is local knowledge of land in various locations in Mexico, however, need to document this knowledge in more areas. Farmers have extensive knowledge about the characteristics of the land, the type of corn and the planting time, which is of great importance because this depends on productivity. In Michoacan there are no reports. The objective was to relate the land classes with the kind of corn and productivity. The study area is located on Atecuaro, south of Morelia, Michoacan. A route from the field and knowledge of farmers four classes of land were identified. Farmers were interviewed to determine the characteristics of the land and the kinds of corn for each class of land. The methodology proposed by Ortiz et al. (1990) was used in this report. Farmers identified four classes of land from three attributes, color, hardness and moisture. The land classes are Polvilla , Revuelta, Charanda and Barrosa . The Polvilla are dark to light brown, soft wet and dusty dry, porous, well drained and high water retention throughout the year. Revuelta are soft wet and hard dry in the dry season retain moisture, but unless Polvilla. The Charanda are reddish, sticky form aggregates very hard when dry and retain little water, are sticky and saturated throughout the year. In all kinds of land planting system 'year time' is set, this means that the farmer sowing plots defines what and which to leave at rest. The types of corn are Alto, Charqueno and Criollo or violent they are different in color, plant size, cob size and ripening. The top is white and yellow corn, planted in Polvilla land in March or April because these lands are wet and cold seed emerge until the rainy season in May or June, the plant height is 3.5 m, cob is on average 30 cm long, cob production is 3.0 to 4.0 t ha-1. The Charqueno corn is white and seeded in Revueltas and Barrosas land is sown in June when the rainy season begins. The plant reaches 2.5 m in height and 25 cm long cob, Revueltas production on land is 3.0 t ha-1. The Criollo or violent corn is planted in all kinds of soil, except in Polvilla, is white and also planted at the onset of the rains, the plant reaches a height of 1.5 m and 15 cm cob. The yield on the cob from other lands is 1.5 to 2.0 t ha-1. Muddy land loses its fertility remain wet throughout the year. In order from highest to lowest cob production must: Polvilla (high corn), Revuelta and Barrosa (Charqueno corn) and all, except Polvilla (Criollo corn). The most important factors in corn production are characteristics of the land, planting time and water retention.

Keywords：*Rural classification, Ethnopedology, traditional knowledge*

P1-5

[IDS1] Folk Soil Knowledge for Soil Taxonomy and Assessment

Soil Mass Balance for an Alfisol in Greece

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In a soil profile that was classified as Alfisol a study of the soil mass balance was attempted. After the uniformity of parent material was confirmed, the soil mass balance was calculated. From the numerical data the movement of materials from the eluvial and their accumulation into the illuvial horizon was confirmed. The increased amount of clay in the illuvial (argillic) horizon is not only the result of the accumulation due to movement of clay from the eluvial horizon, but is also the result of clay neo-formation in this horizon. The losses of clay from the pedon that were calculated, is due to the dissolution of clay minerals and to the removal of dissolution products by water.

Keywords：*Alfisols, soil mass balance*

P1-6

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Aging Effects on Transfer Factor of CS-137 from Drinking Water Treatment Sludge to a Leaf Vegetable

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Sludge from drinking water treatment plants has been effectively reused for potting soil of home garden in Japan. After the nuclear accident at Fukushima Daiichi Nuclear Power Plant, sludges in Kanto and Tohoku areas have been contaminated with radiocesium (Cs-134 and Cs-137). In order to minimize radiation dose from the contaminated sludge to the public, Japanese government started to regulate the shipping of the sludge, which contains more than 400 Bq/kg of radiocesium, for the use in the home garden. Leaf vegetables are often planted in the home garden, and thus it is important to clarify the transfer of radiocesium from the sludge to leaf vegetables. In the present study, we determined the transfer factor of Cs-137 from the sludge to a leaf vegetable, Japanese mustard spinach (komatsuna). Aging effects of C-137 in the sludge were also examined by repeated cultivation in a container.

Potting soils consisted of Akadama soil, leaf mold, Kurotsuchi, chemical fertilizer (8% nitrogen, 8% phosphorus, and 8% potassium by weight), and sludge from drinking water treatment plant. First, a 15-L Akadama soil, a 9-L leaf mold, a 6-L Kurotsuchi, and a 600-g chemical fertilizer were mixed well. This soil mixture was then divided into three portions (5, 4.5 and 3. 5 L) and placed in containers separately. Finally, 0.5 L and 1.5 L of the sludge were mixed into the 4.5-L and the 3.5-L soil mixtures, respectively. These three kinds of potting soils contained the sludge at the rates of 0% (0% sludge), 10% (10% sludge), and 30% (30% sludge). Seeds of komatsuna were sowed in these potting soils, and grown komatsuna was harvested. This process was repeated four times between 4 April, 2012 to 5 May, 2013. Each Cultivation started on 4 April, 8 August, 12 December, 2012, and 4 April, 2013, and komatsuna grown for one to two months under natural light. The temperature was controlled at 25 ± 5˚C during the cultivation periods. The harvested komatsuna was dried at 80˚C and powdered using a grinder for the analysis of Cs-137. After the harvest, potting soils were air dried, and then three subsamples were collected from the each dried potting soil. Garden lime (40 g) and chemical fertilizer (35 g) were mixed with the dried potting soils (5 L) two weeks before the next seeding. Activities of radiocesium in komatsuna and potting soil samples were analyzed using a germanium detector.

In the first cultivation, Cs-137 was detected in all komatsuna harvested, and the Cs-137 activities in komatsuna were 15 Bq/kg-dry for the 0% sludge sample, 190 Bq/kg-dry for the 10% sludge sample, and 410 Bq/kg-dry for the 30% sludge sample. The activity of Cs-137 in the potting soil samples increased with the sludge content. The 0%, 10%, and 30% sludge samples were contaminated with 17 Bq/kg-dry, 1000 Bq/kg-dry, and 3100 Bq/kg-dry of Cs-137, respectively. From these results, soil-to-plant transfer factors (TF: Bq/kg-dry of Cs-137 in komatsuna/ Bq/kg-dry of Cs-137 in the soil) were 0.87 for the 0% sludge sample, 0.18 for the 10% sludge sample, and 0.13 for the 30% sludge sample. Water contents of the harvested komatsuna were more than 90%; thus, the Cs-137 activities per unit-wet-weight for all harvested komatsuna were below 100 Bq/kg-wet, which is the new standard limit for general foods by Japanese guidelines. After the second cultivation, the activities of Cs-137 in komatsuna were under the detection limit (<11 Bq/kg-dry) for the 0% sludge samples. For the other potting soil samples, the Cs-137 activities in the vegetables decreased with time. These results suggests aging of Cs-137 in the sludge. Decreases in the TFs were significant for the second cultivation in all potting soil samples. The TFs of 10% sludge samples were 0.041 for the second cultivation, 0.006 for the third cultivation, and 0.007 for the fourth cultivation. For the 30% sludge samples, the TFs were 0.019 for the second cultivation, 0.010 for the third cultivation, and 0.06 for the fourth cultivation. These TFs except for the 0% sludge sample of the first cultivation were within the range of the values, which were determined before the Fukushima Daiichi Nuclear Power plant accident.

This work was supported by JSPS KAKENHI Grant Number 24590775.

Keywords：*Cs-137, aging, soil-to-plant transfer factor*

P1-7

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Differential Responses of Drought Induced Reduction in Growth Rate, Plant Radio-Cesium Uptake and Distribution between the Tolerant and Sensitive Blackgram Species (vigna Mungo)

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Plant uptake of Cs^{137} was examined to determine how plant-water-interactions influence the uptake and distribution of Cs^{137} between the two blackgram varieties. Salinity tolerant, U Taung-2 (BT) and sensitive variety, Mutpe Khaing To (BS) were grown in pot filled with Cs^{137} contaminated soil from Nihonmatsu, Fukushima. The average soil Cs^{137} concentration was 1084 Bq kg^{-1}, and the soil type was sandy clay loam; the sand: silt: clay proportion was 62:18:20. After growing for 15 days in a temperature controlled growth chamber, the plants were subjected to either drought stress by adding polyethylene glycol (PEG 6000) 10 and 15% to the medium to reduce the osmotic potential of soil or field capacity condition (0%). The analysis of growth traits and water relations showed the different strategies for two blackgram varieties under water stress conditions. The reduction in total leaf area, total biomass and plant growth analysis parameters as well as relative water content were higher in BS than BT under the two drought treatments. Both plants exhibited lower Cs^{137} concentration in the leaves, shoots and roots under drought treatments than field capacity. Under drought treatments, the uptake and distribution of Cs^{137} were found for BT, while it was seriously limited in BS especially in leaf portion with the treatment of 15% PEG. Our results showed that two blackgram varieties exhibit different Cs^{137} accumulation and distribution patterns among the parts of plant tissues depending on their growth performance, water movement pathway and tolerance level to abiotic stress.

Keywords：*blackgram, hydraulic conductance, plant growth, radio-cesium, water stress*

P1-9

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Radiocesium Interception Potential and ^{137}CS Concentration in Particle-Size Fractions of Soil

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Significant quantities of radionuclides were released into the environment due to the Tokyo Electric Power Company Fukushima Daiichi Nuclear Power Plant accident. Cesium-137 is the most important radionuclide for estimating the radiation exposure to the public for a long-term because of its high fission yield, relatively long half-life (30.1 y) and transferability in the biosphere. The physicochemical speciation of a radionuclide is an important factor in determining the fate of radionuclide in the environment. It is well known that most radiocesium is strongly bound to the clay fraction on the weathering fronts in the interlayers of the micaceous minerals expand into a wedge shape, known as frayed-edge sites (FESs). The radiocesium interception potential (RIP), a measure of FESs in a soil, represents the selective adsorption capacity of cesium in soil, which was established by Cremer et al. (1988). The RIP values of clay minerals and soil have been reported to be varied among soil series, and are negatively correlated with the soil-to-plant transfer factor. However, RIP values in particle-size separates, and the relationship with the concentration of ^{137}Cs has not been previously reported. In the present study, soil samples were separated into particle-size fractions and their concentration of ^{137}Cs and RIP value were determined. The surface soil samples were collected from 13 agricultural fields in Aomori, Japan in 1991-2004. The soil samples were dried at 50-60 °C for one week and passed through a 2-mm sieve. Cesium-137 in the soil sample was fractionated to the forms that were the exchangeable and bound to organic matter after decomposed with hydrogen peroxide; then the residue was divided into four particle size fractions including clay (<0.002 mm), silt (0.002-0.02 mm), fine sand (0.02-0.2 mm) and coarse sand (0.2-2 mm) by sieving and sedimentation. The silt fraction was not recovered because of the incomplete separation of silt from clay by the sedimentation method. The concentration of ^{137}Cs in the particle-size fractions was determined using a well-type Ge gamma-ray detector for counting 74000-640000 s. The RIP value was determined by measuring Kd values of spiked carrier free ^{137}Cs, which was defined as the ratio of ^{137}Cs in solid and liquid phases, under equilibrium condition with 0.1 M $CaCl_2$ + 0.5 mM KCl solution. The concentration of ^{137}Cs and RIP value in the soil samples were in the range of 1.0 to 28 Bq kg^{-1} and 199 to 3960 mmol kg^{-1}, respectively. The RIP value in the clay fraction was 1090 - 13500 mmol kg^{-1}, which was one order of magnitude higher than that in the coarse sand (133 - 2700 mmol kg^{-1}) and fine sand fractions (91 - 1630 mmol kg^{-1}). This indicates that not only clay fraction but also fine and coarse sand fractions have strong bound sites for radioactive cesium. The ratio of the ^{137}Cs concentration to RIP value was within a factor of 2 among the particle-size fractions in the same soil sample. It indicates ^{137}Cs deposited onto the soil particles, irrespective of the particle-size fractions, gradually adsorbs according to the amount of the specific sites for radioactive cesium determined by RIP.

Keywords：*radiocesium interception potential, ^{137}Cs, particle size fractions, physicochemical speciation, agricultural soil*

P1-10

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Mitigation of Radioactive Contamination from Farmland Environment and Agricultural Products

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Radioactive Cs contamination of vast area including crop land with a focus on TEPCO Fukushima Daiichi Nuclear Power Plant accident in March 2011, still ask farmers to inhibit the uptake of radioactive material to the crops in the farmland even today a lapse of three years. Several removal technologies from the paddy and upland soils, volume reduction of waste materials, and potassium fertilizer application to reduce the uptake of radioactive cesium to the edible part of plant will be presented. In the case of food supply, the concentration of radioactive substances in food less than standard value (100 Bq/kg). Furthermore, it should be paid the attention to reduce the radiation exposure of farm workers during their labor in the fields, by removing or shielding the radioactive cesium from the environment. As the contaminated soil is mainly derived from the fertile top soil, removal of contaminated soil and applying non-contaminated but low fertile soil instead of contaminated top soil means to reduce the fertility, so we also attempting to compensate the productivity after the decontamination of the field by applying such as zeolite to improve CEC and also applying forage grasses to reduce the probability of erosion of replaced topsoil from the field.

Keywords：*Cesium, Decontamination, Cs transfer factor, Remediation*

P1-11

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Layer-To-Layer Variations of 137cs Content in Soil throughout a Calendar Year within the Alienation Zone of the Chernobyl Npp

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The aim of the current research is the analysis of changes of the 137Cs specific activity level in different layers of soil during the calendar year. Soil samples were collected at a depth of 0 to 5 cm (0 to 2 inches), at a depth of 5 to 10 cm (appr. 2 to 4 inches) and from the litter layer. Three testing areas were studied within the territory of the Chernobyl nuclear power plant alienation zone ? 'Dytiatky', 'Paryshev' and 'Lelev', which differ by levels of 137Cs soil pollution. Soils on all of the testing areas belong to sod-podsolic type. Two of the testing areas - 'Paryshev' and 'Lelev' - are characterized with a thick 5-cm layer of litter; the litter layer is rather thin - 1.5 cm - within 'Dytiatky'. To investigate variations 137Cs contamination in their soils during a calendar year, sample drawing was conducted monthly from 2007 till 2012. Only areas with a surface that complies with all of the following criteria were selected for soil sampling:

-undamaged in course of the nuclear waste deposition and accident response operations;

- grass-covered;

- smooth and homogeneous.

Within all of the testing areas, gradual decrease in the annual average values of the 137Cs content for all the layers of soil has been observed.

The analysis of variation of the 137Cs specific activity levels in soil specifies that the annual fluctuations of the content of this radionuclide can be considerable (up to fivefold). In different soil layers fluctuations of the 137Cs content are staggered. Within testing areas 'Paryshev' and 'Lelev', the maximum of the 137Cs content in the litter layer corresponds to its minimum in layers from 0 to 5 cm and 5 to 10 cm deep. Within the testing area 'Dytiatky', fluctuation of the 137Cs content in the litter correlates directly to fluctuations in the 0 to 5 cm soil layer, and inversely in the deeper soil layer of 5 to 10 cm below surface.

The correlation analysis between the content of 137Cs in different soil layers and weather conditions (an amount of precipitation and air temperature) has been made. As a result, it has been established that weather conditions produce no impact on layer-to-layer variations in levels of specific activity of this radionuclide in soil throughout a calendar year.

Possibly, changes in levels of specific activity of 137Cs in different soil layers result from biotic processes in soil throughout a calendar year.

Keywords：*Chernobyl NPP, 137Cs, different layers of soil*

P1-12

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Using a Collection of Soil Monoliths for the Study of Natural Radiation of Soils in Russia

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One of the pressing environmental problems is radiation pollution of ecosystems. Soil as a basic element of ecosystem absorbs, stores and keeps radionuclides, preventing their further spread in the landscape.

In the history of the Earth can be separated several periods of “nuclear era”. First period - the local pollutions of areas. It was associated with a targeted production of ores containing radionuclides, their research and applications in medicine (the end of XIX - the beginning of XX century).

Second period - large-scale contamination of all media. It began with the explosion of the atomic bomb 'Trinity' and subsequent 'nuclear race' superpowers. Most active on the number of tests (an average of 55 per year) occurred in 1955-1989 years. There are 3 types of nuclear tests: 1) Atmospheric. During the period from 1945 to 1996. produced more than 2,000 tests in the world.

2) Underwater. They led to the release of large amounts of radioactive water and steam.

The danger of these types of tests was to their rapid spread over very large areas. Officially, these nuclear tests were banned in 1962.

3) Underground. They constitute about 75% of all nuclear tests during the period of 'cold war' and were banned in 1996. Third Period - peaceful atom and nuclear disasters. It is characterized by the preservation of the nuclear threat and widespread dissemination of radionuclides (Chernobyl, Fukushima-1)

To assess the extent and character of anthropogenic soil contamination of radionuclides were used collection of soil monoliths of funds The Dokuchaev Central Soil Science Museum.

This collection was selected in different years (covers all 3 periods) and contains more than 1,700 monoliths. It represents a wide range of soil types and subtypes of all natural zones of Russia and partly in other countries. Collection of monoliths is crucial for determining the natural radiation background soils. Among the collection has a series of monoliths, selected at different times (at least two periods) to the same place.

Studies have been conducted radionuclide content (Ra226, Th232, K40, Cs137) in the samples (taken from a depth of 0-5, 5-10, 10-20, 40-50 and 90-100 cm) 5 monoliths presented two types of soil (Umbric albeluvisols from the Tula region, and the segregation of the anthric chernozem of the Republic of Bashkortostan). Monoliths from the Tula region were selected in 1927 and 2010, and of the Republic of Bashkortostan - 1928 and 2009.

Comparison of radionuclide content in the soil profile showed that the largest difference (110 Bq/kg) observed in Cs137 (samples from the Tula region), and the lowest - Ra226 (5-15 Bq/kg) and Th232 (10-20 Bq/kg). Difference for potassium was 150-170 Bq / kg, compared with the data of cesium is not so much. Based on the data obtained the maximum accumulation of cesium and hence its retention occurs in the top 5-10 cm of soil, i.e. humus horizons.

In soil samples taken in 1927 and 1928 Ra226 content does not exceed 45 Bq / kg , Th232 - 35 Bq / kg, potassium - 400-700Bk/kg (most in the lower horizons) and Cs137 - 20 Bq / kg. For samples of 2009 and 2010 Ra226 content: in soils under forest remains at the same level, tillage - slightly reduced; Th232: in soils under forest - growing, tillage - is reduced, potassium decreased in all cases; cesium under forest increases (in the Tula region, these values reach 130 Bq / kg), and arable land becomes even less, due to agricultural use.

On the distribution of radionuclides in the profile, regardless of the time of selection of monoliths, the largest radium content is observed in the upper part of the soil profiles, thorium - in the middle, potassium - in a lower part, cesium - at the top (first 5-10cm).

Keywords：*radium-226, thorium-232, potassium-40, cesium-137, soil monoliths, monitoring*

P1-13

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Model-Based Estimation of Inhibitory Effect of Potassium Application on Cs-137 Uptake by Rice

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A large amount of radionuclides was released into the environment after the Fukushima Daiichi nuclear power plant of TOKYO ELECTRIC POWER COMPANY (TEPCO's FNPP) accident on 11 March 2011. Radiocesium (Cs-134 and Cs-137) in agricultural products has been intensively monitored because radiocesium has a relatively long half-life and a high biological availability. The Japanese Ministry of Health, Labor and Welfare has established provisional regulation value for radioactive substances in food (500 Bq kg^{-1} for grains) in March 2011 and new limit (100 Bq kg^{-1} for grains) in April 2012. Because cesium (Cs) is a group I alkali metal with chemical properties similar to those of potassium (K), the exchangeable K content in soils correlates negatively with soil-to-plant transfer of radiocesium. The inhibitory effects of K application on uptake of radiocesium were reported in researches conducted after the TEPCO's FNPP accident. However, quantitative effect of K application on radiocesium uptake by rice was not clear and the effect of K application could not be estimated before cultivation. Therefore, large amounts of K were applied to paddy fields in the Tohoku and Kanto areas of Japan to reduce radiocesium uptake levels in future harvests of brown rice, the application level was decided on the basis of empirical data regardless of soil type, soil fertility, etc. It is necessary to develop a model to estimate inhibitory effect of potassium application on radiocesium uptake before the cultivation.

Radiocesium contaminated soils and brown rice were collected from paddy fields in Tohoku region on October 2012. The soils were filled in a polypropylene container (12.4 cm × 8.2 cm and 4.2 cm in height) in 3 cm depth and decontaminated rice seeds (Oryza sativa L. cv. Hitomebore) of 5 g were sowed on the soil. Decontaminated soil was covered on the seed in 1 cm depth. Rice seedling was cultivated in a glasshouse and sampled nine days after sowing. The concentrations of Cs-137 in brown rice harvested from the paddy fields and rice seedling were detected by germanium detectors. The exchangeable K prior to the cultivation of rice seedlings was extracted using the semimicro-Schollenberger method, and its concentrations were measured with an atomic absorption spectrophotometer.

The concentration of Cs-137 in rice seedlings was significantly and positively correlated to the concentration of Cs-137 in brown rice harvested from the paddy fields. This indicated that the concentration of Cs-137 in brown rice produced in a paddy field could be estimated by the concentration of Cs-137 in rice seedling grown in the contaminated soil collected from the paddy field. Theoretical model was developed to calculate the concentration of Cs-137 in rice seedling using the available K concentration in soil and two parameters. The two parameters were related to K and Cs uptake kinetics and the available Cs-137 concentration in soil. The values of parameters were estimated by using the concentration of Cs-137 in rice seedlings and the exchangeable K content in soil measured. The results suggested that the concentration of Cs-137 in brown rice could not be lowered below new limit for grains by practical potassium application in some soil examined. The model in the present study could estimate the effect of K application prior to cultivation and the estimation could be used to decide the K application level.

Keywords：*available radiocesium concentration, brown rice, potassium, rice seedling, theoretical model*

P1-14

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Relationships between Radiocesium Interception Potential (rip) and Soil Properties

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<Introduction>

The accident in the Fukushima Daiichi nuclear power plant caused severe soil contamination by radiocesium in the areas around Fukushima, Japan. The health risks associated with the long-term intake of radiocesium from food have been of great concern. In order to evaluate the phytoavailability and mobility of radiocesium in soils, it is important to determine how strongly radiocesium is fixed by soils. Cesium is a monovalent cation and adsorbed on the negative charge sites derived from organic matters and clay minerals in soils. The ion-exchange selectivity for radiocesium over other ubiquitous cations in soils is low for the negative-charge functional groups of organic matters whereas high for the interlayer sites of 2:1 clay minerals. A frayed-edge-site (FES), located in intermediate zone between non-expanded (1.0 nm) and expanded (1.4 nm) layers of weathered mica has great affinity with Cs. Once fixed by FES, radiocesium is hardly desorbed. Therefore, FES is an important factor determining radiocesium behavior in soils. However accessibility of radiocesium to FES in soil depends on the complex interactions with soil components. The capacity and selectivity of FES for radiocesium is evaluated by the parameter called Radiocesium Interception Potential (RIP). The purpose of this study is: 1) to generate RIP distribution map in the area contaminated with radiocesium by the accident 2) to evaluate the relationships between RIP and soil properties.

<Materials and Methods>

Soil samples were collected from plowed layer of 500 agricultural fields within 300 km of the Fukushima Daiichi nuclear power plant. The soil types include Andosols, Gleysols, Fluvisols, and Cambisols. Radiocesium concentrations, RIP values, and relevant soil properties of the soils were determined. For the selected samples, soil organic matter was decomposed by H2O2 with heating and then RIP values were determined. In addition, 1 mol L^{-1} CH_3COONH_4 extractable radiocesium (ex-Cs) concentrations were determined by Ge gamma-ray detector for the soils before and after the decomposition of soil organic matter.

<Results and Discussion>

The RIP values were in the range from 73 to 7400 mmol kg^{-1}. The RIP distribution map visually showed that the radiocesium fixation ability of soils was varied by regions. Even among the same soil types and geological features, the RIP showed a wide range but tended to be lower for Andosols. Total carbon contents were negatively correlated with RIP values whereas other soil properties did not have significant correlation with RIP. When vermiculite, illite or smectite was not detected in the soils, RIP values were low. The characteristics of Andosols, higher accumulation of organic matters due to the dominance of reactive aluminum-bearing minerals such as allophane and imogolite were in accordance with the properties of low RIP soils. After the decomposition of soil organic matters, the RIP values were increased. In addition, amounts of ex-Cs were decreased for high RIP soils, whereas increased for low RIP soils. It was likely that radiocesium fixation by FES was blocked by organic matter coating on the clay minerals. The RIP map in combination with soil radiocesium concentration map gives fundamental information to evaluate the long-term behavior of radiocesium in agricultural soils.

<Acknowledgement>

This study was performed under a contract with the Agriculture, Forestry and Fisheries Research Council, MAFF, Japan.

Keywords：*soil, radiocesium, RIP*

P1-16

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Natural Radionuclide Measurements in Soil Samples from Tanke-Ilorin, North-Central Nigeria

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Natural radioactivity measurements have been made in 30 soil samples collected from communities in Tanke-Ilorin, Nigeria using gamma-ray spectrometry of the Nigerian Center for Energy Research and Development (CERD) Laboratory. The work has been carried out keeping in mind the health effects of radio-elements in the environment and evolution of the area as satellite town of the University of Ilorin. The results revealed the presence of potassium, uranium and thorium radio-elements. The activity concentrations of the radionuclides range from 252.03 to 494.02 $BqKg^{-1}$ for ^{40}K with a mean of 379.30 ± 31.15 $BqKg^{-1}$, 2.08 to 12.87 $BqKg^{-1}$ for ^{238}U having a mean of 6.81 ± 2.03 $BqKg^{-1}$ and ^{232}Th concentration ranges from 6.55 to 11.85 $BqKg^{-1}$ with a mean of 9.05 ± 2.95 $BqKg^{-1}$. The derived absorbed dose rate ranges from 20.01 to 30.02 $nGyh^{-1}$ with a mean of 24.91 ± 1.18 $nGyh^{-1}$. Consequently, the annual effective dose received by the population is estimated to range from 0.18 to 0.26 $mSvy^{-1}$ with an average of 0.22 $mSvy^{-1}$. The radio-activities in soil samples of the area are found to be below the typical range of 0.3 − 0.6 $mSvy^{-1}$ for average terrestrial gamma rays exposure due to radionuclides in the soil as reported by UNSCEAR, 2000.

Keywords：*Radioactivity; Gamma-ray spectrometry; Health; Soil sample; Nigeria*

P1-17

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Development of Low-Level-Radiocesium Concentration Analysis System for Irrigation Water Using Solid Phase Extraction Disks

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Massive amount of radioactive materials were discharged into the environment from Fukushima Daiichi Nuclear Power Station, Tokyo Electric Power Company in Mar 2011 and a vast area centered on Tohoku region was contaminated. Among the various type of radionuclide, 137Cs having 30.2 year-long half life is a major target for monitoring. Those radioactive materials which released into the environment partially migrate to the agricultural, forestry, fishery and animal products. Therefore, there has been considerable research on migration controls, clarification of migration mechanism, understanding migration routes and so on. As the water such as rivers, lakes, groundwater, reservoirs, irrigation water and paddy water is a considerable migration media in migration routes, thorough understanding of radioactive material concentration in water by form, even in low concentration should improve future prospect on radioactive material concentration and dynamics of migration in production environment such as mountain forests, fields, rivers, lakes and grazing for agricultural, forestry, fishery and animal products and more effective countermeasures can be taken.

This research study covers development of rapid and simplified method to measure radiocesium in water samples in irrigation water channels and reservoirs which are pipelines for water to the fields and a filtration and separation system using solid phase extraction disks which selectively separate and retain dissolved cesium into the disks.

Differently from relatively low turbidity water such as mountain stream water, the water in irrigation water channels and reservoirs tend to contain high levels of suspended solid. Dual filtration and separation system, consisting of the first step for filtering water samples and capturing suspended solid and the second step for passing the filtered water samples through solid phase extraction disks, was adopted. In addition, disk-type filters, but cartridge-type filters, were selected to filter and capture suspended solid for simplified operation process which is also suitable on site.

Disk-type filters for suspended solid and solid phase extraction disks were placed into multiple filter holders respectively or into a single filter holder by stacking all disks together. Water samples were placed in a pressure vessel and pressurized and passed through the disks in single or multiple filter holders with a flow rate in a range from 40 to 100 mL/minute. The 10 μm-rated and 1 μm-rated polypropylene-type nonwoven filter disks (3M™ Lab Scale Filter Disk LB Series) and the 0.45 μm-rated polyethersulfone-type membrane filters (3M™ LifeASSURE™ PES Membrane Filter Disks) were selected as the disk-type filters to capture suspended solid by particle size. To capture dissolved radiocesium, solid phase extraction disks composed of highly selective cobalt-modified ferrocyanide adsorbent bound in polytetrafluoroethylene matrix (3M™ Empore™ Rad Disk Cesium) were used. Cesium adsorbing capacity of the disk is 40mg.

With the above system, suspended-solid-form and dissolved radiocesium were separated simultaneously from several liters of irrigation water samples. By separating dissolved radiocesium into the solid phase extraction disks, radiocesium was highly concentrated in the disks and potassium was released as effluent. As the results, concentrations in suspended-solid-form and dissolved radiocesium of irrigation water were efficiently measured respectively. When potassium concentration in samples is smaller, lower detection limit can be obtained.

Passive sampling method to analyze dissolved radiocesium in irrigation water is also discussed. The solid phase extraction disks were immersed in irrigation water channels or reservoir for a certain period of time and dissolved radiocesium was adsorbed and concentrated on the disks.

By using the passive sampling measurement method with the solid phase extraction disks, wide variety of environmental water analysis will become available which was never before easy, such as analysis of very small amount of environmental water like paddy water which is difficult for sampling, variation analysis on time-weighted average and analysis of contamination distribution in planer and vertical direction at river, reservoir and irrigation channels.

This study was performed under a contact with the Agriculture, Forestry and Fisheries Research Council, MAFF, Japan.

Keywords：*irrigation water, low-level-radiocesium, suspended solid, dissolved radiocesium, solid phase extract*

P1-18

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Correlation between Soil Properties and Radioactive Cesium Absorption by Legume Crops

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Introduction: Contamination of the environment by radioactive substances after the catastrophe of the Fukushima Daiichi Nuclear Power Plant (FDNPP) occurred in 2011 is a matter of great concern for the agricultural communities in Japan. By the accident, enormous amounts of radionuclides such as ^{131}I, ^{132}I, ^{132}Te, ^{134}Cs and ^{137}Cs, were released into the environment. In the radioactive contaminants, ^{134}Cs and ^{137}Cs have relatively longer half-lives of 2.1 and 30 years, respectively. Therefore, radioactive Cs causes the main problem of radioactive contamination around FDNPP, especially Fukushima Prefecture, Japan. Since Cs is univalent cation, radioactive Cs exhibits the same behavior as potassium in plants. Following the FDNPP accident, one of farmers' organizations, NPO Yuukinosato Towa, which locates in Nihonmatsu city, Fukushima Prefecture, far 50~60 km from FDNPP, has measured concentration of radioactive Cs in all crops that the NPO has treated. According to their results, legume crops were tended to contain higher concentration of radioactive Cs than the others. However, the reasons are not clear. In this study, we conducted field experiments to investigate the relationship among soil chemical properties and absorption of radioactive Cs by legume crops.

Methods: Field K and M, where soybean harvested in 2011 contained 174 Bq/kg (^{134}Cs=77 Bq/kg and ^{137}Cs=97 Bq/kg) and not more than 25 Bq/kg of radioactive Cs, respectively, were selected as the experimental fields in this study. They were located at hilly lands in Nihonmatsu City, Fukushima Prefecture, Japan. Four varieties of *Glycine max* (black soybeans, blue soybeans, *kaori* soybeans and *kouji-irazu* soybeans) and *Vingna angularis* were sown in Field K and three varieties (black soybeans, blue soybeans, and *kaori* soybeans) were in Field M. Topdressing of potassium sulfate (120 and 240 kg-K_2O/ha) was also examined in two soybean varieties (*kaori* and *kouji-irazu*). Experimental plots in triplicate were established in each field according to the random block design. Seeding was in June and the harvest was in November. Concentrations of radioactive Cs in soil and grains were determined using a germanium semiconductor detector. Transfer factor (TF) was calculated using the formula: TF = (^{137}Cs concentration in the dried plant [Bq/kg]) / (^{137}Cs concentration in the dried soil [Bq/kg]). Concentrations of exchangeable and water-soluble cations (K^+, Na^+, Mg^{2+} and Ca^{2+}) in the soil samples were determined using an atomic absorption spectrophotometer. Other soil chemical properties such as total C and total N, pH(H_2O) and CEC were also measured.

Results: In Field K and Field M, concentrations of radioactive Cs in the surface soil (0~20 cm) were approximately 1,109±227 and 800±275 Bq/kg, respectively. While radioactive Cs concentrations of the grains harvested in Field M was under the detection limit (<10 Bq/kg), those in Field K varied from undetectable (<10 Bq/kg) to 76 Bq/kg. There was no statistical difference between concentration of radioactive Cs in soil and grain. Using the data of concentration of radioactive Cs in soil and grain, TF of each plot in Field K was calculated. Correlation between the TFs and some soil properties was found. This indicates that radioactive Cs absorption of legumes is not necessarily uniform even in the same field. In Field M, concentrations of water-soluble and exchangeable K^+ (12.4 and 54.1 mg K_2O/100 g ds, respectively) were higher than Field K (10.3 and 18.2 mg K_2O/100 g ds, respectively), which may be the main reason why grain radioactive Cs concentrations harvested in Field M were smaller than those in Field K. Effect of topdressing of potassium and difference between the varieties were slight. In Field K, the TFs and soil pH gradually increased along to the slop direction. Opposite correlations between TF and concentrations of water-soluble K^+, total C, total N and CEC were found. The results suggest that soil chemical properties greatly affect radioactive Cs absorption of legume crops.

Acknowledgement: We specially thank the NPO Association Yuukinosato Towa and the members for their collaboration in this research. This research was financially supported in part by the Mitsui & Co., Ltd. Environmental Fund, Japan.

Keywords：*radioactive cesium, legume, soil properties*

P1-19

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

The Vertical Distribution of Cs-137 in Bavarian Forest Soils

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Persistently high activity concentrations of radioactive Cs-137 (T1/2 = 30.17 a) in various animals and fruits originating from Bavarian forest ecosystems suggest that the contamination of soils in these ecosystems is still critical even decades after the severe inputs following the Chernobyl nuclear accident. Aware of the fact, that such inputs are a global threat that can re-emerge at any time, a new monitoring network was established in cooperation with the Bavarian State Ministry of the Environment and Public Health, to enhance the value of long-term radio- protection strategies in forests. Based on the investigation of 48 forest sites throughout the entire state territory, the project delivers a total of 889 gamma spectrometric records and demonstrates the current Cs-137 contamination situa- tion of Bavarian forest soils, providing a valuable update on the residual contamination levels and thus a compre- hensive inventory for any future radioprotection manage- ment. First results of this project are presented hereby. The total Cs-137 areal activity densities in Bavarian forest soils currently vary between 640 and 61,166 Bq m-2, with the peak areal activity density of each profile being located in the uppermost, humus rich mineral A-horizon in 68 % of all cases. Moreover, the results detect a positive correlation of humus thickness and relative areal Cs-137 activity density in humus horizons (R2 = 0.50), validating previous findings on that topic by means of a very comprehensive data set across 2.56 Mio ha forest stands by showing that humus bodies [7.5 cm still contain at least 50 % of the total areal topsoil activity density.

Keywords：*Radiocesium* □*Humus* □*Forest soils* □*Forest ecosystems* □*Bavaria*

P1-20

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Rice Fields can be Affected by Radiocesium in Irrigation Water Originating from Forested Mountain Areas

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An extraordinary earthquake, rated at magnitude 9.0, and the following large tsunami on March 11, 2011 severely damaged the Fukushima Daiichi Nuclear Power Plant (FDNPP). As a result, enormous amounts of radionuclides were released to the environment, followed by radioactive fallout that caused wide contamination of farmlands mainly in the eastern part of Japan. Cs-134 and Cs-137 are known as the long-lived radionuclides whose half-lives are 2.06 and 30.2 years, respectively. Since rice is the most important staple food in Japan, contamination of the rice fields with radiocesium and their transfer into rice grain are a matter of public concern. Rice fields consume large amounts of irrigation water, about 500–2,000 mm per a cropping season. This suggests that radioactive contamination levels of rice may be affected by the quality of irrigation water.

In this study, we focus on in-valley rice fields in Fukushima Prefecture, closely located to forested areas, where huge amounts of radionuclides are accumulated. We report changes in radioactivities of Cs-134 and Cs-137 in the soil, rice straw and grain for 2 years after the FDNPP accident, and investigate the effect of irrigation water contamination from the neighboring mountain forest on the radioactive levels of rice.

Materials and methods

Soil and rice: Five in-valley rice fields (Site I-V) in different watershed areas were selected in Nihonmatsu City, Fukushima, located in 40−50 km north-west from the FDNPP. Rice cultivation schedules were roughly summarized as follows: spring tillage, flooding and puddling in mid May, transplantation in May–early June, midsummer drainage at the end of June–July, and harvest in September–October. Soil samples (gray lowland soil or fine textured grey soil) were collected from the sites in September 2011, May and October 2012, and levels of radiocesium contamination were evaluated. Three sampling points, point A within 3 m of the water inlet, point B in the center of the rice field and point C within 3 m of the drain outlet were determined for each site. Three or four soil cores were collected using a soil sampler (5 cm ϕ × 30 cm length) from the plough layer (ca. 0−15 cm depth) at each sampling point and thoroughly mixed. Rice straw and grains were harvested at A–C points of each site.

Irrigation water: In 2012, irrigation water samples were collected from four different watershed areas and the radiocesium originating from forested areas was evaluated by separating them into dissolved and particulate components followed by sequential extraction.

Radiocesium measurement: Radiocesium was analyzed using Ge gamma-ray detector connected to a multichannel analyzer system.

Results and discussion

The average of radiocesium concentrations (Cs-134+Cs-137) in the soil samples decreased from 3,420±807 Bq/kg in September 2011 to 2,527±734 and 2,356±683 Bq/kg in May and October 2012, respectively. No statistical difference was found among points

A–C. Radiocesium in the rice grain harvested in 2011 and 2012 was not more than the current legal limits for radioactive materials in food in Japan (100 Bq/kg). The examined 11 of 15 samples were less than the detection limit in 2012. Rice straw collected in 2011 and 2012 contained 149±23 and 71±22 Bq/kg of radiocesium, respectively. No correlation between the soil and straw radiocesium concentrations was found. In 2012, radiocesium concentration of rice straw collected at point A was significantly higher than the others (Holm test, $p<0.05$), that was not observed in 2011. Radiocesium concentration in the irrigation water samples was 0.13–0.33 Bq/L under stable runoff conditions, while it was 1.15–22.2 Bq/L under storm runoff conditions. Greater forest area was associated with higher potentially-bioavailable fractions. The radiocesium newly added into rice fields via irrigation water was estimated to be 87-205 Bq/m^2. The fact suggests radiocesium migrating via irrigation water is impacting rice radiocesium accumulation near water inlet, although soil radiocesium has become non-bioavailable due to strong bounding to clay minerals.

Acknowledgement

We specially thank the NPO Yuukinosato Towa for their great collaboration. This research was financially supported in part by the Mitsui & Co., Ltd. Environmental Fund, Japan, and the River Fund in charge of the Foundation of River and Watershed Environment Management, Japan.

Keywords：*Forested mountain, Irrigation water, Rice field, Radiocesium*

P1-21

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Adsorption Rate of Dissolved Radiocesium in Water onto Soil

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INTRODUCTION

Huge quantities of radionuclides were released into the environment after the Fukushima Dai-ichi nuclear power plant (Tokyo Electric Power Company) accident. Agricultural land and forests in eastern Japan were heavily contaminated with radiocesium: Cs-134 (half-life 2.07 y) and Cs-137 (half-life 30.1 y). Fukushima Prefecture, in particular, was heavily contaminated with radiocesium, one of the more prevalent radionuclides, which was deposited in the soil. Following the nuclear power plant disaster, more than 90% of the radionuclides were distributed in the upper 6 cm of the soil column in wheat fields, and within 4 cm of the surface in rice paddies, orchards, and cedar forests. Radiocesium is known to adsorb onto soil and to bind strongly to clays. In 2011, elevated radiocesium concentrations of more than 500 Bq kg^{-1} were measured in brown rice from some paddy fields. One source of the radiocesium contained in the brown rice was irrigation water. We therefore examined the kinetics of radiocesium in paddy field irrigation water and soils.

MATERIALS AND METHODS

Two samples of Gray Lowland soil from Fukushima Prefecture contaminated with radiocesium were used in our experiment. One soil sample was collected from a field in northern Nakadori (Soil A), and the other was collected from a field at the Fukushima Agricultural Technology Centre (Koriyama) (Soil B). Brown rice from the Soil A field had a radiocesium concentration of more than 500 Bq kg^{-1}, and that from the Soil B field had a radiocesium concentration of less than 100 Bq kg^{-1}. Soil A was collected from 15–45 cm below the ground surface, where the soil was expected to be less polluted, on 12 June 2012. Soil B was collected from 5–45 cm below the surface on 14 June 2012. After air-drying, the soil was passed through a 2-mm-mesh sieve and well homogenized before analysis.

We created the radiocesium extract from branches of conifer washed with tap water at a 1:50 (v/v) ratio for 13d. Treatment water with a dissolved Cs-137 concentration of 200 Bq kg^{-1} was created by filtering the water samples through a membrane filter (0.45 μm) to remove deciduous conifer needles from the extract, followed by dilution as necessary.

Dried soil samples (20.0 g) were weighed and placed in plastic containers. Then, 100 mL of treatment water was added to each container. The soil suspension was left in a dark plant growth chamber (LH-220S; Nippon Medical & Chemical Instruments, Osaka,

Japan) maintained at 25 ℃ for 10 min, 30 min, 1 h, 20h, 24 h, 48 h, 72 h, or 168 h. Then, the supernatant was removed and passed through a membrane filter (0.45 μm) before analysis for dissolved radiocesium.

The supernatant samples were compressed into plastic vials, and their radioactivity was measured with a germanium semiconductor detector with a multichannel analyzer (Canberra, USA) for 4,000 s. The decay was corrected back to when treated. The residual ratio was defined as the amount of Cs-137 remaining in the treatment water (i.e., the dissolved Cs-137 concentration in the supernatant) to the original dissolved Cs-137 concentration in the treatment water.

RESULTS AND DISCUSSION

The residual ratios of Cs-137 in the treatment water after adsorption onto soil A for 10, 30, 60 min, and 20 h were 7.2%, 11.7%, 10.0%, and 2.8%, respectively, and the ratios after adsorption onto soil B were 9.0%, 3.9%, 4.2%, and 3.9%, respectively. Thus, more than 90% of the dissolved radiocesium in the treatment water was adsorbed onto both soils within 10 min. The adsorption rate of radiocesium in 10 min was higher from the water above soil A than that above soil B. The rate of adsorption of soil A was lower in 30 and 60 min, but it was again higher at 20 h than that of soil B. We therefore concluded that dissolved radiocesium is adsorbed onto soil within 10 min, and the Cs-137 residual ratio depends on soil properties.

Keywords：*dissolved radiocesium, irrigation water*

P1-22

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Effects Of Differences in Land Use on the Radiocesium Vertical Distribution in Soil Profile after Fukushima Daiichi Nuclear Power Plant Accident

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The Great East Japan Earthquake occurred on March 11, 2011. Hydrogen explosion at Fukushima Daiichi Nuclear Power Plants caused a wide range of soil contamination by radiocesium. It is essential to understand the present situation of downward migration of radiocesium in soil profiles, because there is a concern that the downward migration can be expected to spread contamination to underground water system. In general, radiocesium is specially adsorbed by Frayed edge sites of clay mica in soil, so rarely migrated downward. But there are unknown things about radiocesium's behavior in soil; especially as for the downward migration, effects of water solubility and organic conjugation cannot be denied. In Fukushima prefecture, there are three important land uses of the primary industry that are forests, farmlands and grasslands. Each type of land uses has different characteristics such as plants, soil properties, root mat, which considered as the factors to contribute the migration of radiocesium. Therefore, in this study, we monitored the vertical distributions of radiocesium in soil profiles under various land use in order to clarify the effect of land uses on the downward migration of radiocesium.

Four times surveys were conducted from June 2011 to December 2012. The study sites were 3 forests (Mixed forest, mature cedar forest, young cedar forest), 3 farmlands (paddy field, farm field, tabacco field), and 2 grasslands (pasture, meadow) in Kawamata town, Fukushima prefecture. In order to measure the vertical distribution of radiocesium in surface soil, sectioned soil samples were taken using a scraper plate with a sampling area of 450 cm2 (width 15 cm, length 30 cm). The sampling was done with 0.5cm increments for the depth of 0-5cm, 1.0cm increments for the depth of 5-10cm. The radiocesium was determined by gamma-ray spectroscopy.

As a result, the temporal changes in the vertical distributions of radiocesium in soil profiles were influenced by the land uses patterns. In the forests, the radiocesium concentration in surface tended to increase with time, indicating radiocesium migrated from litter layers to soils with the decomposition of litters. But, in the mature cedar forest, there were little changes in the proportion of radiocesium inventory in the litter layers. It indicated that the coniferous canopies intercepted the radiocesium deposition to forest floor and caused the secondary deposition of the radiocesium. In the agricultural fields, the migration of radiocesium was especially affected by the difference in vegetation. In the tobacco field which was bare ground on slopes, there would be a sideways transition because of the soil erosion. On the other hand, the farm field was not affected by the soil erosion because plants were covered. In addition, after the accident, large amounts of radiocesium were adsorbed onto the withered plant residue in the farm field and slowly migrated to the soil surface. In the paddy field, there was no effect of the soil erosion and the deposition to the litters because there were no slope and plant litters as at the accident. However, since the surface soil of the paddy field has the coarser field texture (SiL), it became clear that the paddy field showed the relatively high downward migration of radiocesium. The grasslands were strongly affected by the formation of the root mat. Exceptionally, in the pasture, the downward migration was observed up to 5cm in June 2011, resulting from the soil disturbance by cattle grazing. On the other hand, in the undisturbed meadow, high concentration of radiocesium existed over a root mat depth range, indicating the downward migration was progressed with the growth of root mat.

In addition, we compared the absolute amount of radiocesium concentration at the depth of 9-10cm in each site, normalized to March 12, 2011. The result was that the forest showed the highest concentration of all other sites, followed by the farmland and then the grassland, although the distribution rate at the depth of 9-10cm was highest in the paddy field. This was because the bulk density of the forest soils is about 1/3 of the other sites, hence the comparison of the concentration required extra attention. As a result of this study, differences in land uses affect not only first deposition of litters and soils distribution of radiocesium but also the trend of downward migration.

Keywords：*cesium, migration, vertical distribution*

P1-23

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Prediction of Radiocesium Concentration in Brown Rice Based on the Water-Soluble Potassium Ion Concentration in the Soil and the Potassium Ion Concentration in the Soil Solution

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Objective

The accident at the Fukushima Daiichi nuclear power plant in 2011 released large amounts of radiocesium into the atmosphere, contaminating agricultural and forest land around Fukushima Prefecture in Japan. Because of the long half-lives of ^{134}Cs (2.06 y) and ^{137}Cs (30.2 y) and the strong adsorption of ^{134}Cs and ^{137}Cs on soils, there is a concern for remaining on the surface of agricultural land and persist in the environment for a long time. We began monitoring the distribution of radiocesium in soil in Fukushima Prefecture in March 2011. Using our data, Nuclear Emergency Response Headquarters delimited rice planting areas outside the 20-km exclusion zone and the Deliberate Evacuation Area in Fukushima Prefecture. However, brown rice grown in some areas of the northern part of the prefecture in 2011 exceeded the provisional regulation value for agricultural crops at that time (500 Bq kg^{-1}). Consequently, the planting of rice crops for 2012 was restricted in these areas. Tsukada et al. (2002) reported that the transfer factors of ^{137}Cs and stable Cs decrease with increasing potassium concentration in the soil. We reported that the concentration of radiocesium in brown rice decreases with increasing exchangeable potassium (Ex-K) concentration in the soil (Saito et al, 2012). However, the value of Ex-K in the soil of rice planting period takes much time after soil sampling. So, the farmers have no time for taking countermeasures against lack of potassium in their field. Therefore, instead of Ex-K, development of simple and quick analysis methods is desired.

Here, we confirm the relationship between the potassium ion (K^+)concentration in soil solution, water-soluble potassium (K) in soil during the rice planting period and the radiocesium concentration in brown rice, and develop a simple and quick analytical method for predicting the radiocesium concentration in brown rice.

Materials and Methods

We grew rice in two fields with different soil types (Gray Lowland soil and Andosol) in the northern part of Fukushima Prefecture, where rice has been grown for many years. The experiment used a split plot with 3 replications; each plot was 3.0 m × 10 m. Soil samples (surface to 15 cm) were collected on September and October 2012 from each plot using a stainless steel soil auger (length: 30 cm; diameter: 5 cm). The soil samples were air-dried for 21 days, thoroughly mixed, and sieved through a 2 mm sieve. The dried soil samples were compressed into cylindrical polystyrene containers. Soil solution samples (5 cm depth) were collected on July 2012 from each plot using sampling device (DIK-8392). Threshed grain samples retained on a 1.8-mm sieved were used for rice analysis. The brown rice samples were compressed into 0.7 L Marinelli beakers. The concentration of radiocesium in each beaker was measured with a Ge γ- ray detector connected to a multichannel analyzer system for 3600-7200 s. Ex-K and water-

soluble K were butch-method, and their concentrations were determined by atomic absorption spectrophotometry. The soil solution samples were determined by atomic absorption spectrophotometry after passing through a membrane filter of 0.45 μm.

Results and Discussion

The concentration of radiocesium in brown rice decreased with increasing Ex-K concentrations in soil. When the Ex-K concentration in soil exceeded 200 mg kg^{-1}dry weight, the radiocesium concentration of brown rice was below the new Japanese standard in food (100 Bq kg^{-1}). On the other hand, the concentration of radiocesium in brown rice also decreased with increasing water-soluble K concentration in soil. When water-soluble K exceeded 20 mg kg^{-1}dry weight, the radiocesium concentration of brown rice was below the 100 Bq kg^{-1} standard. Thus, the concentration of radiocesium in brown rice can be predicted by analysis of water-soluble K. The concentration of radiocesium in brown rice decreased with increasing K^+ concentration in soil solution. When the K^+ concentration in soil solution exceeded the 5.0 mg L^{-1} during the rice plant panicle formation stage or later, the radiocesium concentration of brown rice was below the 100 Bq kg^{-1}standard. We conclude that the concentration of radiocesium in brown rice can be predicted from the K^+ concentration in soil solution.

Keywords：*Radiocesium, Brown rice, Potassium, Soil solution*

P1-24

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Terrestrial Gamma Radiation Dose and its Relationship with Soil Ph Level in Seri Gading Industrial Area, Batu Pahat District, Malaysia.

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An extensive survey was carried out for gamma dose rates in the Sri Gading Industrial Area, Batu Pahat District, Johor, Malaysia. The study area was chosen due to its highest terrestrial gamma radiation in Batu Pahat District. The measurements of absorbed dose in air were conducted above the soil surface at height of 0 meter using Ludlum Model 19 survey meter at 100 random points within the area. Gamma absorbed dose rates in air outdoors (GDR) were calculated to be in the range between 139.2 nGy/h and 539.4 nGy/h with an arithmetic mean of (337.7±67.4) nGy/h. Workers of Sri Gading Industrial Area are subjected to external gamma radiation exposure (effective dose) ranging between 0.171 and 0.662 mSv/y with an arithmetic mean of (0.414±0.083) mSv/y. The soil pH level was measured at the point where absorbed dose in air was taken to determine the possible association between the GDR and pH soil level using the Pearson r correlation. It is found that the simple linear correlation between the two quantities is inversely proportional with the Pearson r value = -0.12.

Keywords：*terrestrial gamma radiation dose, gamma absorbed dose rates, external gamma radiation exposure (effective dose), soil pH level*

P1-25

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Effects of Decontamination and Potassium Fertilization on Radiocesium Concentrations in Rice and Vegetables Cultivated in Evacuation Area at Okuma Town, Fukushima

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Significant quantities of radionuclides were released into the environment because of the TEPCO Fukushima Daiichi Nuclear Power Plant (FDNPP) accident in 2011, thereby seriously damaging the agricultural products in Fukushima, The FDNPP is located in Okuma Town, where the entire region was severely contaminated by radioactive nuclides, including Cs-134 and Cs-137, and was designated as the "evacuation area." The prospects for reactivation of agriculture were not observed in this region. However, to obtain the scientific data for future recultivation, test cultivations of several crops, including rice, eggplant, pumpkin, green soybean, sweet potato, and cabbage in contaminated and decontaminated soils were conducted in 2012. Moreover, to investigate the effects of potassium fertilization, radiocesium concentrations in crops were compared between crops cultivated in intensively potassium fertilized fields and control fields in 2013.

Soil samples of 30-cm depth were collected from contaminated and decontaminated fields before and during cultivation and from intensively potassium fertilized and control fields during and after cultivation. During cultivation, radiocesium abundances in soils at contaminated upland, decontaminated upland, contaminated paddy, decontaminated paddy, and ancient black rice paddy fields under cultivation were 3680, 877, 1820, 1640, and 1070 kBq/㎡, respectively, and the weighted average of the concentrations for a 15-cm depth were 31.6, 7.46, 15.4, 13.7, and 14.8 kBq/kg, respectively. Radiocesium concentrations in decontaminated upland soil decreased by one-quarter compared with those in contaminated upland soil by removing the surface soil. However, radiocesium concentrations in decontaminated paddy soil slightly decreased compared with those in contaminated paddy soil. This was because the paddy field was disturbed by animals, and radiocesium was mixed into deeper soil before cultivation.

Radiocesium concentrations in the edible parts of eggplants and pumpkins cultivated in the decontaminated field (14.3 and 35.1 Bq/kg fresh weights, respectively) were lower than the standard limit in foods in Japan (100 Bq/kg fresh weight). However, radiocesium concentrations in other crops, including rice plants cultivated in the decontaminated field and all crops cultivated in the contaminated field, were higher than the standard limit in foods in Japan. For most crops, the transfer factor values from soil to edible part were within the ranges reported by the IAEA (2010), but they were relatively high.

For most crops cultivated in intensively potassium fertilized fields, radiocesium concentrations decreased compared with those in control fields. However, for pumpkin and Japanese radish, decrease in radiocesium concentrations because of heavy potassium manuring was not observed. Moreover, radiocesium concentrations in many crops except for sweet potato, cabbage, and Japanese leaf vegetable (komatsuna) cultivated in intensively potassium fertilized fields were lower than the standard limit in foods in Japan.

Keywords：*test cultivation, evacuation area, transfer factor*

P1-26

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Development of a Device for Measuring the Vertical Distribution of Radioactivity in Soil Using Geiger-Muller Tubes

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On March 11, 2011, a great earthquake hit in northeast Japan that caused Fukushima Daiichi Nuclear Power Plant accident. Immediately after the accident, 131I, 134Cs and 137Cs were detected in the fallout. Among them, 134Cs and 137Cs have been fixed so strongly on clay minerals in soil that topsoil in agricultural field has been contaminated. For the decontamination of agricultural field, we need to estimate an appropriate soil thickness for decontamination which is normally determined by soil sampling method. However, since the soil sampling method requires a lot of time and costs, a simple in-situ method is needed. In this study, therefore, we have developed a new device that can measure vertical distribution of radiocesium concentration. The device consists of four Geiger-Muller tubes as detectors of radiation and five lead plates to enhance the directionality. We installed the device in an undisturbed paddy field in Iitate Village, Fukushima and compared counting rate in each depth and the vertical distribution of radiocesium concentration in the sampled soil. By defining leakage coefficient to remove influences out of range of measurement, we calculated counting rate of sensors. As a result, a liner relationship was obtained between the corrected counting rate and the radiocesium concentration. The result means that our device can be promising to measure the radioactive cesium concentration in each depth of soil in in-situ fields. With a field test of the device in an undisturbed rice field in Iitate Village, Fukushima, we confirmed that the vertical distribution of soil radioactivity was properly measured with the device developed.

Keywords：*radiocaesium, vertical radioactivity distribution, Geiger-Muller tube*

P1-27

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Challenge in Remediation of Agricultural Soil Contaminated by Radioceasium in Fukushima, Japan

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Most of radioactive cesium released from Fukushima Daiichi nuclear power plant has been accumulated in the topsoil within 5 cm. For decontamination of the top soil, Japanese government (Ministry of Agriculture, Forestry and Fisheries) has authorized three methods: topsoil stripping method, puddling method, and plowing method to replace surface soil with subsoil. Among three methods, the topsoil stripping method is being carried out and a lot of flexible container bags containing contaminated topsoil are piled up in the paddy field. We have not yet found the final disposal site of the contaminated soil. For agricultural regeneration and early return village, it is urgent and important to find a feasible decontamination method that farmers can conduct by themselves. Therefore, we are challenging a field test that buried the contaminated soil in the ground by a combination of the topsoil stripping method and the plowing method. We named this method 'Madei-method' that means we treat contaminated soil very carefully. Currently, we are monitoring the radiation dose from the buried contaminated soil by using a newly developed soil radiation sensor. At the moment, leakage of radioactive cesium has not been confirmed from the buried contaminated soil despite rapid changes in ground water due to rainfall and irrigation to the paddy. This can be explained in terms of the filtering effect of the clay particles even if water penetrates the contaminated soil and colloidal clay particles move downward.

Keywords：*radioceasium, decontamination, Fukushima, clay, monitoring*

P1-28

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Dynamics of Radioactive Cesium at Paddy Fields in Lower Basin of Agano-River, Niigata, Japan

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Agano-River flows from Fukushima Prefecture, Japan. After the accident of nuclear power plant on 11 March 2011, many rice farmers afraid to produce rice contaminated radioactive cesium (Cs). Hence we monitored Cs concentration of soil and brown rice at 43 paddy fields in lower river basin of Agano-River in Niigata Prefecture, Japan. The soil of this area is gley, and includes weathered granite. The soil sample took from the cultivated layer near the water inlet of each paddy field. At the same point, we cultivate 30 rice stubbles, and prepared brown rice around 1 Kg. We measured Cs concentration of soil and brown rice by using a germanium semiconductor detector (SEG-EMS, Seiko EG&G). Consequently, Cs134 and Cs137 of brown rice were not detected in any samples. However, in every paddy field, the concentration of Cs137 of soil detected and varied widely. The site where Cs134 detected, the concentration of Cs137 was bit high. Considering the half-life period of Cs134, detected Cs of soil at this area was came from the accident of nuclear power plant. Therefore we should monitor the concentration of radioactive nuclide in soil in this area for the sustainable agriculture.

Keywords：*radioactive cesium, germanium semiconductor detector, paddy field*

P1-29

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Plot-Scale Spatial Variability of Radioactive Cesium Profile in Contaminated Paddy Soil in Fukushima

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Due to the accident of Fukushima Daiichi Nuclear Power Station, broad area in eastern part of Fukushima Prefecture, Japan was severely contaminated with radionuclide. Three years after the accident, decontamination of the nuclide from farmland is being conducted. For the highly contaminated land, although peeling off of the considerably contaminated layer is adopted in governmental decontamination projects, optimum depth is roughly determined because the accurate vertical profile of the radioactive cesium is not easily estimated from the results of a few soil samples per a plot. The present study aims to characterize the spatial variability of cesium profile in contaminated paddy field in Fukushima and to provide clear statistical meaning of the cesium profile measured by the standard sampling method.

The investigation and soil sampling was conducted in a paddy field plot having a length of 110 m and a width of 30 m. The field is located in Iitate village, Fukushima Prefecture, which is 40 km north-west of the Fukushima Daiichi Nuclear Power Station. Although rice had been cropped till 2010, neither cropping nor tillage has been performed in the field since the accident in March 2011. In December, 2012, cylindrical soil cores having diameter of 5cm and length of 20cm were taken with plastic samplers at intervals of 1 or 2 m along the center lines of the rectangular plot in the long side and short side directions. Total number of the samples was 82. Additionally in May 2013, a square mesh with 20 cm interval was set in the middle of the field and samples with the same dimension were taken at the grid points within 1 by 1 m domain: 36 samples were obtained. The cylindrical samples were cut into slices with 1 cm thickness (for 0-6cm layer) or 2 cm thickness (for 6-10cm layer). The slices were dried in an oven and packed in plastic bottles. The radioactivity was measured using a NaI scintillation detector lightly insulated with lead plates. Difference in number of photons detected in 200 seconds with and without samples was converted to the radioactivity of the sample in Bq kg-1. This was because the insulation was not perfect and the effect of background beams should be eliminated. The parameters for the conversion was determined by comparing the radioactivity of 5 standard samples measured by a germanium semiconductor detector and the count of photons by the NaI scintillation detector.

Total mean of Cs concentration averaged through 0 to 10cm layer ranged 5,000 to 120,000 Bq kg-1. The coefficient of variation (CV) of the Cs concentration amounted to 50 %. Mean infiltration depth, which was estimated from first order moment of the concentration profile, was 2.79cm. They also ranged 1.3 to 5.5cm and the CV was 38%. The most of the profiles had peaks of concentration within 0 to 3 cm from the surface. However not a few profiles had peaks at deeper layer. Although the factors affecting the peak location were not elucidated from the observation, the conventional approximation of Cs profile by exponential function should be replaced by more general functions such as Gaussian function for the determination of optimal depth to be peeled off. Semivariances of the Cs concentration averaged through 0 to 10cm and the mean infiltration distance revealed no significant spatial correlation: influential range was less than the minimum interval of the sampling points. This analysis suggests Cs profiles measured from small core samples randomly distributed over the fields.

By the sampling at 1 or 2 meter intervals, correlation between the mean concentration and undulation of ground surface was not found. However the sampling at the 20 cm square grids showed effect of the ground undulation. Cesium locally concentrated at concave portion in the scale of some centimeters to tens of centimeters, suggesting the effect of horizontal convection due to surface water flow. Because such clear concave portions are few, samplings at depressed points such as the trail of tractor wheels should be avoided to know the concentration averaged over the field.

Keywords：*Decontamination of radionuclide, Nuclear Power Station , Soil remediation*

P1-30

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Seasonal Changes In Soil Radiocesium Distribution in Rice Fields and their Effect on Rice

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After an extraordinary earthquake rated at magnitude 9.0, a large tsunami hit the Pacific coast of Japan on March 11, 2011. As a result, the Fukushima Daiichi Nuclear Power Plant (FDNPP) was severely damaged and enormous amounts of radionuclides were released to the environment. The subsequent radioactive fallout caused wide contamination of lands mainly in the vicinity of the FDNPP. Among various radionuclides, Cs-134 and Cs-137 have relatively longer half-lives of 2.1 and 30.2 years, respectively. Therefore, long-lasting effects of the radiocesium contamination in farmlands on human health, ecosystems and agricultural activities are a matter of public concern. It is known that the dominant proportion of radiocesium was deposited in forested areas in Fukushima prefecture. Migration of radiocesium from forest ecosystems to other environments is expected to be considerably slow. On the other hand, radiocesium in river water in Fukushima prefecture ranged from < 0.2 to 3.9 Bq/L with an average of 1.12 Bq/L, according to the MEXT survey in 2011. This suggests that radiocesium load to rice fields associated with water supply is not ignorable, since rice fields consume large amounts of irrigation water, about 500-2,000 mm per a cropping season. This study aims to elucidate seasonal changes in soil radiocesium activities in rice fields and radiocesium absorption by rice in Ohta area, Minamisouma City, Fukushima Prefecture, Japan, located in about 22 km north from the FDNPP. The source of the irrigation water is Ohta River from Yokogawa Dam, whose catchment area is severely contaminated with radiocesium.

Materials and methods

Four rice fields were selected in Ohta area in 2013. Zeolite granules (3 Mg/ha) and potassium fertilizer (300 kg-K_2O/ha) were incorporated at the spring tillage. Three sampling points, point A within 3 m of the water inlet, point B in the center and point C within 3 m of the drain outlet were determined for each site. Soil cores (0-15 cm in depth) were sampled from each point immediately after the spring tillage (20 April), during the midsummer drainage (7 July) and at the harvest (18 September). After thoroughly mixed, radiocesium concentration of each sample was analyzed by NaI(Tl) gamma-ray spectrometry. Concentrations of exchangeable K and other cations in the soil samples were determined using an atomic absorption spectrophotometer. Vertical distribution of radiocesium in soil was also evaluated using the soil samples collected with a scraper plate. Rice straw and grains were harvested on 18 September at A-C points of each site and their radiocesium concentrations were determined using a Ge gamma-ray detector. Transfer factor (TF) was calculated using the following formula: TF = (total radiocesium in the dried plant sample [Bq/kg]) / (total radiocesium in the dried soil sample [Bq/kg]).

Results and discussion

Seasonal changes in the total radiocesium concentrations of the soil core samples showed a slightly-decreasing trend. Vertical distribution of radiocesium in soil indicated dramatic change at point A after the midsummer drainage: radiocesium concentration in the top layer (0-2 cm in depth) was dramatically elevated. Such phenomenon was not observed in the sample collected at point B.

The results strongly suggest the contribution of radiocesium load to the rice field newly introduced via irrigation water. Radiocesium in more than half of the rice grain samples exceeded the current legal limits for radioactive materials in food in Japan (100 Bq/kg). The TFs were 0.02-0.08, higher than the values recorded in other regions of Fukushima Prefecture. In particular, the rice samples at point A absorbed significantly higher radiocesium concentration. Clear correlations in radiocesium concentration between the soil and rice samples (grain and straw) were found ($p<0.05$). Concentrations of exchangeable K in soil decreased until the midsummer drainage. This may be due to excessive irrigation during the vegetative growth period of rice. Large supply of radiocesium via irrigation water after the midsummer drainage, washout of bioavailable K due to excessive usage of irrigation water, and low clay contents of soil are assumed to contribute to the high radiocesium absorption by rice.

Acknowledgement
This research was financially supported in part by the Mitsui & Co., Ltd. Environmental Fund, Japan.

Keywords：*Irrigation water, New loading, Radiocesium, Rice field, Vertical distribution*

P1-31

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Estimation of Radiocesium In/out Flows in Paddy Fields in Fukushima, Japan

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I. Introduction

Various radionuclides, released from the Fukushima Daiichi Nuclear Power Plant of Tokyo Electric Power Company in March, 2011, once spread over the environment and severely polluted agricultural soils in Fukushima Prefecture. As a result, brown rice harvested at a 0.2% of paddy fields exceeded the provisional regulation value (500Bq/kg) in 2011. Paddy field is the main agricultural land use in Fukushima; however, knowledge on radionuclides' behavior in paddy fields is insufficient especially on the amount of their in/out flows. Such information is necessary for estimating radionuclides contamination in brown rice and developing models for predicting radionuclides dynamics at watershed scale. This study focused on estimating in/out flows of radiocesium, the most problematic radionuclide with half-lives of 2 or 30yr at four different paddy fields in Fukushima.

Ⅱ. Monitoring and measurements

Field monitoring has been conducted in the following four paddy fields in Fukushima since spring in 2011 or spring in 2012. ; (1) a reorganized paddy field facing to forest in one side (738 m^2), (2) one of the terraced paddy fields surrounded by forest in three sides (349 m^2), (3) one of the terraced paddy fields surrounded by forest in three sides (128 m^2). (4) two reorganized paddy fields in Fukushima Agricultural Technology Centre (658 m^2×2).

Water levels and turbidity (as formazin turbidity unit, FTU) of irrigation and drainage water (in/out flows) in paddy fields and precipitation have been measured at every 10 or 30 minutes. Water samples have been collected once a month for atmospheric precipitation, irrigation, surface drainage, subsurface pipe drainage, and seepage water on a ridge between terraced paddy fields. A membrane filter with a pore size of 0.025μm was used to suspended solid (SS) and filtrate samples. Suspended and dissolved concentrations of radiocesium (^{134}Cs+^{137}Cs) were determined by Ge semiconductor detector after drying the SS and filtrate samples, respectively. Based on the relationship between turbidity and radiocesium concentrations, and flow rates of irrigation and drainage water calculated from their water levels etc., in/out flows of radiocesium in paddy fields were estimated for the monitoring period of one year (23rd May, 2012 ~ 27th May, 2013).

Ⅲ. Results and Discussions

Total radiocesium concentrations of water samples ranged from 0.01 Bq/L to 1.1 ×10^3 Bq/L, which increased with SS concentration ranged from 2 mg/L to 65 g/L. Dissolved radiocesium concentration ranged from 0.001 to 0.9 Bq/L. The rates of dissolved radiocesium to all radiocesium were 2~25% for atmospheric precipitation, 6~40% for irrigation water, 0.001~40% for surface drainage, and 2 ~ 98% for subsurface pipe drainage. Radiocesium concentration of water samples, mainly taken at usual meteorological conditions, were 0.1~0.31 Bq/L for irrigation water, 0.02~1.4 Bq/L for surface drainage, and 0.2~0.9 Bq/L for atmospheric precipitation. Radiocesium inflow by irrigation, inflow by atmospheric precipitation, and outflow by surface drainage were ranged 10^2~10^3 Bq/m^2, 10^2~10^3 Bq/m^2, and 10^3~10^4 Bq/m^2 in the (1),(2) and (3) paddy fields for the one year, respectively. Radiocesium net flow in the 3 fields for the one year was estimated to be outflow of 0.2%, 0.2%, and 0.7% of the amount of radiocesium in soil to depth of 25cm, respectively. Without any disturbance, radiocesium is calculated to become half in 6.1 yr, and to become 1/5 in 39.9 yr by the atomic nucleus decays on the assumption that the radioactivity levels of ^{134}Cs and ^{137}Cs released in March, 2011 were almost the same ; the fact recognized. On the other hand, the radiocesium in the (1), (2) and (3) paddy fields is calculated to become half in 5.8 yr, and to become 1/5 in 34.6 yr in average on the additional assumption that radiocesium net flow rate is constant every year for each paddy field. This calculation cannot help containing uncertainty because of several factors that carryout of radiocesium by rice harvest is not accounted in this point, and that meteorological conditions are different every year etc.. Therefore, these monitoring and analysis have to be continued in more years.

This study was performed under a support of the Ministry of Environment, Japan.

Keywords：*radiocesium, paddy fields, in/out flows, suspended solid*

P1-32

[IDS4] Critical Issues of Radionuclide Behavior in Soils and Remediation

Soil-To-Plant Transfer Factors of Cs-137 for the Korean Diet and their Potential Use after a Nuclear Accident

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Transfer of a radionuclide from soil to plant is usually quantified with the transfer factor (TF, dimensionless) defined as the ratio of the plant concentration to the soil concentration. It is normally about the plant grown to edible maturity in the soil mixed with radionuclides to a certain depth before planting. After the Chernobyl and Fukushima nuclear accidents, radiocesiums such as Cs-134 and Cs-137 were almost entirely responsible for mid- to long-term contaminations of arable land. Therefore, it is meaningful to prepare for the radiocesium contamination of arable land by a potential nuclear accident. One of the most important things to do may be to have a tool for deciding on the use of the contaminated arable land. If the soil contamination is above the level which is likely to make the plant concentration higher than the authorized limit for foods, it can be recommended not to cultivate the arable land. The reference soil concentration (RC, Bq/kg), which is considered to make the plant concentration equal to the food standard (Bq/kg), can be calculated by dividing it by an appropriate transfer factor value. In Korea, some amount of Cs-137 TF data has been produced for several food crops important in the Korean diet over the last 33 years. This work was done almost exclusively by Korea Atomic Energy Research Institute (KAERI). For rice and soybean, TF values of Cs-137 in a total of 13 and 6 different soils, respectively, were measured through greenhouse experiments. For barley, Chinese cabbage, radish, lettuce, carrot and squash, only one or two different soils were tested for such measurement. Field studies for fallout Cs-137 were also performed for rice and Chinese cabbage to obtain 12 TF values in each crop. The experimental values are applicable for the first harvest after pre-planting depositions, whereas the field-study values may be applicable for several-year-aged depositions. An appropriate TF value may be the representative value, which is generally expressed as the geometric mean (GM) of all the available values of relevance. In this case, the plant concentrations from the soils whose Cs-137 concentrations are close to the RC (RC-I) may be higher than the food standard at a probability of nearly 50%. If the soil concentration is not substantially lower than the RC, therefore, it is necessary to check the plant concentration after harvest. In consideration of inevitable uncertainty in the TF value, a safety factor can be introduced in calculating the RC. The safety factor can be changed and a possible one may be the geometric standard deviation (GSD) of the available TF values, which shall become a multiplier of the GM or a divisor of the RC-I. Even in this case (RC-II), such a risk as mentioned above can be expected to have a probability of about 17%. For an almost 100% guarantee, the extreme TF value can be used. It may be the observed maximum value (RC-III) or the GM multiplied by 2GSD (exponential of 2 σ of natural logarithms of available TF values, RC-IV), whichever is the greater. The more number of TF values are used, the more reliable results the above mentioned methods can give. For a research purpose, however, the crops having Cs-137 TF values in 2 or more different soils were all adopted and the four different types of the RC were calculated with 100 Bq/kg used as the food standard. For radish and Chinese cabbage, which have only one experimental TF value of Cs-137 in spite of their great importance for the Korean diet, different types of the RC were calculated using the same safety factors as applied for rice. The presented RCs are applicable for the sum of radiocesiums from pre-planting depositions to be mixed with topsoil to a certain depth as a result of plowing. At the event of the Fukushima accident, plowing for planting was not finished in most of the rice and soybean fields. Those RCs are recommendable only for interim uses and efforts have to be made to obtain more TF values particularly for radish and Chinese cabbage.

Keywords: *Radiocesium, Transfer factor, Korea, Nuclear accident, Reference soil concentration*

P1-33

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Soil Carbon and Nitrogen Affected by Perennial Grass, Cover Crop, and Nitrogen Fertilization

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Soil C and N sequestration and the potential for N leaching can be influenced by the type of perennial grass, cover crop, and N fertilization due to differences in crop yields and the amount of residue returned to the soil. We evaluated the effects of the combinations of perennial grasses (energy cane vs. elephant grass), cover crops (clover cover crop vs. none), and N fertilization rates (0, 100, and 200 kg N ha-1) on soil organic C, total N, NH4-N, and NO3-N concentrations at the 0-90 cm depth from 2011 to 2012 in central Georgia. Soil organic C at 15-30 cm and total N at 0-5 cm were greater for elephant grass with cover crop and 100 kg N ha-1 than for energy cane and elephant grass with no cover crop and N fertilization. In contrast, soil NO3-N at 0-5 cm was lower for energy cane with no cover crop and N fertilization than for energy cane with cover crop and 100 to 200 kg N ha-1. Elephant grass increased soil total N at 0-5 cm compared to energy cane. Cover crop increased soil organic C at 5-30 cm, total N at 5-15 cm, and NO3-N at 15-30 cm compared to no cover crop. Nitrogen fertilization increased soil organic C and total N at 0-5 cm and NO3-N compared to no N fertilization, but soil organic C at 15-30 cm was lower with 200 than with 100 kg N ha-1. Soil organic C, total N, and NO3-N decreased from 2011 to 2012, regardless of treatments. Preliminary results suggest that elephant grass with clover cover crop and 100 kg N ha-1 can sequester more soil C and N than other treatments and increased N fertilization rate can increase the potential for N leaching.

Keywords：*Soil carbon, Soil nitrogen, Perennial grasses, Cover crop, Nitrogen Fertilization*

P1-34

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Soil Carbon Sequestration And Soil Aggregation Affected by Perennial Energy Crops

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Dedicated energy crops, such as perennial grasses could have significant impacts on soil C sequestration and structure development. Over many years large areas of grassland have been converted to crop production. Consequently, soil organic matter decreased with the use of agricultural management practices, particularly tillage. Losses of soil organic matter are related with a decline in soil structure. Reestablishment of perennial grasses for biomass production on marginal agricultural lands has many benefits including increasing soil C sequestration and minimizing decomposition of soil organic matter through the use of minimum tillage. The objective of this research was to estimate potential C sequestration and soil structure development with the reestablishment of warm- and cool-season grasses on previously cropped land. Experimental treatments included three grass species and fallow. Switchgrass (Panicum virgatum), big bluestem (Andropogon gerardii), and intermediate wheatgrass (Thinopyrum intermedium) were established in 2000 at the USDA-ARS Research Farm near Brookings, SD, USA. Soil samples were collected to evaluate root biomass, soil organic carbon (SOC), particulate organic carbon (POC), and aggregate size distribution in 2005. There was no difference in SOC between fallow and grass treatments. However, POC was highest in the plot of intermediate wheatgrass, but there was no difference among other treatments. Wet aggregate stability was significantly higher and soil bulk density significantly lower in grassland soils compared to the fallow treatment. There were also large differences in aggregate size distribution among grassland soils. Grassland soils had more of larger aggregates (> 2.00 mm) compared to fallow. The amount of aggregates in 0.59 to 1.00 and 1.00 to 2.00 mm size classes was not different among grass species. After 4 years of grass establishment, root biomass was significantly higher in grass treatments compared to fallow, but SOC did not change significantly. Carbon content of root biomass accounted for less than 6% of soil organic C and for about 30% of particulate organic C. Our results indicate that the measurement of root biomass is very important when estimating potential C sequestration of grasslands over a relatively short-term period. Estimated C sequestration by root biomass trapped in the aggregates in the top 20 cm during the first four years of reestablishment was 0.46, 0.73, and 0.55 Mg C ha^{-1} yr^{-1} for switchgrass, intermediate wheat grass, and big bluestem, respectively.

Keywords: *Dedicated energy crop, perennial grass, Carbon sequestration, Soil aggregation*

P1-35

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Growth Responses and Accumulation of Cadmium in Energy Crops: Switchgrass (panicum Virgatum L.) and Prairie Cordgrass (spartina Pectinata L.)

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Abstract:Phytoextraction is a promising technique used to remediate heavy metals from contaminated soils. Identifying bioenergy crops that can be produced successfully on marginal lands, such as those polluted by heavy metals, reduces the pressure to produce energy crops on land that would otherwise be used to produce food crops. In this study, the phytoremediation capability of two warm season perennial grasses, a natural population of prairie cordgrass (Spartina pectinata L., IL 102) orginated from Illinois and 'Cave-in-rock' switchgrass (Panicum virgatum L., CIR), was determined through their response to cadmium (Cd). In a greenhouse setting, growth rate, cadmium tolerance, accumulation and translocation were measured at concentrations of 0 (control), 5, 10, 30, 50, or 100 mg/L of Cd mixed with Hoagland's solution in an aerated hydroponic system. Plant growths of prairie cordgrass and switchgrass significantly reduced when the Cd concentration was higher than 10 mg/L. However, there were significant differences of Cd tolerance, translocation and accumulation between the two energy crops. The tolerance index (Ti) was 53.59-92.17 in IL 102 and 45.00-87.89 in CIR. The translocation factor (Tf) of both energy crops was increased with the Cd concentration in solution, and Tf of IL 102 was higher than CIR. Both of the energy crops proved to be good accumulators of Cd, and the bio-concentration factor (BCF) of the roots was higher than the shoots. The highest BCF of the shoots was found when the Cd concentrations were 10 mg/L and 30 mg/L in IL 102 and CIR, respectively, indicating high Cd retention in the shoots. The BCF of the roots in both energy crops decreased as the Cd concentration was increased, being 97.06-325.73 and 56.52-144.53 in IL 102 and CIR, respectively. It was concluded that both energy crops could be utilized in phytoremediation when the Cd concentration is less than 10 mg/L; however, prairie cordgrass has higher tolerance, translocation and accumulation capabilities which makes it a better candidate for phytoremediation and biofuel production on Cd polluted soils than swtichgrass.

Keywords：*Energy crops, Cadmium, Tolerance, Bio-concentration factor, Translocation index*

P1-36

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Soil Carbon Sequestration on Conservation Reserve Program (crp) Lands Managed for Bioenergy Feedstock Production

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Using Conservation Reserve Program (CRP) land dominated by perennial warm-season grasses for bioenergy feedstock production could have impacts on changes in soil C sequestration and soil quality. The objective of this study was to evaluate the effects of various agronomic practices for biomass production on changes in soil quality and C storage on land enrolled in CRP, in which switchgrass (Panicum virgatum) was dominate. The field study was conducted in three CRP sites located in Moody Co, Gregory Co, and Marshall Co, SD, USA during 2001-2004. The agronomic treatments included five levels of N fertilization (spring application of 0, 56, 112, and 224 kg N Na^{-1} and split application of 224 kg N ha^{-1}), two harvest timings (at anthesis and after killing frost), and two harvest frequencies (every year and alternate years). Changes in C sequestration and soil quality factors including soil pH, field moisture content, bulk density, total C and N, inorganic C, SOC, and aggregate stability, caused by biomass production practices, were determined from differences before and after the agronomic treatments. After four years biomass production changes in soil carbon in switchgrass CPR land varied with locations. Soil carbon increased (4 Mg C ha^{-1} yr^{-1}) in the site (Moody Co.), which had relatively high biomass yield and stand persistence. Soil carbon decreased in sites (Gregory and Marshall Counties), which had lower biomass yield and poor stand persistence. These variations may be related to switchgrass persistence and response to growing environment such as precipitation and temperature. Nitrogen fertilization has positive impact on C sequestration when biomass yield was increased by N fertilization. Harvest timing and frequency affected soil organic carbon and varied with site and depth. In general, harvest after a killing frost and alternate year harvest tended to have a more positive impact on soil organic carbon than harvest at anthesis and every year harvest, respectively. These may also be related with switchgrass persistence. Soil aggregate stability was not severely changed during the four years of biomass production. Nitrogen fertilization and harvest management did not have an impact on changes in soil aggregate stability except for the Gregory site, in which soil aggregate stability in the plot harvested after a killing frost was significantly lower than that in the plot harvested at anthesis. Soil pH responded to N fertilization. Soil pH decreased with increasing N rate up to 30 cm deep. Our results indicated that CRP land managed for biomass production has the potential for carbon sequestration when biomass production is maximized and stand persistence is maintained, and soil quality can be maintained with proper management when CRP lands are used for biomass production.

Keywords：*carbon sequestration, switchgrass managment, biomass*

P1-37

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Environmental Impact of Bioenergy Landscapes in the United States

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Production of sustainable bioenergy to meet the US EPA's renewable fuel standard RFS) and reduce greenhouse gas emissions (GHGs) compared to fossil fuels will require significant land use changes across the US. While corn grain ethanol can meet volume requirements, it has negative impacts on the environment, particularly soil carbon depletion and an increased GHG balance compared to fossil fuel use. Perennial grasses have been proposed as viable bioenergy crops because of their potential to yield significant biomass on marginal lands without displacing food and contribute to greenhouse gas (GHG) reduction by storing carbon in soil. Switchgrass, miscanthus, restored native prairie, and corn stover (residues) are among the feedstocks being considered in the agricultural regions of the United States. In this study, we used an extensive dataset of site observations for each of these crops to evaluate and improve a combined ecosystem and economic modeling framework about how both yield and GHG fluxes would respond to different land use strategies. Using this model-data integration approach, we found 30-75% improvement in our predictions over previous studies and good model-data agreement of harvested yields and soil carbon stocks ($r^2 > 0.62$ for all crops). We found that growing perennial grasses would result in average onsite GHG reductions of 0.5-2.0 Mg CO2e ha-1 yr-1compared to current practices, not including fossil fuel offsets. After conversion to bioenergy and complete life cycle assessment, offsite GHG savings can increase by up to 150%, providing a dry biomass supply of 11-22 Mg ha-1 yr-1 for energy use. We used the projected yields to determine a least cost allocation of land required to meet a 16 billion gallon cellulosic ethanol RFS mandate. We mapped a 24 million hectare bioenergy landscape composed of a mix of perennial grasses on land not currently used for food production and utilization of corn stover from agricultural land. Preliminary analysis suggests that this land allocation scheme can meet the cellulosic ethanol volume requirements, reduce GHG emissions to the atmosphere compared to fossil fuels, and improve soil quality.

Keywords: *bioenergy, soil carbon, GHG, perrenial grasses*

P1-38

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Does Nitrogen Fertilization Effect Biomass Yield, Nitrate Leaching, or Greenhouse Gas Emissions in Illinois-Produced Miscanthus× Giganteus?

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For many crops, including perennial energy grasses, yields are improved through applications of nitrogen fertilizers. In this study, urea was applied annually in the spring at 0, 60, and 120 kg N ha−1 to the biomass feedstock grass, Miscanthus × giganteus, to determine N effects on biomass yields, nitrous oxide and carbon dioxide emissions, and nitrogen leaching. The study was conducted from 2009 through 2012 on M. × giganteus planted in July 2008 in Urbana, Illinois, USA (N 40.0622501, W -88.1915366). There were no biomass yield responses to N fertilization rates in 2009, 2010, or 2011, but in 2012, the N fertilized treatments produced significantly more biomass that the unfertilized controls. There was no significant carbon dioxide emission response to N rates in any year 2009 through 2012. Nitrogen fertilization did not increase cumulative nitrous oxide emissions in 2009, but cumulative nitrous oxide emissions did increase in 2010, 2011, 2012 with N fertilization. Following the 2009 growing season, there were no differences in nitrate leaching related to N fertilization rate, but there was greater nitrate leaching in the fertilized plots than in the unfertilized plots following the 2010, 2011, and 2012 growing seasons. Because N fertilization did not always result in increased biomass productivity, but did result in increased nitrous oxide emissions and nitrate leaching in most years, this study illustrates the need for continued study of N fertilization on M. × giganteus in order to maximize yields and minimize negative environmental effects.

P1-39

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Biomass and Seed Yield of Oilseeds in Ne Montana for Use as Hydro-Treated Renewable Jet Fuel

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Hydro-treated renewable Jet (HRJ) fuels can potentially offset the demand for petroleum based transportation fuels. However, identifying suitable feedstock supplies remains a primary constraint to adoption. A multi-year, multi-site experiment initiated in fall 2012 investigated the yield potential of six winter types and twelve spring types of cool-season oilseeds. Sidney, MT was one of nine sites in the western U.S. with the others in California, Colorado, Idaho, Iowa, Minnesota, North Dakota, Oregon, and Texas. Winter types of Camelina sativa (1), Brassica napus (4), and B. rapa (1) were planted on September 19, 2012 to a 0.95 cm depth on 19.1 cm row spacing. A wet spring during 2013 delayed planting about 4 weeks. Spring types of Camelina sativa (1), B. napus (4), B. rapa (1), B. juncea (2), and Sinapis alba (2) were planted on May 4, 2013 and B. carinata (2) on May 6, 2013 to a 0.64 cm depth on 20.3 cm row spacing. Seeding rates varied by entry and were between 4 to 11 kg ha-1. All plots were under no-till management. Fertilizer monoammonium phosphate, potassium chloride, and ammonium sulfate were banded with the planter 5.1 cm below and to the side of seed at 56, 45, and 112 kg ha-1, respectively. Urea at 112 kg ha-1 was broadcast on May 9, 2013 for winter types and banded with other fertilizers during planting for the spring types. Plots were 3 by 9 m with each treatment (oilseed entry) replicated four times. Camelina 'Joelle' was the only fall-seeded entry that survived the normal to mild winter with little to no snow cover on plots and where minimum air temperature reached -29°C. Stands of 'Joelle' in the spring were excellent. 'Joelle' plots were harvested on July 15, 2013. For spring types, above ground plant parts for plant yield component determination were taken on Aug 5, 2013. Hailstorms during the next three of five days resulted in >95% seed loss, preventing normal seed yield harvest. B. carinata and camelina were the least and most susceptible to hail damage, respectively. Seed yield estimates for spring types were based on the proportion of seed to above ground biomass in yield component samples obtained the day before the first hail storm and on above ground biomass measured after the hail storms on August 14, 2013. B. napus 'Invigor 8440 LL' had the greatest seed yield of all entries and was 1372 kg ha-1; above ground biomass was 2860 kg ha-1. Compared to 'Invigor 8440 LL', seed yields and biomass of other entries were 89% and 66% (Camelina sativa 'CO46'), 62% and 113% (Camelina sativa 'Joelle'), 60% and 61% (B. napus 'DK340RR'), 49% and 54% (B. juncea 'Pacific Gold'), 47% and 51% (B. napus 'SC.28'), 37% and 52% (S. alba 'Tilney'), 35% and 46% (B. napus 'Gem'), 35% and 78% (B. carinata '080814EM'), 32% and 53% (S. alba 'IdaGold'), 25% and 33% (B. juncea 'Oasis'), 23% and 89% (B. carinata 'A110'), and 4% and 18% (B. rapa 'Eclipse'), respectively. Harvest index (HI), i.e. proportion of seed in above ground biomass, was 48% (B. napus 'Invigor 8440 LL'), 65% (Camelina sativa 'CO46'), 26% (Camelina sativa 'Joelle'), 47% (B. napus 'DK340RR'), 44% (B. juncea 'Pacific Gold' and B. napus 'SC.28'), 34% (S. alba 'Tilney'), 37% (B. napus 'Gem'), 21% (B. carinata '080814EM'), 29% (S. alba 'IdaGold'), 37% (B. juncea 'Oasis'), 13% (B. carinata 'A110'), and 10% (B. rapa 'Eclipse'). Neither of the carinata entries was mature at the time of harvest, which likely had an adverse impact on seed yield as suggested by their relatively low HI values. The relatively late planting date in spring 2013 and hail storms near plant maturity likely limited the production potential of spring types. Overall, camelina was the only winter type that showed potential as an oilseed feedstock due to its survivability over winter. For spring types, B. napus, Camelina sativa, and B. carinata showed the greatest potential. However, additional years of data are needed to show the production potential of the oilseeds across varying growing conditions.

Keywords：*oilseed, canola, camelina*

P1-40

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Effect of Different Types of Wastewater on Soil Properties and Biomass Production in a Low Ph Soil

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Energy crops, also called as 'bioenergy crops', are usually grown for the purpose of energy production (biofuel, biogas or biochar). Currently, these energy crops contribute a relatively small proportion to the total energy produced from biomass each year, but the proportion is set to grow over the next few decades. As these crops are not grown for food production, there is no health risks associated to the consumers. The possibility of using biomass as a source of energy in reducing green-house gas emissions is a matter of great interest. Rapid growth of urban population results in production of huge quantities of wastewater. Only 16.09 % of total wastewater is reused in Australia and approximately 14% of treated effluents are reused for irrigation in Australia. Thus, untreated water can easily find its way into water systems such as rivers, lakes, groundwater and coastal waters, causing serious water pollution. Therefore, utilisation of wastewater for non-edible crop production can be an effective method to manage this resource, targeting three main advantages are: i) the fertilizing properties of the water (fertigation) reduce part of the demand for synthetic fertilizers, ii) the practice increases the available agricultural water resources and iii) it may lower treatment costs. The main objective of this study is to evaluate the environmental and energy sustainability of biomass production by different energy crops irrigated with four types of wastewater (winery, piggery, dairy farm and municipal) and freshwater. Sunflower (Helianthus annuus), maize (Zea mays) and sugar beet (Beta vulgaris) were grown in a greenhouse pot experiment and irrigation levels were maintained at 80% field capacity throughout the experiment. After 100 days the plants were harvested and dried after recording the fresh biomass and root weights. Piggery wastewater showed the highest biomass (sunflower - 154.67g/pot; maize - 246 g/pot and sugar beet - 290.67g/pot) and root yield (sunflower - 18.33g/pot; maize - 27.67 g/pot and sugar beet - 40.17g/pot), whereas winery wastewater showed the lowest. This can be attributed to the pH and EC induced toxic effects caused by winery wastewater application. Hence, the wastewater sources should be assessed for toxicity before using it for irrigation to crops. This study showed that the wastewater irrigation to the selected crops enhanced the growth of plants and the order of effectiveness was piggery > dairy > municipal > winery wastewaters. Among the crops, sugar beet produced high biomass followed by maize and sunflower. The root weights also followed the same trend as the whole biomass of the plants. However, the nutrient contents (N and P) accumulated in the crops under the irrigation of different wastewater sources need to be determined for more information on the effects of wastewater.

Keywords：*Energy crop, Wastewater, Helianthus annuus, Zea mays, Beta vulgaris and Biomass.*

P1-41

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Growing Populus I-214 and Miscanthus on Agricultural Land - Four-Year Study Experience for Bioenergy Purposes

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The quantity of plant fractionated biomass of Populus I-214 and Miscanthus and soil characteristics were studied for a four-year period in the area of Zlatna Panega, Bulgaria. P-I 214 was afforested under the scheme 2.00 x 1.00 m distance. The results obtained are at the low limit for growing and capacity for plant biomass production due to the following factors: temperature regime for the studied period in the area, soil decline and reduced agro-technical and ameliorative activities in sustaining and improvement of soil fertility.

Keywords：*Populus I-214, Miscanthus, biomass, soil*

P1-42

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Perennial Herbaceous Crops Used for Bioenergy: a Review of their Impact on Soil Organic Carbon

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Perennial herbaceous crops are perceived as a sustainable alternative to annual crops used as bioenergy feedstock. In particular, perennial crops are well recognized for their positive effects on soil quality, and in particular organic C, compared to annual crops. They potentially have a significant positive contribution to the C footprint of the production system through soil C sequestration. Our objective was to investigate whether there is variability in the response of soil organic carbon (SOC) to various perennial crops used for bioenergy production, and their associated management practices. We searched the available peer-reviewed literature in which the impact of common perennial herbaceous crops (e.g. miscanthus, Miscanthus spp.; switchgrass, Panicum virgatum; bermudagrass, Cynodon dactylon L.) on SOC was measured. We classified the studies according to previous or reference land use, current management practices, plant species, study duration, site characteristics (soil, climate), and depth of soil sampling. Forty studies were retained for this analysis. Studies were generally concerned with either the direct effects of different plant species or the impact of their associated management practices (fertilization, harvest frequency etc.). Studies also varied according to previous or reference land use (i.e. annual crops, grassland or forest). Overall, the response of SOC to plant species was greater when the reference land use was annual cropping rather than native vegetation (grassland or forest). Among the different plant species, and compared to annual cropping, miscanthus and bermudagrass generally had positive effects on SOC whereas the effect of switchgrass appeared to be more variable. Overall, harvest frequency showed no consistent effect on SOC. The effect of applying N fertilizer to the grasses was also variable. In cases where SOC was increased, the effect was generally related to increased plant biomass. Overall, there appears to be variability in the response of soil organic C to perennial grasses used for bioenergy, but more long-term studies are required to make broader generalizations and quantification of the effects.

Keywords :

P1-43

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

A Camelina Sativa Production System in Central Montana and its Effect on Soil And Environment

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Camelina sativa has been identified as an oilseed bioenergy feedstock, but a sustainable production for this energy crop has not yet been well developed. Moreover, there is a major concern about bioenergy feedstock production directly competing for land use with food crops and bioenergy crop production affecting environment. One potential resolution is using camelina as a rotation crop to grow in traditional fallow periods in wheat-based production systems, resulting in a complementarity, rather than substitution, to food crops. This study investigates the impact of using camelina as a rotation crop on crop yields, N loss to atmosphere and groundwater, water use efficiency, and system profitability. Br tracer was used to study water and NO3 movement from the shallow soil profile to groundwater.

Keywords：*Camelina sativa, cropping system, land use, sustainability*

P1-44

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Scope of Native Grass Species as Potential Bioenergy Crops Grown in a Flyash Amended Phosphorus-Rich Soil and its Effects on Soil's Phosphorus Availability

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Increase in population and the consequent rise in natural resources utilisation has put enormous pressure on the environment. While growing bioenergy crops for energy production reduced the pressure on environment to an extent, soil characteristics are found to be slowly deteriorating. This is mainly because of the use of high-yielding non-native plant species, which possess the tendency to drain the soil's nutrient pool significantly. Grass species such as Arundo donax (Giant reed), Pennisetum purpureum (Napier grass) are commonly being used as bioenergy crops due to its effectiveness in growing under lower water requirements and also highly saline conditions. However, some varieties of these grass species are known to be invasive and also have the potential to alter the soil characteristics after few cropping cycles. Hence, this research work explored the opportunity of using Australia's native grasses as near replacements for imported grass species and their effects on soil characteristics. The grass species were evaluated on their capacity to produce biomass on par with napier grass and their efficiency in releasing oxalic acid from the roots and mobilising phosphorus (P) from P rich soil. Napier grass is known to release excessive oxalic acid and hence oxalic acid exudation from the Australian native grass species is used as a reference in this study.

The overall objective of this study was to evaluate the biomass producing capability of native grass species grown on flyash (FA) amended P rich soil and the specific objective is to determine their effects on soil characteristics such as pH, organic acid production and plant available P (Olsen P). The soil used for the study was a low pH (4.7) collected from an abattoir wastewater irrigated site (Primos Port Wakefield Abattoir, Australia), which was rich in P content as received from the wastewater. The soil was dried, sieved to < 2 mm and incubated with 15 % FA (pH – 10.6) collected from Port Augusta Power Station (Port Augusta, Australia) for 21 days. The Australian native grass species used in the study were C4 grasses with napier grass (a C4 grass) as a reference. The young saplings of C4 grasses such as Enneapogon nigricans (Black-head grass), Themeda triandra (Wallaby grass), Chloris truncata (Kangaroo grass) and Enteropogon acicularis (Umbrella grass) were grown on the incubated soil samples and were maintained under optimal moisture conditions in a greenhouse for three months. At the end of 12 weeks, the plant shoots were harvested, dried and weighed for dry biomass. After harvesting the plants, the soil was also dried and analysed for pH, oxalic acid contents and Olsen P levels. The pH of the FA incubated soil increased to 7.6, which limited the Olsen P level.

The results showed that the native grass species are rational competitors of napier grass in terms of biomass production with the order of biomass growth of plants at the end of three months as follows: napier grass (4.86 g) > wallaby grass (4.24 g) > umbrella grass (4.19 g) > kangaroo grass (4.07 g) > black-head grass (3.96 g). The production of oxalic acid and increase in Olsen P as measured from the harvested soil also showed similar trends as biomass production; however, the levels of oxalic acid were less in native grasses grown soil compared to that of napier grass. This can be attributed to the decrease in pH to < 7 as a result of oxalic acid exudation by the roots. Hence, this study demonstrated that Australian native grass species has not only the potential of utilising P from P-rich soil, but also optimise the soil characteristics thereby protecting the soil environment from degradation and plant invasiveness.

Keywords：*Biomass production,soil quality, Olsen P, flyash, pH, root exudates, oxalic acid*

P1-45
[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Soil Quality Changes under Bioenergy Cropping in Tropical Soils: from Corn Feed Plant to Oil Palm Plantation.

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Among energy production systems, bioenergy productions may provide good aspects on environment. But, they still have negatif impacts on soil and water, because there are still changes in soil properties, especially of agricultural productive lands. Soil quality changes according to the use and management as well as specific inherent quality of soil. As a part of the multi-year research, this very beginning research was conducted to study the changes of soil quality under bioenergy cropping in tropical Ultisols and Oxisols. Location of the study, Panyipatan District Tanah Laut Regency South Kalimantan Province was determined based on the purpose of research and site-specific factors, such as climate, soil, and plants in accordance with procedures stratified purposive sampling. The soil was sampled from 0 - 15 cm soil surface, and were analyzed in the laboratory according to standard procedures. Soil quality was evaluated quantitatively. The soil quality index (SQI) was calculated using the procedure of SMAF (Andrews et al., 2004) which consists of three stage of prosedures, i.e selection of soil indicators to build minimum data set (MDS), interpretation of soil quality indicators using curve-fitting model, (Curve Expert Version 3.1) (measured indicators MDS were transformed to MDS scores), and integration of soil quality indicators to SQI. Taken from the previous research (Makalew et al., 2010), MDS soil quality indicator of study sites includes soil quality indicator bulk density (BD), available water content (AWC), soil pH, phosphate (P-available), soil organic carbon (SOC), and water-filled pore space (WFPS). In this year research, the MDS includes also variable aggregate stability (AGG) and available pottasium (K) according to Winhold et al., 2009. The results showed that all the variables in MDS decreased, especially the TOC. The TOC decreased in 3 locations were consecutively 2.55 %; 2.21 %; and 1.88 % to 1.75 %; 0.89 %; and 1.40 %. SQI values of bioenergy cropping were also decreased, which SQI corn field were 71; 74.05; and 70.05 to SQI of bioenergy cropping filed were 66.84; 57.61; and 64.05. Beside the ecologycal factors, the research will cover the economy and social factors affected by land use change from feed plant, corn filed, to bioenergy cropping, oil palm plantation.

Keywords：*Soil quality; Soil Quality Changes;Corn Feed plant; and Oil Palm Bioenergy Cropping*

P1-46

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Impacts of No-Tillage and Liming on Soil Characteristics and Sugarcane Yield in Brazilian Long-Term Experiment

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In Brazil the sugarcane crop is cultivated in almost 9.2 million hectares, which 60% of plantations are concentrated in Sao Paulo state. The government of Sao Paulo State has mandated that in flat (less than 12% of slope) sugarcane production areas feasible for mechanized harvest, the use of fire to reduce biomass before harvesting must be banished completely up to 2014. Due to this social pressure, nowadays the majority of fields are harvested without burning (3.38 million hectares), then a great amount of straw (15 Mg of dry matter) is deposited over the soil. The benefits of sugarcane straw are already well known, such as; to control the soil erosion, to control of weeds, to increase the soil organic matter and to increase the soil moisture. However, after 5 harvests when the sugarcane field is re-planted, the straw increase the cost with tillage in almost 30%. Despite the possibility to use the straw to produce cellulosic ethanol, is desirable the adoption of conservation agriculture principles in order to maintain the sustainability of system; comprising minimum mechanical soil disturbance, trash retention and legume rotation. Furthermore, producers must wonder if the surface application of lime materials will be as effective as incorporation at reducing soil acidity in no-tillage. In order to study the interaction of lime rates and soil managements, it was installed a permanent trial in 1998, using a commercially green harvested sugarcane field at its 5th ratoon, which had been planted in 1993. This long-term experiment was set up in an eutrophic Clayed Rhodic Hapludox (Oxisol) located at Experimental Station of IAC/APTA, Ribeirao Preto city, Brazil. It was adopted a randomized complete block design in a split-plot scheme, with four replications. The main plots two soil managements, conventional tillage (moldboard plowing, 30 cm depth followed by two applications of offset disk harrow) and no-tillage (crop residues left on its surface after spraying the area with glyphosate) and the subplots consisted of four dolomitic limestone (0; 2,0; 4,0 and 6 Mg ha-1). The limestone was applied at three times (in 1998, 2003 and 2008), even before planting soybean as a crop rotation, followed by sugarcane crop. At the beginning of the experimental period, soil chemical characteristics were determined (at 20 cm-depth) and the main results were pH (0.01 M CaCl2) = 4.8; SOM = 31 g dm–3 and base saturation (V) = 41 %. It has been evaluated the agronomic and technological characteristics of soybean and sugarcane; as well as the changes on the physical and chemical soil properties. Here it shows the results from the current sugarcane variety IACSP95-5000 and some results about soil attributes before and after planting in 2010.

The results of soil analysis before and after planting the current sugarcane variety showed that the effect of liming on pH and base saturation, could be verified just in the uppermost layers (0-10 cm) in the no-tillage, but below 20 cm, conventional and no-tillage have presented the same linear trend for all soil chemical attributes evaluated (cations exchangeable capacity, levels of phosphorus, calcium, potassium and magnesium). Nevertheless, the non-exchangeable Ca and Mg contents increased 14 times in no-tillage at the uppermost layer. The highest bulk density it was observed at layer 10-20 cm depth in no-tillage (1,3 g cm-3), but no significant different of conventional (1,25 g cm-3) and no difference it was observed before and after harvesting of the current sugarcane variety. Regarding the seven first years, the carbon stock in conventional tillage was 0,67 and in the no-tillage was 1,63 Mg C ha year-1 (Segnini et al., 2013). Samples collected in 2010 showed 5,5 Mg C ha-1 higher in no-tillage from soil surface to 70 cm depth. Considering the last three harvests, there was a quadratic response (r2 = 0,95*) with the highest stalk yield at the lime rate 2,0 Mg ha of limestone in no-tillage system.

In conclusion, the association of green harvested sugarcane system with no-tillage was effective, to reduce the soil acidity below the point of placement, to increase the carbon stock at 70 cm layer, to increase in average the stalk yield in 10 Mg ha-1. It seems to be the best example of sustainable crop system to produce energy and food.

Keywords：*bioethanol, conservation agriculture, straw, carbon stock, Saccharum officinarum*

P1-47

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Biogas By-Product Digestate: A New Amendment that Causes New Soil Alterations and Requires New Approaches for Understanding

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The use of bioenergy crops can manifest itself in many different ways, among others by means of anaerobic digestion. Although its application may be locally restricted, e.g. to parts of Europe, these areas are strongly influenced by both the crop production as well as the consequent use of the by-products, namely the anaerobic digestate. While the methane gas is used for generating electricity, the digestate seems to be a cost-effective fertilizer of organic origin with almost mineral character, especially regarding nitrogen. However, as the use of crops for anaerobic digestion has evolved enormously within a short period, not all aspects of the use of the digestate as a fertilizer have been taken into account recently.

Our research thus focusses on the effect digestates may have on soils amended with digestates for fertilization. Emphasis is put both on the direction of the impact as on the intensity with the help of different digestates. While the impact on soil nutrient content is already part of the recent research, the impact on soil physical parameter remains widely unknown. Thus, we investigated the changes in soil structure and stability. Regarding the first aspect, micro-scaled infiltration and dispersed clay content were measured, while the physicochemical parameters of rheometry allowed for the quantification of a micro-scaled shear resistance. Interactions of mechanical and hydraulic processes were accounted for by the determination of hydrophobicity and the analysis of 1:1 soil solution viscosity and surface tension. The measurements were completed by chemical analysis of the soil and soil solution. All the data are used to explain interdependencies and interactions in the wake of digestate use.

With our results we want to draw attention to the fact that digestates can increase hydrophobicity due to organic substances of amphiphilic character and change the pH in interaction with the nitrogen cycle. Furthermore, they also influence the soil structure due to monovalent cations, e.g. sodium. Additionally, the soil solution's viscosity was linked to the soil solution's surface tension and also the content of dissolved organic carbon. We sum up our findings in a comprehensive description of ongoing processes in soils after digestate amendment that enable a sustainable fertilizer management.

Keywords：*biogas, anaerobic digestate, soil physical properties, soil physico-chemical properties*

P1-48

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Soil Microbial Communities and Nitrous Oxide Emissions in a Corn-Based Biofuel Cropping System

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Recently, the Canadian government has released a biofuel strategy as a way to combat the country's dependence on fossil fuels. The increased demand on the agricultural sector to provide plant biomass for food, animal grain, as well as biofuels is challenging. A major environmental issue associated with biofuel cropping systems is the long-term sustainability of soil health, because of the large volumes of agricultural residues that are removed from fields. These crop residues are vital resources for sustaining soil productivity and an important source of nutrients. The taxonomic diversity of soil microbial communities is intrinsically linked to the quality of crop residue that is returned to soils. The soil microbial community drives important biogeochemical processes, such as crop decomposition, nutrient mineralization and denitrification, therefore alterations in quality and quantity of residue in biofuel agro-ecosystems may be of functional significance. The impact that residue removal has on soil microbial community dynamics and microbially-driven processes, such as greenhouse gas (GHG) emissions remains poorly understood. The objective of this research was to provide new knowledge linking soil microbial processes with key soil ecosystem services, including GHG emissions and C sequestration. A long term field study a corn-soybean-wheat rotation has been grown under contrasting agricultural management practices on four 1.5 ha fields. Two fields had conventional tillage management (CT), and two fields had no-tillage management (NT). Starting in November 2008, a differential crop residue management was applied to the fields with two continuing to have residue returned (+R), and two having residue removed or no residue returned (-R). N_2O fluxes were measured from the soil half hourly as atmospheric gas samples using a tunable diode laser trace gas analyzer. Soil samples were collected over the growing season at spring tillage, crop physiological maturity, crop senescence, post biomass harvest and fall tillage treatment, non-growing (frozen soil), spring thaw, and pre-seeding. From the soil samples, DNA was extracted and a quantitative PCR approach was used to enumerate abundance of nitrifying and denitrifying communities. The removal of crop residues resulted in significantly lower DOC and lower inorganic nitrogen. Daily N_2O fluxes varied between treatments within the year. A major emission of N_2O occurred in association with spring thaw, and significant differences were observed between fields with the highest emissions from the CT field with residues removed(-R). All nitrifying and denitrifying genes (amoA, nirS, and nosZ) were successfully quantified in both fields throughout the study. Copies of the amoA gene were higher in the +R compared to the -R fields. Gene quantities of nirS indicated that a population of denitrifiers containing the nitrite reductase gene was present at similar levels in both fields. Significant differences in the population of denitrifiers containing nosZ were evident, with nosZ gene copies being more abundant in CT+R field. The results identify both changing abundance of microbial populations in the soil environment, and provide ecologically meaningful associations between changes in abundance and N_2O emissions in situ. These results contribute to the development of a scientific basis for choosing sustainable cropping systems that are productive and provide biomass for biofuel systems while minimizing their environmental impact through decreasing their contribution to GHG emissions and maximizing C sequestration.

Keywords：*nitrous oxide, denitrification, nitrification, quantitative PCR*

P1-49

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Water Quality Improvement, an Important Consideration to Delineate Sustainable Fertilization and Harvesting Strategies for Cellulosic Bioenergy Crops

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There has been increased interest in the optimized fertilization and harvesting of perennial crops for maximizing biomass yields since President Bush's proposed mandate for 35 billion gallons of ethanol by 2017, mostly from cellulosic sources. The goal so far has been to 'increase biomass yield per unit of fertilizer' application. Alongside there has also been increased concern about water quality and nitrate leaching with increased acreage under biofuel crop production. This study provides an alternative analysis and strategy to manage fertilization and harvesting in a biofuel crop- switchgrass, to 'minimize nitrogen loss per unit of biomass' produced.

We used field based monitoring in switchgrass (Panicum virgatum L) and modeling (SALUS; System Approach to Land Use Sustainability) to estimate nitrogen (N) pools and fluxes in a gradient of N-fertilizer applications ranging from 0 to 196 Kg/ha (0, 28, 56, 84, 112, 140,168, and 196 kg N ha-1) and two harvesting scenarios, one (fall) and two (summer and fall) harvests per cropping season. The study site was located in southwestern Michigan at the Great Lakes Bioenergy Research Center (GLBRC) intensive site for sustainability research. Annual precipitation received in the area is ~890 mm, of which approximately half falls as snow. Soils are mesic Typic Hapludalfs of Kalamazoo series and are developed on glacial outwash. Switchgrass was planted in 2008, and no nitrogen fertilization was done during establishment year. Since 2009 nitrogen fertilizer was applied only once per year. In 2009, granular 46% urea was applied. In subsequent years, liquid 28% Urea Ammonium Nitrate (UAN) was applied. Biomass was harvested in late fall annually. Nitrate (NO3-) leaching below root zone (1.0 m from surface) was determined by measuring concentrations in soil pore water and multiplying it with downward water flux (drainage) to ground table. Soil pore water was extracted at intervals (weekly to fortnightly except when ground was frozen) using low tension porous ceramic cup based tube samplers installed at a 45º angle. Water flux to ground table was modeled (daily time step) using the Systems Approach for Land Use Sustainability (SALUS) model (Basso et al. 2006, Ritchie and Basso 2008) which accommodates management practices, water balance, soil organic matter change, nitrogen and phosphorus dynamics, heat balance, and plant growth and development. The soil water balance module is based on CERES models (Ritchie 1998) with revision for infiltration (Basso et al. 2008), soil water export (Suleiman and Ritchie 2004), evaporation (Suleiman and Ritchie 2003), and runoff (Basso et al. 2008). Among the different treatment, nitrate leaching increased exponentially with increase in fertilizer application. Higher fluxes were associated with time of fertilizer application and wet periods. Relating pore water nitrate, nitrate fluxes and biomass yield to plant nitrogen uptake revealed optimum fertilizer rate for switchgrass, in the south west Michigan region, to differ with the establishment phase. Yield responses to fertilizer application also varied from 2009-2011. Responses to N-fertilization were observed up to 156 kg/ha in 2009 and up to 68 kg/ha in 2010 (2008-2010 were establishment years). No significant yield differences were observed in 2011 (fully established crop). Harvesting strategies affected nitrate fluxes primarily due to changes in drainage and evapo-transpiration. The Findings suggest that nitrate loss in perennial bioenergy crops can be significantly mitigated by adopting fertilizer rates which provide minimum losses per unit of biomass produced. Nitrogen fertilizer use in agriculture, for food or energy, cannot solely be evaluated it terms of increased production. Achieving sustainability would require evaluating strategies to maintain environmental quality with economic returns. The strategy to 'minimize nitrogen loss per unit biomass' meets both goals.

Keywords：*Bioenergy, sustainability, nitrate, leaching, drainage*

P1-50

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Biomass Production of Prairie Cordgrass Using Urea And Kura Clover as a Source of Nitrogen

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In established perennial grass biomass production systems, application of nitrogen (N) fertilizer can be one of the greatest expenses, from both a financial and environmental perspective. The objective of this study was to determine N fertilizer replacement value of kura clover (Trifolium ambiguum Bieb.), a rhizomatous N-fixing legume, for biomass production of prairie cordgrass (Spartina pectinata Link.), a native warm-season grass, on marginal land.

Field plots were established at four diverse environments in Illinois (IL), Minnesota (MN), South Dakota (SD), and Wisconsin (WI) in 2010. Kura clover was transplanted on 30-cm centers in the field in all treatments in which it was a component. Prairie cordgrass seedlings were transplanted within the kura clover on 60, and 90-cm centers. Monoculture prairie cordgrass stands were established at the same population densities of mixed stands and fertilized with 0, 75, 150, and 225 kg N ha-1 to determine fertilizer N replacement value of the kura clover.

Biomass at each location was harvested in the fall in 2011 and 2012. Yields varied by location. Yield of prairie cordgrass and kura clover mixtures were lower than that of prairie cordgrass monocultures at all N fertilizer rates and all locations in 2011 and 2012. Although yield tended to increase with nitrogen application, response of prairie cordgrass to nitrogen was not consistent across locations in 2011 and 2012. Prairie cordgrass planted on 60-cm spacing was always higher yielding than when planted on 90-cm spacing in 2011; however, in 2012 this yield difference was reduced. In 2012 yield of prairie cordgrass planted on 60- and 90-cm spacings was similar at all locations except for WI.

P1-51

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Factor Analysis of Methane Production Potential From Crop and Livestock Biomass

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Due to the current efforts put into reducing the amount of CO2 to cope with the climate changes, interests about biomass resources are increasing. Biomass resources are the energy which can continuously be circulated and possess carbon neutral properties as they do not increase the amount of CO2. In terms of biomass conversion technology, direct combustion(pellet, chip), diverse energy conversion technology such as thermochemical conversion (hydrothermal experiment, carbonization, hydrothermal carbonization etc.), and biological conversion(biogas, bio-ethanol) are being applied, but in case of biomass wastes occurring in the agricultural field, biogas technology is being evaluated as the most commercialized technology. Anaerobic digestion technology which apply the domestic agricultural biomass are being evaluated as in the early stage of supply in the empirical commercialization, and even though about 25 locations are currently in-operation, all the facilities are localizing piggery slurry and food wastes as the raw material. Therefore, this study researched and calculated the occurrence units of biomass waste from 36 types of vegetables and animals in the agricultural field and analyzed the anaerobic digestion characteristics according to each biomass characteristic. Additionally, through the analysis of biochemical methane potential which applies the batch anaerobic reaction, anaerobic organic matter decomposition efficiency and biochemical methane potential of various agricultural biomass were analyzed. In order to do so, foreign biochemical methane potential standard method(Germany VDI4630, America ASTM) were examined and standard method needed for the evaluation of anaerobic decomposition efficiency of vegetable and animal raw materials were developed and established. Additionally, agricultural anaerobic microbial reactions were analyzed through the kinetics analytical techniques and influence factors of anaerobic digestion through statistical analysis were derived and analyzed. As a result, biochemical methane potential of agricultural biomass waste was displayed as 0.220～0.646 Nm3/kg-VSadded for animals and 0.207～0.427 Nm3/kg-VSaddedfor vegetables and displayed about 30~70% of decomposition efficiency compared to analytical biochemical methane potential. In terms of anaerobic decomposition efficiency of organic matters, regulation VDI4630 and method of constraint suggested in this study have been compared for animal raw material. It has been displayed that it can increase the accuracy to the maximum of 0.9%～3.2% and the optimal S/I ratio of anaerobic digestion was evaluated as 0.5. Furthermore, as a result of conducting statistical analysis, representing factors which cause great influence on anaerobic digestion were displayed as crude fat(either extract, EE), crude fiber(crude fiber, CF), nitrogen(N), and copper(Cu). It has been evaluated that crude fat acts from lag phase time, crude fiber acts from the decrease of biochemical methane potential, and nitrogen and copper act through restraints of anaerobic digestion.

Keywords：*Biomass, Anaerobic digestion, Biochemical methane potential, Biogas, Methane*

P1-52

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Nitrous Oxide Emission, Nitrate Leaching, and Nitrogen Removal Influenced by Nitrogen Fertilization From Production of Switchgrass in South Dakota, USA

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Understanding the effects of nitrogen (N) fertilization on nitrous oxide (N2O) gas emission, nitrate (NO3-) leaching, and N removal of switchgrass is an important consideration when using this grass as a biomass feedstock. The objective of this study was to determine the effect of three N fertilization rates (0, 56, and 112 kg N ha-1 using urea as the N source) on N2O emission, NO3- leaching, and N removal of switchgrass planted in June 2008, and evaluated from 2010 through 2011 in Bristol, South Dakota, USA. Biomass yield increased with N rate up to 56 kg ha-1 in 2010 and 2011, but no further yield increases were seen with additional N. While there was no significant increase in N removal of switchgrass with N fertilization in 2010, N removal significantly increased with increasing N fertilization rates in 2011. In contrast, cumulative N2O emission significantly increased with N fertilization rates in 2010 but there was no significant increase in cumulative N2O emission in 2011. Cumulative NO3- leaching with N fertilization at 56 kg N ha-1 was similar to that at 0 kg N ha-1, but there was a substantial increase at 112 kg N ha-1 in 2010. There was no significant difference of cumulative NO3- leaching with N fertilization in 2011. Overall, excessive N fertilization (above 56 kg N ha-1) of switchgrass led to increased N2O emission, NO3- leaching, and harvested N without a significant increase in biomass production.

Keywords：*Switchgrass, Nitrous oxide, Nitrate leaching, Nitrogen removal, Nitrogen fertilization*

P1-53

[IDS10] Impact of Bioenergy Cropping on Soils and the Environment

Exploring Metal(loid) Accumulation Ability of Miscanthus Sacchariflorus Genotype Geodae-Uksae; Implication to Application for Phytoremediation

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Miscanthus is one of the most promising bioenergy crops due to its potential for high biomass production. Thus collection and development of Miscanthus spp. have been conducted in Korea recently. A new Miscanthus sacchariflorus genotype named 'Geodae-Uksae 1' was collected from communities of Miscanthus spp. Its biomass yield was 50% higher than normal M. sacchariflorus.

Although Geodae-Uksae provides effective biomass yield and potential for bioenergy, researches on its phytoremediation potential for heavy metals and other pollutants in soils are rare. Therefore, the current study was carried out to examine the ability of Geodae-Uksae for heavy metal(loid) (Cd, Cu, Pb, Zn, and As) accumulation in its root and shoot for phytoremediation. The experiments were carried out with two different parts including hydroponic culture and soil based-pot experiment using Miscanthus cultivars, 'Geodae-Uksae 1, 2, 3' (G1, G2, G3) and 'Cosmopolitan' (Co). In the hydroponic culture study, plants (G1, G2, G3) were grown using Hoagland's solution (NH_4^+ 1.0, K^+ 6.0, Ca^{2+} 4.0 mM) with four different levels of heavy metals (Cd, Cu, Pb, Zn, and As) for 8 weeks. The treated concentration ranges were 0 to 0.8 mg L^{-1} for Cd, 0 to 2.0 mg L^{-1} for Cu, 0 to 1.0 mg L^{-1} for Pb, 0 to 8.0 mg L^{-1} for Zn, and 0 to 4.0 mg L^{-1} for As. The pot experiment was conducted by growing plants (G1, G2, G3, Co) with artificially contaminated soil in a greenhouse for 12 weeks. The heavy metal concentration in the spiked soils ranged 0 to 25.4 mg kg^{-1} for Cd, 39 to 1030 mg kg^{-1} for Cu, 12 to 1013 mg kg^{-1} for Pb, 116 to 1551 mg kg^{-1} for Zn, and 6.6 to 125 mg kg^{-1} for As, respectively. After cultivation for 12 weeks, both plant tissue and soils were analyzed for heavy metal concentrations. The ability of each cultivar and species for heavy metal accumulation were determined using the total content of metal in the whole above ground tissues through multiplying the weight of biomass by the metal concentration in the tissue.

In hydroponic culture experiment, G1 showed the highest accumulation for Cd at 3.5 mg per plant. For copper, G2 accumulated the highest amount at 7.5 mg per plant which was more than twice of that determined in G1 and G3. The lead content of G3 (450 μg per plant) was higher than those from G1 and G2, while the accumulated Zn content was higher with G2 and G3 (5.7 and 5.6 mg per plant, respectively) than G1. No significant difference in As content was found among the genotypes. In the pot experiment, G1 and G3 appeared to accumulate higher metal contents in the shoot than G2 and Co with being tolerant at high concentration of metals in soils.

Keywords: *Miscanthus, bioenergy crop, phytoremediation, metalloid*

P1-54

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Assessment of Potentially Toxic Element Pollution in Soils And Rice (oryza Sativa) in Selected Paddy Soil of Iran

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The accumulation of toxic heavy metals in rice grown in paddy soil may lead to health disorder in recent years. Accordingly, the quantities of heavy metals (Cd, Pb, Ni and Zn) were determined in soil, water and different parts of rice (Oryza sativa) plant sampled from Lenjan region, located nearby industrial area in Isfahan province. Results revealed that heavy metals concentrations in water samples were below standard levels except Ni, in which the course of their long-term cumulative effects should be considered. The paddy soil in Lenjan region was most severely contaminated by Cd, followed by Ni, Pb and Zn. The levels of Cd, Pb, Ni and Zn were above the standard limits in this area. The BAF for Cd was maximal compared to other metals at the different regions. Most of the heavy metals studied were found to accumulate mostly in roots of paddy plants and all of them had higher concentrations than the standard level, while other parts including the stems and grains contained high concentrations of Cd and Pb were observed in all regions.

Keywords：*Heavy Metal, Lenjan, Pollution, Rice, Transfer Factor*

P1-55

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Heavy Metal Pollution of Mining District in Guangdong Province and its Control Strategies

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1. Introduction

Guangdong province, in southeast China, is rich in mineral resources and belongs to the subtropical monsoon type climate. There are dozens of mines in Guangdong province. Dabaoshan polymetallic sulfide mine and Lianhuashan tungsten mine are the two of largest-scale mines. Most of minerals are polymetallic sulfide ores including pyrite, wolframite, scheelite, arsenopyrite, magnetite, chalcopyrite, chlorite and feldspar. Arsenic and cadmium are the major associated elements in mineral ores. The mining and smelting processes would lead heavy metal pollution to local and regional environment. As and Cd are the most serious contaminated elements in environment. The bioavailability of these toxic elements was very high mightily due to the low pH value and organic matter content in the red soil. Hence, proper measures on As and Cd pollution management and control in the mining area should be formulated and implemented immediately.

2. As and Cd combined contamination at an abandoned Tungsten mine, southern China

Lianhuashan tungsten mine (23°38′30.4′′N, 116°50′4.7′′ E.), was one of the biggest tungsten mines in Guangdong Province, southern China. Extensive environmental study showed that As concentration in agricultural soils ranged from 3.5-935 mg kg-1 with the mean value of 129 mg kg-1. In addition, As concentration reached up to 325 μg L-1 in the groundwater, and the maximum As concentration in local food were 1.09, 2.38 and 0.60 mg kg-1 for brown rice, vegetable and fish samples, respectively. Health impact monitoring data revealed that As concentrations in hair and urine samples were up to 2.92 mg kg-1 and 164 μg L-1, respectively, indicating a potential health risk among the local residents. Beside As pollution, Cd was another heavily contaminated element. The Cd concentration in the agricultural soil samples was ranged from 0.10-2.20 mg kg-1, and the Cd concentration in 26.4% soil samples over the limitation of agricultural soil environmental quality standards of China

3. The use of calcium peroxide (CaO2) as a process applied to Arsenic contaminated soil

To reduce As bio-available and uptake in celery, calcium peroxide (CaO2) was applied as a stabilizer. In pot experiment, CaO2 applied at 2.5 and 5 g kg-1 significantly increased celery shoot weight and decreased shoot As accumulation, which was ascribed to the formation of stable crystalline Fe and Al oxides bound As and the reduction of labile As fractions in the soil. The labile As fractions were pH dependent and it followed a “V” shaped profile with the change of pH. In field experiment, the dose of CaO2 application at 750 kg ha-1 was optimal and at which the celery was found to produce the highest biomass (63.4 Mg ha-1) and lowest As concentration (0.43 mg kg-1). CaO2 probably has a promising potential as soil amendment to treat As contaminated soils.

4. Silica foliar application to alleviate As or Cd toxicity to rice

Pot or field experiments were conducted to investigate the effects of foliar application of silica sols on the alleviation of Cd or As toxicity in contaminated soil to rice. Results showed that the foliar application of silica sols provided an effective alternative to reduce Cd or As accumulation in the grains of rice grown in contaminated soils. Compared with the soil application of silica, foliar application was more effective and economical. The sequestration of Cd or As in cell wall or increasing activity of antioxidant enzymes by silica foliar application was probably the reason of foliar Silica sol application to alleviate the toxicity and accumulation of Cd or As in the grains of rice.

Keywords：*Arsenic, Cadmium, Amendment, silicon*

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[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Effects of the Alkaline Material Addition on Chemical Fractions of Heavy Metals in a Contaminated Soil Under Flooded and Non-Flooded Conditions

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In situ immobilization of heavy metals using soil amendments can be a speedy and inexpensive tool for remediation of heavy metal-contaminated soils, and thus many efforts have been made to establish this approach. However, as far as we know, there are few reports examining the effects of soil amendments on heavy metal forms under anaerobic conditions such as in rice paddies. In the present study, we examined the effects of alkaline material addition on heavy metal forms in flooded soils, and compared the results to those of soils under aerobic conditions.

A heavy metal (Cd, Pb and Zn)-contaminated Illuvial Paddy soil and an alkaline material (Mitsubishi Materials Co., Tokyo) mainly made of CaCO3 and CaSO4 were used in this study. Air-dried soil sample was incubated under the following four conditions for 90 days: i) non-flooded, ii) non-flooded + alkaline material addition, iii) flooded, and iv) flooded + alkaline material addition. The pH and Eh were determined after 1, 7, 14, 30, 60 and 90 days of incubation, and heavy metals were fractionated using a sequential extraction procedure. Acid volatile sulfide (AVS) was measured before incubation and after 60 days of incubation under flooded conditions. Also, samples incubated for 90 days under flooded conditions were used to investigate the influences of air-drying at 22 °C for 3 days and oven-drying at 65 °C for 10 hrs on heavy metal forms in the soil.

Addition of the alkaline material significantly increased the soil pH (from 5.4 to 7.0) and decreased the exchangeable fraction of all the metals examined in the soil samples ($P < 0.01$), compared to the unamended ones. In contrast, the addition of alkaline material significantly increased the inorganically bound fraction for Cd and Zn ($P < 0.05$). Effect of reductive condition on mobility of heavy metals was different among heavy metals. Exchangeable fraction of Cd and Pb were decreased with decreasing Eh under flooded condition without soil amendment, and only Cd had a significant positive correlation with Eh. It is known that Cd has higher affinity for sulfide than Pb and Zn. Because sulfate ion concentration of the soil sample before incubation was low compared to the other agricultural soils in Japan, the content might not be sufficient for the formation of sulfides with metals other than Cd. Metal sulfides would be fractionated into organically bound fraction, but this fraction did not increase with decreasing Eh for all the metals. Hence the decrease of Cd and Pb in exchangeable fraction with time under flooded condition without alkaline material may be due to the sulfide formation, but the amount was not so large. Like for the exchangeable fraction, metal distribution in the other fractions, especially for occluded and residual fractions, was also remarkably different between flooded and non-flooded conditions. In particular, Pb concentration was significantly lower in inorganically bound, organically bound, and occluded fractions under flooded condition, compared to those under the non-flooded conditions, whereas the opposite trend was observed for the residual fraction. The ratio of exchangeable fraction of heavy metals under flooded conditions were increased by both air drying and oven drying irrespective alkaline material addition. However, also after drying, the ratio of exchangeable fractions for Cd and Zn in samples with alkaline material were much lower than those in samples without alkaline material. From these results, it was shown that the alkaline material is effective in immobilization of heavy metals also under flooded conditions. Although we did not investigate the uptake of heavy metals from soils by plants, application of the alkaline material may be effective in reducing accumulation of heavy metals in plants (e.g., rice).

Keywords：*alkaline material; paddy soil; heavy metals*

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[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Fractionation Of Residual Zn in Some Mazandaran Prov. Soils -Iran

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This experiment was conducted to study different chemical forms of Zn (native and applied Zn) in some selected paddy soils of Mazandaran -RAN. Twenty soil samples with the widest range of physicochemical properties, especially with respect to the levels of available Zn and P were selected out of some 40 surface soils (0-30 cm) collected in rice paddies of east Mazandaran - IRAN. A randomaized completely block factorial experiment (20×2) with two levels of Zn (0 and 10 µg Zn/g soil as ZnSO4.7H2O) and three replications was carried out on 20 soils in the greenhouse.

Different chemical forms of Zn i.e., exchengable, sorbed, organic, carbonate, and residual were fractionated by 0.5M KNO3, XH2O, 0.5M NaOH, 0.05M Na2EDTA and 4M HNO3 extractants, respectively in order to determine the amount and of Zn fractions.The extracted Zn was determined by atomic absorption and ICP-AES instruments.

The results showed that KNO3-Zn (exchangeable Zn) was determined as non detectable (ND) zinc. Total Zn, in untreated soils (native Zn) ranged from 49.3 to 84 µg/g with a mean of 63.4 µg/g. Distribution of native Zn in different soil chemical fractions were in the fallowing order:

Residual >>> Carbonate> Organic> Sorbed> Exchangeable

Most of the applied ZnSO4 was converted to residual and carbonate forms as much as 40.4 and 34.9 percent respectivily. Redistribution of Zn fractions as affected by 10 µg Zn/g soil were in the fallowing order:

Residual > Carbonate> Organic> Sorbed> Exchangeable

Keywords： *Zn, Carbonate, Exchengable, Organic, Sorbed, Mazandaran.*

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[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Variation in the Grain Iron and Zinc Minerals Among Promising Low-Grain Cadmium Rice (oryza Sativa L.) Cultivars

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Mineral nutrition of iron (Fe) and zinc (Zn) are important for human health. However, selection for rice (Oryza sativa L.) cultivars that have low cadmium (Cd) accumulation in grains would lead to the changes in nutrient concentration and composition of grains. Therefore, this experiment was conducted to study the interactions of Cd with the Fe and Zn in grains of 4 rice cultivars (RD5, RD15, Khao' Niaw Ubon 1 and Khao' Niaw Ubon 2) that had previously been identified as low-grain Cd accumulations, together with the prevailing cultivars (Khao Dawk Mali 105 and RD6). Among 6 rice cultivars tasted, there were significant differences in Cd (0.01 to 2.09 mg kg-1 grain) and Zn (10.2 to 27.5 mg kg-1 grain) concentrations in their grain. However, there was no significant difference in Fe (4.77 to 36.9 mg kg-1 grain) concentrations. Significant positive correlations between grain Cd concentration and Zn was detected in the prevailing cultivars ($r = 0.471$, $p < 0.01$). However, there was no correlation between grain Cd and Zn concentrations in a promising low-grain Cd rice cultivars ($r = 0.008$). A similar result was also show by Cd and Fe ($r = -0.065$). Present results suggest that it possibility to screening rice cultivars with low-grain Cd along with high Fe and Zn contents.

Keywords：*rice, cadmium, zinc, iron, cultivar*

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[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Effect of Organic Matter Amendment on as Release in Soil Solution and Accumulation by Paddy Rice Grown in As-Contaminated Paddy Soils

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Previous studies have shown that organic matter (OM) in the soil could affect arsenic (As) mobilization and bioavailability. The increase of As uptake into rice plants has become a potential dietary risk to human health. This study investigates the effects of organic matter amendments on the As release in the soil solution and accumulation in paddy rice grown in As-contaminated soils. Rice (Oryza sativa L.) cultivar (Taikeng 9, TK9) and three soils (Penchen (Pc), Chengchung (Cf), and Guandu (Gd)) with different characteristics collected from Taiwan were used in this study. Pc and Cf soils were spiked with 0 and 150 mg As kg^{-1}, and Gd soils was a geogenically As-contaminated soil (soil As concentrations: 28 and 135 mg As kg^{-1}). The soils were amended with, 0% (control), 1% and 4% organic matters (soybean meal (SB), cattle-dung compost (CD), and sugarcane dregs compost (SC)). The results of soil flooding incubation study indicated that organic matter applications enhanced the release of As into soil solutions, and the extent of enhancement was higher in SB treatments than CD and SC treatments in three tested soils, due to the concentrations of dissolve organic carbon (DOC) was higher in the SB application. The DOC in soil solutions can enhance the As mobilization through the lowering redox potential, compete adsorption with As on soil minerals and forming soluble DOC-As complexes. The As concentrations in soil solutions of Cf soils was higher than Pc and Gd soils, and the As concentration in soil solution of 4% SB treatment is above 15 mg L^{-1}, because Cf soils had high pH and low contents of clay, iron, and aluminum oxides. The accumulation of As in rice plants (roots and shoots) was enhanced by organic matter amendments compared with control treatments, and the SB treatments had the higher As accumulation due to the higher As concentrations in soil solutions. In addition, the rice plants grown in As spiked Cf soils amended with 4 % SB and SC treatments was dead, possibly resulting from high As concentrations in soil solutions and thus causing serious As phytotoxicity.

The results of this study indicate that organic matter amendments could enhance the release of As from soils and As uptake by rice plants, especially for application of easily decomposable organic matters (such as SB). This effect of application of organic matter on As release into soil solutions could be more notable in soils with high pH and low As sorption capacity (such as Cf soil), thus resulting in the increase of As toxicity to rice plants. Therefore, it is important in evaluating the properties of organic matters and soils carefully before adding organic materials into As-contaminated soils.

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[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

The Effects of Phosphate Application on as Release into Pore Water and Uptake by Rice Seedlings Grown in As-Contaminated Paddy Soils

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Inorganic arsenic (As) is identified as non-threshold, class 1 human carcinogen. Rice consumption is a major route of As exposure to human for the population of worldwide in recent years. Phosphorus (P) is the essential nutrient for plant growth. Phosphate is an analogue of arsenate. It could compete sorption sites on soil minerals with As and also transport pathways of As uptake into rice plants from soils. Therefore, this study investigates the effect of phosphate application on the As release in pore water and uptake by paddy rice grown in As-contaminated paddy soils.

Rice (Oryza sativa L.) cultivar (Taikeng 9, TK9) and three soils (Penchen (Pc), Chengchung (Cf), and Guandu (Gd)) with different properties were collected from Taiwan and used in this study. Pc and Cf soils were spiked with 0 and 80 mg As kg^{-1}, and Gd soils was a geogenically As-contaminated soil (soil As concentrations: 13 and 91 mg As kg^{-1}). Phosphate were added as calcium dihydrogenphosphate. Due to the differences in P retention capacity among three tested soils, Cf and Pc soils were amended with 0, 6, 12, 30 and 60 mg P kg^{-1}, and 0, 8, 16, 40 and 80 mg kg^{-1} for Gd soils. Rice seedling were pre-cultivated in soil for 2 weeks and then transplanted to As-contaminated soil and grown for 50 days. The concentrations of As, As species, P and Fe in soil pore water and plant tissues were measured.

The results indicated that the concentrations of As and Fe in soil pore water increased with growth time, due to the reductive dissolution of iron oxides of soils. It also showed that the concentrations of As released in pore water were enhanced by the amounts of phosphate amendment, resulting from the competitive adsorption between P and As on soil minerals. The extent of enhancement by P application was significant in Cf soils, but there was not significant in Gd and Pc soils, because Cf soils had high pH and low contents of clay and iron oxides. The accumulation of As in rice plants (roots and shoots) was enhanced by phosphate amendments compared with control treatments, and the biomass (roots and shoots) and shoot height of rice plants grown in As spiked Cf soils amended with the highest phosphate treatments (60 mg kg^{-1}) was lower than other phosphate treatments, possibly resulting from high As concentrations in soil pore water and thus causing serious As phytotoxicity. The results of this study indicate that the application of phosphate could enhance the release of As from soils and As uptake by rice plants, especially for the soils with high pH and low contents of iron oxides. Therefore, it is important in evaluating the application rates of phosphate fertilizer and soil properties before adding phosphate fertilizer into As-contaminated soils.

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[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Cadmium Uptakes By Different Rice Cultivars Related To Iron Nutritional Levels In Plant And Iron Plaque Formation

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Paddy rice (Oryza sativa L.) is a major staple crop in Asia and Cd accumulation in paddy soil posing risk to the food safety of rice has been much concerned. In the present study, rice plants were cultivated in hydroponics and under different Cd exposures, and then the relations of iron plaque formation and iron nutritional levels in plant to Cd uptake and translocation were investigated. Two japonica rice cultivars, Taikang 9 (TK9) and Taoyuan 3 (TY3), bred in Taiwan were used for testing. The cultivars TK9 and TY3 were suggested to represent high and low capability of iron plaque formation, respectively. Rice seedlings, which were in the morphological development stage with five leaves completely emerged, were subjected to the levels of 0, 1, 2, 5, and 10 μM Cd. After the experiment period about two weeks, the plants were harvested to measure plant height, root length, and dry weight for illustration of plant growth responses to Cd exposures. Dithionite-citrate-bicarbonate (DCB) extracted Fe and Cd (from root surfaces) and plant Fe and Cd (in root and shoot tissues) were determined for assessment of iron plaque formation, plant iron distribution, and Cd uptake and translocation in rice plant.

In the results, there was not any adverse effect of Cd exposure levels ranged from 1 to 10 μM on rice seedling growths for both TK9 and TY3 cultivars. The Cd uptakes by rice plant were significantly enhanced by increase of Cd exposure levels. For TK9, the Cd concentrations in root and shoot were ranged from 4.23 to 102.55 mg kg-1 and from 1.37 to 14.04 mg kg-1, respectively. For TY3, the maximum values of Cd concentrations in root and shoot however were 11.80 and 2.88 mg kg-1, respectively. Compared with TK9, TY3 took up much less Cd in plant. In addition, for TK9 and TY 3, the Fe concentrations in root were significantly increased with increase of Cd exposure levels. The Fe concentrations in shoot for TY3 were also significantly increased by Cd exposures. However, the Fe concentrations in shoot for TK9 were significantly decreased with increase of Cd exposure levels. And consequently the total uptakes of Fe (i.e. sum of Fe in root and shoot) by TY3 (ranged from 47.39 to 53.73 μg pot-1) were higher than those by TK9 (ranged from 26.17 to 39.27 μg pot-1) under Cd exposures. Moreover, the DCB-extracted Fe concentrations for TY3 were ranged from 918.31 to 1112.29 mg kg-1 due to Cd exposures; however, those for TK9 were ranged from 818.22 to 934.52 mg kg-1. Although TK9 was suggested to have a higher capability of iron plaque formation than TY3 does, TK9 produced less iron plaques on root surface than TY3 did, as given Cd exposures.

Therefore, while under Cd exposure levels ranged from 1 to 10 μM, TY3 accumulated more Fe in plant and produced more iron plaques on root surface than TK9 did. This could be associated with the results showing Cd uptakes by TY3 were much lower than those by TK9. That is, Cd uptakes by the different rice cultivars were given the accumulations of Fe in rice plant. This could be illustrated by a competition between Cd and Fe to absorption by plant, which stands on the Fe uptake strategy induced by Cd stress to prevent from Fe deficiency in plant. However, further studies should be required for investigating why the iron plaque formation would be enhanced by Cd exposures and related to Cd uptakes by different rice cultivars.

Keywords：*paddy rice, root oxidation, DCB extractable, Cd, iron oxide*

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[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Effect of Cd Contaminaton on S Oxidation and its Effect on Cd Extractable by Dtpa in Calcareous Cd Contaminated Soil

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Use of phosphorous fertilizers, which has Cd impurity, and sewage sludge are the main way for arable lands Cd contamination. Adverse effects of Cd on soil biological process and human health via consumption of contaminated plants are properly described. S oxidation in soils is mainly a biological process that may be influenced by adverse effects of Cd. On the other hand, S oxidation and acid production through dissolving Cd in carbonate forms besides decreasing soil pH may enhance soil Cd availability in calcareous contaminated soils. An experiment was conducted to study effects of S application on soil pH, EC, sulfate as indicators of S oxidation process and DTPA extractable Cd. After 50 days incubation period, the changes in soil sulfate, EC and pH all proved that S oxidation was occurred in contaminated soils. Low rate of S oxidation, as little as 2.5%, may be attributed to adverse effect of Cd on biological S oxidation process. On the other hand, DTPA extractable Cd was not changed after incubation time in all S application rates in treated soils and it may be described by low S oxidation rate or re-precipitation of released Cd in soil, by active ions which present in aqueous phase.

Keywords：*Sulfur; Sulfur Oxidation; Cadmium; Cd- DTPA exctractable.*

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[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Stabilization Soil as to Rice (oryza Sativa L.) with Solid Wastes

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More and more studies reported that soil deterioration by As contamination due to past and present human industrial activity may result in high exposure because the As from the enriched soils would eventually enter the human body through soil ingestion and the food chain. Among in situ and ex situ methods, the stabilization technology was chosen as the treatment for soil As. In our study, the possibilities of remediation As-contaminated soil with solid wastes.

Paddy soils with 62.54 mg kg-1 was collected from Hunan province, named “hometown of nonferrous metals”, which was five- and three-fold higher than Hunan background value and standard value for soils set by the Ministry of Environmental Protection (MEP) of China, respectively, and rice seed (Oryza sativa L.cv Jia Hua-1) were used for pot experiments. Under greenhouse conditions, the solid wastes, such as fly ash, iron mine and manganese mine residues were added into As-contaminated soils and cultivated 30 days. Before reused, those solid wastes were assessed with the ecological risk methods, such as the toxicity characteristic leach procedure (TCLP) of Environmental Protection Agency (EPA) of USA, and identification standard for hazardous wastes (ISHW) of MEP of China, respectively. One 30-day-old seedling was transplanted into one pot containing 5.0kg pretreated soil. At harvest, rice grains and shoots were washed with distilled water to remove surface soil, and oven-dried at 65°C for 96 h until a constant weight was reached. Total concentrations of As, Mn, and Fe in rice plant tissues were measured by inductively coupled plasma mass spectrometer.

The results showed that the As concentrations leached from fly ash, iron mine and manganese mine residues with TCLP were 0.12±0.05 mg L-1, 0.15±0.01 mg L-1, and 0.13±0.03 mg L-1, while with ISHW were 0.008±0.001 mg L-1, 0.007±0.001 mg L-1, and 0.04±0.019 mg L-1, respectively. The soil pH increased significantly ($p<0.05$). Compared to the original soil, the yield of rice grain decreased with the addition of manganese mine residue. In the treatment with 2.0% manganese mine residue, As concentrations in husk and wholegrain were the lowest with 0.13 and 0.06 mg kg-1, respectively. Relationships between Mn concentrations and concentrations of Fe and As in rice plant were significantly negative ($p<0.05$), while the relationship between Fe and As was significantly positive ($p<0.05$). For the remediation of As-contaminated soil, manganese mine residue became the best, followed by fly ash and iron mine residue.

Keywords：*Soil As, rice plant, fly ash, iron mine residues, manganese mine residues.*

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[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Increasing Cadmium Solubility in Contaminated Paddy Soils to Enhance Cadmium Phytoremediation by Nicotiana Tabacum

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Phytoremediation is an attractive method to remediate contaminated soils, due to its low cost and easiness of implementation. It is, however, a slow remediation technique that may require years to achieve the remediation targets. There are several factors that can control the efficiency of this method to reduce contaminant concentrations in a given polluted soil, such as the degree of metal solubility and the ability of the hyperaccumulator plants to grow. Chelating agents, such as citric acid, EDTA, DTPA, and EGTA, can be used to enhance the effectiveness of the phytoremediation technique by making metals more bioavailable to the plants (Ali et al., 2013). These chemicals are usually expensive and thus cannot be applied to a large contaminated site without significantly increasing the cost of the remediation procedure. This research aimed to study two alternative procedures, i.e. acidifying the soil pH and applying low-cost desorbing agents, to enhance cadmium (Cd) solubility in alkaline (alk) Cd-contaminated paddy soils. To lower soil pH, elemental sulfur (S0), hydrochloric acid (HCl), nitric acid (HNO3) and sulfuric acid (H2SO4) were tested at a concentration of 1 N. Magnesium sulfate, magnesium nitrate, magnesium chloride, calcium sulfate, calcium nitrate, calcium chloride, potassium sulfate, potassium nitrate, and potassium chloride were employed as the low-cost Cd desorbing-agents, at a concentration of 1 M. The best reagent to lower soil pH and the most efficient salt to enhance Cd release were determined in our laboratory with soil samples taken from a contaminated paddy field in Mae Sot district, Tak province, Thailand. The capacity of these two chemicals to enhance Cd uptake by Nicotiana tabacum was then directly tested in the contaminated paddy field in Mae Sot.

Results showed that the capability of the studied chemicals to reduce soil pH followed this order H2SO4 > HNO3 = HCl > S0. The capacity of these chemicals to enhance Cd solubility was: HCl > HNO3 > H2SO4 > S0. The HCl desorbed Cd up to 35.8 mg.kg-1, which represented 58 % of the total Cd concentration in the soil. The amounts of Cd released by HNO3 and H2SO4 were 18.8 and 13.6 mg.kg-1, respectively. The electrical conductivity (EC) values measured in soil solution containing HCl, HNO3, and H2SO4 were 34, 33, and 5 dS/m, respectively. Calcium chloride could desorb 2.59 mg.kg-1 of Cd. The efficiency of cations and anions to enhance Cd solubility followed this order: Ca2+ > Mg2+ > K+ and Cl- > NO3- > SO42-, respectively. Therefore, based on the amount of Cd desorbed, the effects of these treatments on the EC values measured in soil solution, and potential environmental threats of the chemicals employed at high concentrations (e.g. NO3- or Cl-), the most suitable reagent to lower soil pH and enhance Cd release at the studied polluted site was H2SO4 and CaCl2, respectively. Adding H2SO4 and/or CaCl2 increased the availability of Cd, which was extracted by DTPA-TEA at pH 7.3.

Results from field experiments revealed that the addition of H2SO4 to decrease soil pH from ~7.8 to ~6.8 (25 liters conc. H2SO4 in 5*5 m2 plot) enhanced Cd concentration in Nicotiana tabacum shoot almost two times more than other treatments. Calcium chloride (CaCl2) did not seem to have a significant effect on Cd uptake, which could be due to the small amount of this salt employed (1 kg/ 5*5 m2). Addition of acid did not significantly modify microbial numbers and species. Additionally, adding the acid or CaCl2 did not promote Cd transport from the top soil (<30 cm), where the heavy metal is mainly present in the soil, to deeper depths.

The results obtained from this study will be useful in choosing the best strategy to remediate Cd at the studied paddy soil in Mae Sot, and other similar Cd-contaminated paddy soils. Further investigations are needed to optimize Cd release from soil components and uptake by Nicotiana tabacum, as well as other hyperaccumulator plants that can potentially remediate Cd from polluted soils.

Ali, H., Khan, E., Sajad, M.A., 2013. Phytoremediation of heavy metals Concepts and applications. Chemosphere 91, 869-881.

Keywords：*Cd phytoremediation in paddy soil, enhancing Cd phytoremediation, Nicotiana tabacum*

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[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Time-Dependent Changes of Plant Water Status to Cd Acute Toxicity and Absorption of Cd in Rice Seedlings

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In Asian countries, the paddy fields are often close to industrial sites and Cd is distributed in soil largely through the chemical discharges of industry into irrigation channels which are used for growing paddy rice (Oryza sativa L.). Paddy rice is a major staple crop in Asia and Cd accumulation in paddy soil posing risk to the food safety of rice has been much concerned. The amount of Cd that enters human diet from rice depends on the amount of Cd accumulated in grains. Thus, Cd was considered in one of the most important metals in food-chain contamination. However, elevation of Cd in soil will also cause physiological constraints, which may decrease the rice plant vigor and adversely affect the growth, development, and yield. Plant water loss has been described as a consequence of Cd toxicity and a perturbation of the plant water status would be one of the primary causes of Cd toxicity, especially at the shoot level. In addition, because Cd-induced stoma closure has been poorly questioned, the phytotoxicity of Cd responding to plant water status may impact on Cd uptake and distribution in plant. The objective of this study thus was to focus on dynamic responses of plant water status to Cd toxicity in rice plant and the relation to absorption of Cd.

In the present study, six rice cultivars of Taiwan were used to present the variation of time-response curves for specific plant water losses among different rice genotypes. The distributions of Cd concentrations in different rice cultivars were also investigated. Four japonica varieties (Taoyuan 3, Tai-keng 9, Tainung 71, and Kaoshong 145) and two indica varieties (Taichung Sen 10 and Taichung Sen 17) were selected for the hydroponic experiments of Cd exposure. Rice plants were cultivated in hydroponics and under a Cd exposure about 1.2 mM. And there was one set with Cd free as a control. Rice seedlings (3 weeks after germinating) of each variety were raised on Cd exposure for 12, 24, 48, and 72 hours, respectively. Three seedlings as replicates were harvested at each time. The root and shoot of seedlings were sampled separately. Then water contents and dry weights of sampled root and shoot were determined and the specific water losses for root and shoot (i.e. the ratio of water loss to dry weight change) were measured. Following HNO3/HClO4 digestion (v:v = 4:1), the Cd concentration of each plant sample was determined by an atomic absorption spectroscopy (AAS).

In the results, the time-dependent changes of specific water loss for Taoyuan 3, Tai-keng 9, and Kaoshong 145 were approaching to a plateau on Cd exposure for 48 hours; however, those for Tainung 71, Taichung Sen 10, and Taichung Sen 17 were unlimitedly increased on Cd exposure for 72 hours. Thus, dynamic responses of plant water status for the six rice cultivars to Cd toxicity could be probably classified into the two groups. One is considered as being Cd-tolerant (e.q. Taoyuan 3, Tai-keng 9, and Kaoshong 145), and the other is considered as being Cd-sensitive (e.g. Tainung 71, Taichung Sen 10, and Taichung Sen 17). The profiles of Cd concentrations in rice root and shoot suggested that at a high leveled Cd exposure (i.e. 1.2 mM) the Cd in plant was predominately accumulated in shoot rather than in root, except for Taichung Sen 17. However, Taichung Sen 17 took much more Cd to accumulate it into root than did other cultivars. Compared with Kaoshong 145, Tainung 71, and Taichung Sen 10, both Taoyuan 3 and Tai-keng 9 presented a relatively high ability to translocate Cd from root into shoot.

Keywords：*Cd stress, paddy rice, time-response curve, plant water loss, hormesis*

P1-66

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Distribution of Arsenic in Soil-Water- Plant (rice, Oryza Sativa L.) of Three Districts, Bangladesh

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Arsenic (As) contamination in soil-water-plant systems is a major concern in rice growing countries and its excessive in ground water is a severe problem in Bangladesh. Rice crop is the most susceptible and accumulates more As because requirement of irrigation water is high. In Bangladesh, rice cultivation depends on ground water irrigation may increase As in the rice crops via plant uptake mechanism. However, information on As concentration in irrigation soil, water and plant is limited and needs further exploration. In the present study, 240 soils, 240 water and 300 rice grain samples were collected from three areas viz. Veramara, Kochua and Chandina Upazillas where rice is being cultivated as major crop. The finding of the study shows that most of the soils of the studied area contain less than 20 ppm As. The highest concentration of As (25.96 ppm) was found in Boro rice grain of Koria union under Kochua Upazilla of Chandpur District. The water sample from different locations of the studied areas contains 0 to 0.83 ppm As. The Concentration of As in rice grain varies from 0 to 1.77 ppm. It is also observed that local verities of rice absorb more As that HYV rice.

Keywords：*Arsenic Soil Water Plant*

P1-67

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Nutrient and Water Management for Mitigating Arsenic Accumulation in Rice

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Considering the enormity of human health hazards associated with contamination of food chain with arsenic, a pot culture experiment in the green house was conducted at Bidhan Chandra Krishi Viswavidyalaya, Kalyani to explore the possibility of its mitigation in rice grains through water and nutrient management. While water management play an important role by altering the redox conditions of the soil in transforming different forms of inorganic As viz., arsenate (AsV) and arsenite (As III) under oxidised and reduced conditions, respectively, P and Si application restrict the uptake of these species of As, respectively, in to the plant body. Thus the treatments consisted 4 methods of water management viz., maintaining water at saturation throughout the growth periods (ST), saturation during the vegetative growth stages (SV), saturation during the reproductive growth stages (SR) and flooded during the rest of the periods, against continuous ponding of water (CP) as control; and two levels each of P viz., 25 mg and 50 mg P2O5 and 0 and 20 mg silicon kg -1 soil. The extent of decrease in As content of rice grains with application of both P and Si was 11.5%, with decreasing water availability from ponding to saturation was about 38% and with combination of water management and nutrient management together was 65%. Application of 50 mg P2O5, 20 mg Si kg-1 soil and maintaining the soil under saturation during reproductive stages, was found to be the best option to mitigate as contamination of rice grains.

Keywords：*Arsenic contamination, mitigation, water management, nutrient management*

P1-68

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Physical Effects on Soil Structure of Iron-Based Remediation Practices Used in As Contaminated Soils

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Uptake of solubilized As in rice is a crucial issue due to reducing conditions typical of traditionally cultivated paddy soils. Iron grit soil amendment is one of the most used soil remediation practices in many countries to immobilize As in soils. Physical consequences on soil structure of this soil remediation practice are very rarely investigated, especially in shrink-swell soils, where wetting-drying cycles can trigger significant structure changes. Paddy fields are generally subjected to many cycles of alternate flooding and drying which can induce changes in soil structure strongly influencing water and solute transport. Unpredicted changes in soil hydrological behavior can in turn affect plant growth and effectiveness of the remediation practice.

In order to identify and directly quantify the physical effects of the iron grit addition on soil pore system, a laboratory experiment was carried out by adding iron grit to two soils with high shrinkage-swelling potential, using repacked soil samples undergone to several wetting-drying cycles. Soil micromorphology and pore image analysis were combined using procedures providing results well correlated with some soil hydrological properties.

A porosity increase was observed in both soils, and the used methodological approach allowed to observe different pore geometries in the two soils, probably due to their different plasticity.

The obtained results showed overall the high potential of soil micromorphology and pore image analysis in order to evaluate the physical effects on soil structure of a soil remediation practice suitable for paddy soils.

Keywords: *Iron grit, Soil porosity, Lab experiment, Soil image analysis*

P1-69

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

The Application of Si And Se Fertilizers for Mitigation of Cd Accumulation in Rice

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In this study, an outdoor pot experiment was performed to explore the effects of silicon (Si) and selenium (Se) fertilizers on rice yields, cadmium (Cd) accumulation and translocation during the five key growth periods of rice. Five fertilization treatments were applied including non-used microfertilizers (control), Si fertilizer applicated into soil (Si), Si fertilizer applicated as foliar spray (Lsi), Si fertilizer applicated into soil combined with foliar spray Si fertilizer (Si+Lsi), and the foliar Se fertilizer application (Lse). The results showed that different fertilization methods of Si significantly decreased the Cd concentrations in brown rice and polished rice without showing any significant reduction of rice yields. Among five treatments, Si+Lsi had best effects for the decrease of Cd in edible grains, followed by the application of Si and Lsi. The addition of Si+Lsi resulted in a 26.3%, 58.4% and 65.7% reduction of Cd concentrations in husk, brown rice and polished rice, respectively. However, the application of Lse decreased the rice yield by 31.0%, and increased Cd concentration in husk by 16.9%, although it could decrease the Cd concentrations in brown rice and polished rice by 12.7% and 23.3%. Therefore our study suggests that the application of Si, Lsi and Si+Lsi fertilizers could be regarded as a potential strategy for mitigation of Cd accumulation in rice, while such role of leaf Se fertilizer application still needs more research.

Keywords：*cadmium pollution; rice; silicon fertilizer; selenium fertilizer; fertilization methods*

P1-70

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Dietary Risk Exposure to Heavy Metals among Poor and Non-Poor Households in Dhaka City, Bangladesh

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The cadmium, lead, arsenic, mercury, antimony, aluminium and lithium content of foods and beverages consumed by poor and non-poor households in Dhaka were analyzed by ICPMS. Eighty food samples were each collected from three markets that were commonly accessed by poor and non-poor households. Ninety four percent males from poor households and 78% males from non-poor households had an estimated dietary exposure to Cd above MPL. Eight percent males from poor households and 83% males from non-poor households had an estimated dietary exposure to Al above MPL, and were considered at risk from Al contamination. All males of poor and non-poor households likewise had dietary risk exposure to As and Pb. The dietary risk exposure to mercury, antimony and lithium by males from both poor and non-poor households was below MPL, thus noted to be within safe limits.

Keywords：*Dietary exposure, Arsenic, cadmium, Lead, Mercury, Poor and Non-poor husehold, Bangladesh*

P1-71

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Spatio-Temporal Variability of Heavy Metals in Paddy Field and Their Socio-Environmental Interpretation

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The totals of 219 surface soil samples from paddy fields were collected in 2011 in Wenling county, Zhejiang province, China to investigate the spatio-temporal variability of Cd, Cu, Ni, Pb, and Zn. Almost all the heavy metals pose potential pollution risks, especially for Cd and Ni. The regions with increased Cd, Cu, Pb and Zn concentrations were found to be located at the junction of Wenqiao and Daxi town, where there distributed booming private industry of family-sized E-waste recycling activities. USEPA model was employed to evaluate the cancer and non-cancer risks for local people. Redundancy analysis (RDA) analysis was performed to provide a survey of variations in heavy metal concentrations which were then interpreted by consideration of soil properties and socio-economical parameters. It can be concluded that Cd, Cu, Pb and Zn were related to anthropogenic factors including agricultural inputs of fertilizers and pesticides, and the local industry development. Ni is mainly derived from soil parent materials, however, anthropogenic factors have played a more important role in Ni accumulation in recent years. And the socio-environmental factors related to this study area explained 40.2% of the variations in heavy metal concentrations. The results of this study help inform pollutant source apportionment and the decision makings on agricultural and environmental management.

Keywords：*Heavy metals; Spatio-temporal variation; RDA analysis; Socio-environmental factors*

P1-72

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

In-Situ Field Application of Electrokinetic Remediation for As-Contaminated Rice Paddy Site

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Heavy metals contamination in the agricultural lands has been a serious environmental issue in Korea. Especially, the lands near industrial complexes, abandoned mine and refinery plants have been contaminated seriously. Among them, paddy rice field contains high portion of fine-grained soil, where soil washing process, most common choice for remediation of metals-contaminated site in Korea, is not applicable. Electrokinetic remediation has been applied to fine grained soil and clay for removal of metals. Since researches on electrokinetic remediation started in 1980, a lot of research groups have tried to develop the technology to real field. However, field scale applications of electrokinetic techniques are limited, and it is still in progress. In this study, we investigated the applicability of in-situ electrokinetic remediation to treat arsenic-contaminated paddy rice field in a full scale (Width: 17m, Length: 12.2m Depth: 1.6m). The test site is located at west coastal side, Janghang, Chungnam, Republic of Korea. The site is near Janghang refinery plant which was established in 1936, and the plant has been operational, with smelting activity involving large volumes of Cu, Pb and Zn. The dust, containing As, Cu, and Pb, which is generated during the operation has been dispersed to inland by sea breezes for the last 70 years. According to a recent site investigation, the whole area within 4 km of the stack in the refinery plant is seriously contaminated. The system removed 38.6% of As from the soil during 24 weeks, and the removal was dependent on the depth of soil. Fractionation analysis showed that As bound to amorphous Fe and Al oxides deceased mainly, and energy consumption was reasonable. From these results, it was concluded that the electrokinetic process could be applied to remediate As-contaminated paddy rice field as an in-situ.

Keywords：*paddy soil, arsenic, electrokinetic, fractionation, extraction*

P1-73

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Effect of Limestone on the Leaching Characteristics of Cd, Zn, and as from Submerged Paddy Soil

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Rice is cultivated in a paddy system, in which there are variations in water depth with the growth of rice, as well as alternating physical and chemical conditions in the subsurface soil such as alternating oxidizing and reducing conditions during periods of drainage and irrigation. Thus, in rice paddies, it is not clear whether the stabilization method is appropriate. In this study, laboratory-scale column tests were performed to simulate the reducing environment of submerged soil to identify the leaching characteristics of Cd, Zn, and As in paddy soil, as well as to examine the stabilization effect of limestone on the contaminants. As the column soils approached a reducing state, the solubility of Mn and then of Fe abruptly increased and continued to increase. This induced the abrupt leaching of Cd and Zn. Thereafter, Cd and Zn were adsorbed and precipitated to the soil surface, and their contents in the leachate decreased as the negative charge on the soil increased due to the increased pH caused by submersion. Meanwhile, the As concentration continued to increase in the form of highly mobile and toxic As(III). In the soil treated with limestone, however, the pH increased throughout the test period, and accordingly, cations, such as Fe, Mn, Cd, and Zn, had significantly lower mobility than in the control soil. The As concentration also continuously decreased due to the large amount of Ca in limestone.

Keywords：*Arsenic, Heavy metal, Paddy, Remediation, Stabilization, Submerged soil*

P1-74

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Regression Model Development for Estimating Total Metal(loid) Contents in Paddy Soil

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This study was performed to predict the total metal(loid) contents (Cd, Cu, Ni, Pb, Zn and As) by enter multiple-regression analysis using chemical properties and extractable contents of metal(loid)s in paddy soil adjacent to abandoned mines. The independent variables included in the regression analysis were soil pH, organic matter (OM), available phosphorus (P2O5), exchangeable calcium, and extractable contents of metal(loid)s. From regression analysis, it was found that the extractable contents of metal(loid)s significantly influenced the total metal(loid) contents in soil. Especially, the contents of extractable Pb, As, Cu, and Zn significantly correlated with its total contents than the other metal(loid)s. The results indicated that the estimated values of total metal(loid) contents using enter multiple-refression analysis significantly correlated with the measured values. Lead showed the highest correlation followed by the other metal(loid)s in the order of : Pb (R2=0.889, p-value=0.000) > Cu (R2=0.771, p-value=0.000) > As (R2=0.762, p-value=0.000) > Zn (R2=0.695) > Ni (R2=0.491, p-value=0.000) > Cd (R2=0.243, p-value=0.000). This predictive model for estimating total metal(loid)s in paddy soils could be applied to the numerous datasets that were surveyed with extractable metal(loid) contents based on Soil Environmental Conservation Act before 2010 in Korea.

Keywords：*Heavy metal, Total contents, Extractable contents, Soil properties, Paddy soil*

P1-75

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Varietal Differences of Rice on the Heavy Metal(loid)s Uptake Grown at the Paddy Soils Near Closed Mines in Korea

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There is an increasing concern over heavy metal(loid)s contamination of paddy soils and its subsequent translocation to rice grains. This study was performed to find the varietal differences of rice on the metal(loid)s (As, Cd, Cu, Ni, Pb and Zn) uptake at the As contaminated paddy soils near two closed mines, MB and PJ, using 6 rice varieties including high Cd accumulating M23 variety. Compared with other varieties (BJ, DA, M23, OD), DS variety was highly accumulated with Cd, Pb and Zn while SP variety was highly accumulated with only Ni. However, there was no significant varietal difference on As and Cu uptake in rice grains. Arsenic content in polished rice harvested on MB field was higher than on PJ, whereas Cd, Cu and Pb contents were lower. These results indicate that the heavy metal(loid) contents in polished rice were closely related with extractable metal(loid) contents in soil.

Keywords：*Varietal differences, Rice, Arsenic, Cadmium*

P1-76

[IDS13] Integrated Management Strategies for As and Cd in Rice Paddy Environments

Study on the Effect of Soil Amendments on Reducing As and Cd Uptake by Rice

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Pot experiment was conducted to investigate the effects of various soil amendments including calcium superphosphate, sulfur and steel slag and fertilizer including sulfur on changes in solubility of Cd and As and uptake by 2 rice cultivars. The reactive Cd and As contents of pot soils extracted with 0.1 N HCl and 1 N HCl were 2.1 and 4.3 mg kg-1 for Cd and As, respectively. Drainage and irrigation of water were performed to develop redox changes as like field condition. For rice cultivar WG, As contents in brown rice were 0.12-0.16 mg kg-1 showing no big difference among treatments. The Cd contents in brown rice were lower (0.22-0.33 mg kg-1) than control (0.40 mg kg-1) in the order of steel slag level 2 (1.4 Mg 10a-1) < steel slag level 1 (0.7 Mg 10a-1) < sulfur level 1 (10 kg 10a-1) treatments, however, the Cd contents were higher (0.47-0.48 mg kg-1) in calcium superphosphate level 2 (143 kg 10a-1) and sulfur level 2 (20 kg 10a-1) treatments. For cultivar HN, As contents in brown rice were lower in all treatments (0.09-0.14 mg kg-1) than control (0.16 mg kg-1), however, Cd contents were higher (0.39-0.41 mg kg-1) than control (0.28 mg kg-1) excepting steel slag level 2 and sulfur level 2 treatments. The results show the effect of calcium superphosphate, sulfur and steel slag on reducing As and Cd uptake by rice and also the dependence on rice cultivar and target elements.

Keywords：*soil amendment, calcium superphosphate, sulfur, steel slag, cadmium, arsenic, rice*

P1-77

[DS2] Soil Development and Soil Properties and Functions

Development of Functions of the Subsurface Drain Systems

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Control of soil water content at paddy fields is one of the most important issues for good yield and environmental harmonization. The aim of this study is clarify the functions of the combination drain systems to control soil water content at paddy fields. Both upper and lower end, main drain has vertical pipes for the smooth subsurface water flow. The vertical pipes at the upper end of main drain inlet water for subsurface irrigation and inlet air for press water during drainage. The vertical pipes at lower end of main drain, which are in the catch basin, regulate groundwater level during subsurface irrigation and rice growing season. One can remove the vertical pipes at lower end of main pipe to outlet subsurface water just before harvest. The supplementary drains filled with rice husk connect with main drains.

The test fields located at Niigata Prefecture, Japan, and have fine layered soil with low permeability. Soil types of these layers are Heavy Clay for plow pan, Light Clay for hard pan, and Heavy Clay for subsoil. Drainage of excess water had been main difficulties at this site. Hence in 2011, combined subsurface drain system introduced to this test field as a demonstration. We monitored vertical profile of water content, groundwater level, bearing capacity, rice yield quality from water outlet, and so on. According to the monitoring results, the combination drain system succeeded to regulate subsurface water by drainage and by irrigation, even in the low permeable fields.

Keywords：*Drain pipe, groundwater, permeability, rice husk*

P1-78

[DS2] Soil Development and Soil Properties and Functions

Influence of Long-Term Application of Different Fertilizers on Soil Acidification and Sugarcane Yield

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An experiment was conducted to observe the changes in pH of red soil subjected to long-term application of different fertilizers. The long-term experiment was conducted with sugarcane grown in red soil. The soil was given following fertilizer treatments: no fertilizer (control); chemical nitrogen, phosphorus and potassium fertilizer (NPK); NPK + organic manure (NPKM); and NPK + sugarcane trash (NPKT). Soil characteristics such as exchangeable aluminium (E-Al), acidity (E-A) and redox (E-H), soil P and K contents, and sugarcane yield were determined. Under the different fertilizer applications the E-Al, E-A and E-H increased but this increase was significantly lower in NPKM and NPKT treatments compared to CK and NPK. Yield data reveal a considerable increase over 15 years from different fertilizer applications compared to CK, but this increase was very high in NPKM and NPKT. Soil available P and K also showed a trend similar to the yield data. Although using organic manure and sugarcane leaf trash with chemical fertilizers enhanced soil acidification, the effects were significantly less than those of chemical fertilizer application alone, and therefore resulted in high yields of sugarcane. Soil pH was found to be positively and significantly correlated with cane yield.

Keywords：*Acidification; fertilization; red soil; organic manure; soil; trash*

P1-79

[DS2] Soil Development and Soil Properties and Functions

Metabolomic Analyses of Phospholipid and Fatty Acid Concentration Changes on a Dairy Farm Due to Changes in Cultivation, Pasture and Fertiliser Addtion

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Introduction

Phosphorus (P) from recently applied fertilisers sustains many modern agricultural systems. Fertiliser applications can exacerbate eutrophication of water ways, wasting a limited resource. Organic P comprises up to 60% of P in agricultural soils and could provide alternative source of P for plant production. However organic P utilisation is hampered by a poor understanding of the underlying biogeochemistry.

Metabolomics combines advanced analytical techniques with bioinformatics and has been used to investigate many complex biological systems, especially human physiology. Metabolomic techniques can identify compounds in complex matrices, find potential target compounds that change depending on soil conditions, and indicate processes that may be contributing to changes in compound identity or concentration. Our research aimed to test the use of metabolomic techniques on soil water samples taken from soil on a dairy farm in south eastern Victoria, Australia.

Methods

The sample site had been prepared (Cultivation × Pasture Type × P Fertiliser Rate) to produce a range of organic matter and soil test P concentrations in a randomised complete block design:

1. Cultivation: Mouldboard ploughed to 150 mm; or left untilled.

2. Pasture: Sown with 100% ryegrass; or a mixture of ryegrass and clover (5:1).

3. Fertilizer: 10, 35 or 100 kg/Ha P fertiliser annually.

Soil cores were extracted (0-20 mm) from all plots and soil water extracted from these cores using centrifugation. Soil water

samples were processed for physicochemical analyses, gas chromatography mass spectrometry (GC-MS), and liquid chromatography mass spectrometry (LC-MS).

LC-Triple quad-MS (LC-QQQ-MS) was used in a targeted study of phospholipids found in soil water. Phospholipids are important metabolites in microbial communities, plants, and animals. LC-QQQ-MS allows for mass resolution of metabolites to a higher level of accuracy than other LC-MS techniques. GC-MS was used to further confirm the identity of the phospholipids by targeting their fatty acid breakdown products. The data sets (physicochemical, LC-MS and GC-MS) were mined to identify significant correlations between the data and treatments. Principle component analyses (PCA), partial least squares-differential analyses (PLSDA) and hierarchal cluster analyses (HCA) were used to investigate the relationships between the treatments and/or types of phospholipid. Adjusted t-tests were used to determine the magnitude of the differences between phospholipid species due to different treatments.

Results

Over 100 phospholipids were identified using LC-MS. Phospholipids that were significantly different between cultivation methods and/or pasture types included phosphtidylcholines (14 identified), phosphatidylethanolamine (14), phosphatidylinositol (5) and phosphatidylglycerols (2), which are thought to be of microbial or fungal origin. Fatty acids identified using GC-MS, corresponded to the side chains and breakdown products of these phospholipids, confirming their identities. HCA showed that non-cultivated plots were more likely to have similar concentrations and types of phospholipid than cultivated plots. Similarly, HCA of non-cultivated plots revealed that mixed sward rather than ryegrass only plots were likely to have similar types and concentrations of phospholipid. PCA showed a clustering of cultivated and non-cultivated plots that described approximately 75% of the variation between the two treatments by the first two principle components. It was noted that the multivariate analyses (i.e. PCA) allowed for the identification of atypical plots (e.g.: boggy) at the site.

Conclusion

This research shows that it is possible to use metabolomic techniques to identify compounds in soil water that may be affected by cultivation either to optimise their concentrations, or as biomarkers of soil condition. Further research is needed to understand why these compounds may be indicative of soil health, function and processes. More importantly, the identification of these compounds should allow for research into determining how they may be accessible to agricultural users. For instance, by characterising organic P species it may be possible to find ways of enhancing P cycling thereby making it more available to plants, thus reducing the reliance on inorganic P amendments. Other advanced analytical techniques such as 31P NMR or qPCR could further enhance the analyses with a greater understanding of the soil chemistry and biology that is occurring in the soil matrix.

Keywords：*Phospholipids, Fatty acids, Metabolomics, Cultivation, Pasture type, Phosphorus, Dairy*

P1-80

[DS2] Soil Development and Soil Properties and Functions

The Streampower Concept for Assessing the Sediment Concentration in Interrill Overland Flow

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The most determining parameters in equations or models for assessing sediment load in runoff are: the critical momentum flux, the mean runoff velocity, the unit stream power or the critical shear strength. Some of those the parameters as critical momentum flux and critical shear strength are difficult to measure and good relationships with soil physical parameters are lacking. Moreover it is shown that the Manning equation is not suitable to calculate the velocity of overland flow during the interrill erosion process, and hence it is preferred to apply relationships using the overland flow discharges measured at stream (or rill) outlets, instead of the velocity parameters.

For assessing sediment concentration in interrill overland flow, the stream power concept can be used in the transport function based on the slope and on the discharge per unit width of the flow.

Laboratory rainfall simulation tests were performed on a large number of inclined soil pans packed with sandy, loamy and silty soils of loess origin and subjected to different rainfall intensities. This resulted in several hundreds of observations of discharge (runoff) and sediment (soil loss) in the runoff water. It was found that the streampower ω (g s^{-3}) was the best predictor of the unit sediment load qs (g s-1 cm-1). A power function fitted the data best. The relationship was also function of the clay content. The higher the clay content, the lower the unit sediment load.

Keywords：*streampower, sediment load, rainfall simulation, loess soils, overland flow, unit discharge*

P1-81

[DS2] Soil Development and Soil Properties and Functions

Sprinkler Irrigation and Soil Tillage Practices in Sugarcane Plantations as Influenced by Soil Texture and Water Storage in Northern Ivory Coast

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Soil survey investigations were carried out in Ferke 1 as well as Ferke 2 sugar mills of northern Ivory Coast to determine soil texture and water storage capacity for sprinkler irrigation and tillage management. The sugarcane farmlands being investigated since 2008 in both locations reached 95 % of the total area under cultivation (11,400 ha). Soil sampling was achieved after harvest or prior to re-plantation at 5 different spots along 2 transects over 30 cm depth in every farmland which covers about 30-40 ha with 432 m-long cane rows as to get an average soil sample of 1.5-2 kg. Soil physical properties like texture and water retention curves were determined locally in the sugar company's soil laboratory. It came out that the majority of farmland soils investigated was coarse-textured for about 64 % in Ferke 1 and 85 % in Ferke 2, with a lower to medium water storage capacity (70-89 mm) over 60 cm depth which corresponds to a readily available moisture less than 60 mm. These light soils were much suitable for the practice of minimum tillage which importantly contributes to reduce sugarcane production costs. The other textural categories such as sandy-clay or clay-loam, rather well balanced and less suitable for the practice of reduced tillage without pre-watering, gave medium to high total available moisture (90-110 mm) and therefore a maximum irrigation application rate (or readily available moisture) of 60-70 mm. Except for the sugarcane plant crop, no significant difference in cane yields resulting from tillage practices was observed over four consecutive cropping seasons. The yield decline from plant cane to the first ratoon is very high under conventional tillage (-16 t/ha) compared with the reduced tillage (+3 t/ha). Even higher cane yield obtained on the second ratoon (89 t/ha) compared with the conventional tillage (83 t/ha).

Keywords：*Key word: soil texture, physical property, water retention, available moisture, reduced tillage, irr*

P1-82

[DS2] Soil Development and Soil Properties and Functions

Impact of Climate Change on Crop Land and Technological Recommendations for The Main Crops in Transylvanian Plain, Romania

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The Transylvanian Plain (TP) is an important agricultural production area of Romania that is included among the areas with the lowest potential of adapting to climate changes in Europe. Thermal and hydric regime monitoring is necessary to identify and implement measures of adaptation to the impacts of climate change. Soil moisture and temperature regimes were evaluated using a set of 20 data logging stations positioned throughout the plain. Each station stores electronic data regarding ground temperature at 3 depths (10, 30, 50 cm), humidity at a depth of 10 cm, air temperature (at 1 m) and precipitation. A transition was detected in the TP from a moderate continental climate to an excessive climate, characterised by a poor distribution of rainfall and the overlapping of many extreme phenomena. For agricultural crops, the periods of drought and extreme temperatures require specific measures of adaptation to climate changes. We recommend hastening the optimal sowing periods reported in the literature by 7 days for corn and soybeans and by 5 days for sunflower and keeping the same periods for sugar beet. During the growing season of crops in the spring (April - October) in the southeastern, southern, and eastern escarpments, precipitation decreased by 43.8 mm, the air temperature increased by 0.37°C, and the ground temperature increased by 1.91°C at a depth of 10 cm, 2.22°C at a depth of 20 cm and 2.43°C at a depth of 30 cm compared with values recorded for the northern, northwestern or western escarpments. Water requirements were ensured within an optimal time frame for 58.8-62.1% of the spring row crop growth period, with irrigation being necessary to guarantee the optimum production potential. Periods of drought (36-83 days) were recorded in June-July and August, which overlapped with days exhibiting temperatures above 30°C; a total of 47.8-58.04 days exhibiting both were recorded during 2008-2012. The biologically active temperature recorded in the TP demonstrates the need to renew the division of the crop areas reported in the literature. For the analysed crops, wheat, corn, soybean, sunflower and sugar beet, superior levels of newly redistributed areas should be ensured by considering the possibility of cultivating a higher percentage of some semi-late or late varieties/hybrids.

Keywords：*climate change, adaptation technologies, Transylvanian Plain*

P1-83

[DS2] Soil Development and Soil Properties and Functions

Nitrogen Partitioning in Artificial Grassland Ecosystems: A 15n Tracer Field Study on the Tibetan Plateau

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Artificial grassland ecosystems that receive high amounts of nitrogen (N) fertilizer in the form of either ammonium (NH4+-N) or nitrate (NO3--N) are expected to result in different N uptake rates by three plant species and fates of NH4+ and NO3-. Using 15N tracer techniques this study examined the uptake and competition for applied N of three plant species within 48 hours. Three plant species viz. Elymus nutans, Festuca sinensis and Poa crymophila were grown either unfertilized or fertilized N application plots for 4 years. Within the two plots, traces of 15NH4+-N and 15NO3--N were added separately. During 2 days of the uptake rate of 15NH4+-N and 15NO3--N by different plant species as well as the fate of two 15N form into plant aboveground tissues, plant roots and surface soil N pools were investigated. In addition, 15N natural abundances of aboveground tissues and roots in 3 plant species and soils in different depths between unfertilized and fertilized plots were also measured before 15N tracer experiment. Results show that (1) Variation in foliar δ15N natural abundance across the three species was 3.10‰ (ranging from 0.32 to 3.42‰) in unfertilized plot and 4.18‰ (ranging from -3.55 to 0.63‰) in fertilized plot. Fertilizer application lowered the δ15N natural abundance values by 2.16-3.87‰ for plant foliage, 0.09-1.88‰ for roots and 0.47-0.57 ‰ for soils after 4 year's application. (2) In the 15N tracer experiment, the NO3-N and NH4-N uptake by E. nutans accounted for 76.58 and 23.42% of the applied N, respectively, in unfertilized plots, and 63.88% and 36.12%, respectively, in fertilized plots. Fertilizer N application significantly decreased 15NO3- uptake by E. nutans. The recovery of NO3-N and NH4-N by F. sinensis was 56.32 and 43.67%, respectively, in unfertilized plots, and 42.74% and 57.26% in fertilized plots. The N uptake pattern of P. crymophila was similar to that of E. nutans. (3) The plant 15N recovery was 43% and 28% when 15N tracer was applied as 15NO3- to unfertilized and fertilized plots, respectively, and 13% and 18% when 15N tracer was applied as 15NH4+. The soil 15N recovery was 57% and 72% when 15N tracer was applied as 15NO3-, but 87% and 82% when 15NH4+ was added. These suggest that there was higher 15NO3- recovery in plant and higher 15NH4+ recovery in soil in the artificial grasslands, especially in unfertilizer N grassland.

Keywords：*artificial grasslands, fertilizer N, 15N tracer, plant N uptake, 15N recovery*

P1-84

[DS2] Soil Development and Soil Properties and Functions

Effects of Different Tobacco Planting Patterns on Soil N Transformation Intensity and the Microbial Community

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The effects of different tobacco planting patterns (T1, monoculture-tobacco; T2, green manure-tobacco with crop rotation; T3, wheat inter-cropping; and T4 wheat-tobacco with crop-rotation) on soil N transformation intensity and soil microbial community of plowed layer (0-25cm) were evaluated in a fixed position experiment in 2009, which was conducted in Gaoqiao Town, Yishui County, Shandong Province by using the technique of indoor culture and phospholipid fatty acids (PLFA). The results showed that the NH4+ and NO3- content in plowed soil were both significantly affected by growth stage and planting pattern, depending on the N form as well. The mean content of NH4+ in all treatments increased and reached at the highest value (66.5 mg/kg) at tobacco budding stage (July 28) and then decreased with the tobacco growth stage. And the NH4+ content in T2 was much higher than that in the other three treatments at the whole growth stages except for the ploughing stage (April 22). The NO3- content in all treatments also had the similar trend that it decreased with the growth stage. But it was always lower in T4 than that in other treatments at the whole stages except for the fast-growing stage (June 20). The ammonification intensity in all treatments had the similar trend that the values increased firstly, then decreased and increased reached the largest value at tobacco mature stage (September 7). The ammonification intensity in T3 and T4 was significant lower than that in T1 both at ploughing and budding stages, but there were no significant difference among all the treatments at other growth stages. The nitrification intensity in all treatments also had the similar trend that the values decreased firstly, reached at the lowest value at fast-growing stage and then increased with the tobacco growth stage, which may be related the temperature and fertilization. Furthermore, the nitrification intensity of all treatments had no significant differences with the growth stage except for T2 and T3 at fast-growing stage. Different tobacco planting patterns had important effect on the soil microbial community. At ploughing stage of tobacco, the total PLFAs content was lowest in T3. At fast-growing stage, it was highest in T2, and had significant differences from other treatments. But at budding stage and mature stage, there were no significant difference among all the treatments. The PLFAs data of different soil microbial floras varied with the sampling time and the treatment, and no significant difference of fungi PLFAs was found in all treatments. The ratios of fungi to bacteria PLFAs and gram-positive bacteria (G+) to gram-negative bacteria (G-) PLFAs indicated that soil microbial community and bacteria community structure were both influenced by the tobacco planting pattern and growing season. Soil microbial community structure had been changed obviously in T4 during the whole growing season compared with that in T1 treatment. Moreover, Principal component analyses (PCA) of different microbial PLFAs at mature stage revealed that an obvious differentiation was found among the planting patterns, and soil microbial community structure changed greatly in the T2 and T3 compared with T1 treatment. All these changes of soil microbial community structure may be related to tobacco growing development, seasonal variation and fertilizer application.

The correlations indicated that the NH4+ content had no significant correlation with the total PLFAs and other parts of PLFAs. But the NH4+ content had significant positive correlation with the total PLFAs and other parts of PLFAs except for the anaerobic bacterial PLFAs. As to the ammonification intensity, there was a significant negative correlation between it and all e parts PLFAs except for the fungi PLFAs and anaerobic bacterial PLFAs. Moreover, the correlations between nitrification intensity and bacterial PLFAs, fungi PLFAs, G+ and G- PLFA , and aerobic bacterial PLFA were all positive significant. This study implied that the different tobacco planting pattern had important effect on soil N transformation intensity and the soil microbial community, and the PLFA technique might give us a better insight into the N transformation process and soil microbial community structure and their functions.

Keywords： *Tobacco planting patterns; Soil ammonification intensity; Soil nitrification intensity; , Soil microbial community; Phospholipids Fatty Acids (PLFAs)*

P1-85

[DS2] Soil Development and Soil Properties and Functions

Cover Crops Species As Affecting Soil Aggregation, Aggregate Stability, Organic Carbon Concentration and Soil Bulk Density in Different Soil Aggregate Fractions

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Soil aggregation is the important factor for plant growth, and directly affects the infiltration of water, soil biodiversity, dynamics of the soil biomass, oxygen availability to the roots and soil erosion. Soil aggregation and the distribution of total organic carbon (TOC) in different aggregate fractions could be affected by soil tillage system and cover crops species. The objectives of this study were to elucidate the effects of crop rotation with cover crop species in the soil aggregation, TOC concentration in the whole soil and in the soil aggregates fractions and soil bulk density (SBD) of the cultivated soil under no-tillage system (NTS) and conventional tillage system (one plowing and two disking).

A field experiment was conducted in Santo Antonio de Goias, GO, Brazil (16 ° 27' latitude, 49 º 17' longitude and 823 m elevation). The regional climate is tropical savanna, characterized as an Aw by the Koppen classification. There are two well defined seasons: the dry season from May to September and a rainy season from October to April with1500 mm annual mean rainfalland 22.7°C annual mean temperature. The area has been under NTS for six years (2001 - 2007) with rotations of corn (2001, 2003 and 2005) and soybean (2002, 2004 and 2006) in the rainy season (summer) and fallow in the dry season (winter). Soil was a Rhodic Ferralsol in gently undulating topography. This was a three years' study with cover crop-rice-cover crop-rice rotations. Crops were planted in November 2007 (cover crops), November 2008 (upland rice), March 2009 (cover crops again), and November 2009 (upland rice again). The cover crops were: 1) Fallow (spontaneous vegetation, predominantly Bidens pilosa, Commelina benghalensis, Conyza bonariensis and Cenchrus echinatus), 2) Panicum maximum Jacq., 3) Brachiaria ruziziensis R. Germ. and C.M. Evrard, 4) Brachiaria brizantha (Hochst. Ex A. Rich.) Stapf. - cultivar Marandu, and 5) millet, Pennisetum glaucum (L.) R. Br. - cultivar BN-2. An additional treatment was included as 6) fallow plus conventional tillage system (CTS, one plowing and two disking) as a control. The experimental design was a randomized block design with seven treatments and three replications. Plots size was 6.0 x 10 m with 1 m buffer between plots. Soil samples were collected from the top 0 to 10 cm after the second rice harvesting (April 2010). The data were used to assess the state of soil aggregation. Parameters expressing the size distribution of aggregates (aggregation indices) were determined by the mean weight diameter (MWD), mean geometric diameter (MGD) and aggregate stability index (ASI). The soil aggregations fractions were divided in three classes by size (> 8mm, 2-8 mm and < 2mm). In the whole soil samples and of the aggregate size classes was determined on finely ground samples the total organic C concentration. This evaluation was made by dry combustion with a Perkin-Elmer CHNS/O Analyser 2400. Regarding soil bulk density, soil

samples were collected in each treatment in all replications, using the volumetric ring (50 cm-3) in the layers 00-0.10 m and 0.10-0.20 m to evaluate soil bulk density. Next, these samples were packed separately in plastic bags and sent to the laboratory for analysis.

No-tillage system provided greater stability of soil aggregates (ranging from 90.10 to 94.44%) compared to fallow plowed (79.50%). Fallow plowed provided the highest amount of aggregates lower than 2 mm (49.96 g per 100g soil), which indicates that plowing soil broke the soil aggregates. The cover crops significantly affected the soil bulk density and the lowest soil density were from the treatments of millet at no-tillage system (1.08 g cm-3) and fallow plowed (1.14 g cm-3). The greater amount of root system on the soil surface probably was the cause to have lower soil bulk density at 0-0.10m (1.20 g cm-3) than at 0.10-0.20m (1.27 g cm-3). The deployment of cover crop straw on the soil surface provided the greater accumulation of total organic carbon in the surface layers of soil. The total organic carbon positively correlated with aggregate stability index in all depths and the total organic carbon concentration correlated negatively with the soil bulk density.

Keywords：*Brachiaria brizantha; Brachiaria ruziziensis; Panicum maximum; Pennisetum glaucum; soil management;*

P1-86

[DS2] Soil Development and Soil Properties and Functions

Lenghtful Sugarcane Cultivation Impact on Some Soil Characteristics.

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Pedologic alterations after long term sugarcane cultivation were studied in Haft tappe sugarcane agro industrial unit in Iran, through field study, laboratory data and microscopic observations. The results illustrated distinct physical contrast included more clay and less sand content, significant reduction in soil porosity and increasing in bulk density in cultivated land profiles. At the other hand some chemical characteristics also have been changed, like notable reduction in electrical conductivity, Sodium absorption ratio and gypsum content in cultivated pedons vs., non-cultivated one. Non- leachable salts like calcite showed no considerable differences in measured Carbonate Calcium equivalent data, but showed noticeable differences in calcite pedofeatures in both cultivated and non-cultivated lands. Also the amount of Cation exchange capacity and soil organic matter were higher in surface horizons of cultivated land profiles.

Keywords：*Cation exchange capacity, Micromorphology, Organic carbon content, Soil salinity, Soil bulk density*

P1-87

[DS2] Soil Development and Soil Properties and Functions

Rubber Plantation is Similar to Natural Secondary Forest in Soil Organic Carbon Storage in a North-Edge Tropical Ecosystem: In a Modified Calculation Method

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Carbon source or sink is the focus of the world in recent ten years as a result of the Kyoto Protocol. In this study, we added a new concept (standardized reference depth, Dsr) into the currently used calculation method to calculate and compare the soil organic carbon storage changes under three major land use conversions (from primary rain forest, respectively, to fallow land, to natural secondary forest and to rubber (Hevea brasiliensis) plantation) in a north-edge tropical ecosystem of Southwest China. On a 30-year basis, soil organic carbon storage didn't decrease significantly with the land use type changed from primary rain forest to fallow land (only low about 10.3 %), but increased significantly, about 49.3% with converting to the natural secondary forest and 41.6% to rubber plantation. And rubber plantation is similar to natural secondary forest for soil carbon sequestration in this region. Compared with the modified method, the current method overestimated carbon storage under the fallow land by 8.8 % more than the actual storage, as the reference depth being more calculated 13.9 cm (Dr-Dsr=13.9) without the reference depth standardization process, and overestimated by 3.6 % under the rubber plantation, as calculated more 4.9 cm of the reference depth, but underestimated the natural secondary forest by 6.4%, as the less 9.7 cm of reference depth. Thus the modified process by the standardization of the reference depth on the base of the currently used method is necessary in the evolutions and comparisons of soil carbon or other nutrient storage changes.

Keywords：*Soil organic carbon storage;land use conversion; modified calculation method; rubber plantation, tropical forest; the Kyoto Protocol*

P1-88

[DS2] Soil Development and Soil Properties and Functions

Study on the Salt Ions Spatial Distribution and Plant Community Succession Relations of Reed Marsh of Shuangtaizi River Estuary

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Take the Shuangtaizi River estuary wetland as the study object, soil, plant samples obtained in 2009 October field survey were indoor analyzed in research of salt ions degenerative succession and vegetation community relations. The results show that: according to growth index change of the reed biomass, coverage, and plant height, degradation succession order of reed community is Reed-Reed / Limonium - Reed / Artemisia anethifolia - Reed / Suaeda salsa - Aeluropus littoralis / Suaeda salsa-Suaeda salsa. With the degradation succession, the content of the salt ion of Suaeda salsa community was significantly higher than that of other five kinds of plant community. Electrical conductivity was negatively correlated with reed biomass, plant height, and were positively correlated with ($P<0.01$) soil soluble salt ions (except CO32-). The experimental results illustrate the effect of salt ions on plant growth through Electrical conductivity. The electrical conductivity is significantly positive correlation with pH ($P<0.01$), which shows that test area occurs soil salinization accompanied by alkalinization.

Keywords：*estuarine wetland; reed community; degradation succession; salt ions.*

P1-89

[DS2] Soil Development and Soil Properties and Functions

The Effect of Soil Compaction on Population Densities of Bacteria and Fungi

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Compaction is the process of densifying a soil mechanically and influencing thus physical properties of the soil. Physical properties influence all biological and many chemical processes in the soil. Microbial activities and biochemical processes are important to nutrient bioavailability. The effects of soil compaction state on population densities of bacteria and fungi during the growth of wheat were studied in a pot experiment. Two soils (clay and sandy loam texture) were used. The soils were compacted to three levels (natural compaction, 10% and 20% compaction). The population densities of bacteria and fungi were determined at various stages (1, 15, 45 and 60 day after planting) during the plant growth. The experiment was laid down in randomized complete factorial design with three replications in agricultural faculty of Guilan University. The results indicated that the effect of soil compaction state and plant growth stages for both bacteria and fungi population densities were significant ($P < 0.01$). With increases in soil compaction from 0% compaction to 10% compaction, total numbers of bacteria decreased but numbers of fungi increased and population densities of bacteria decreased with increases in soil compaction from 10% to 20% compaction. The plant growth stages also had an important impact on soil population densities of bacteria and fungi, with strong negative association between population of fungi and bacteria. With crop growth bacteria population decreased from 15 to 45 day after planting then increased from 45 to 60 day after planting.

Keywords：*soil compaction, fungi, Bacteria*

P1-90

[DS2] Soil Development and Soil Properties and Functions

Spatial Distribution of Nitrifers and Nitrification Associated with Aggregates along A 2000 Year Chronosequence of Rice Cultivation

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Periodic short-term redox cycles induced by paddy management over long time periods have strong effects on soil biogeochemical processes. Our previous study observed that soil nitrification and nitrifiers can be affected by these periodic short-term redox cycles induced by specific paddy management for variable duration of rice cultivation history. Since soils are comprise of different sizes of aggregates, silt and clay, and microbes has been reported heterogeneous distribution within soil aggregates. Analysis of components usually yields more information than analysis of the whole. Therefore, the present study aimed to evaluate spatial distribution patterns of ammonia-oxidizing bacterial (AOB), ammonia oxidizing archaea (AOA) associated with different sizes of aggregates, and nitrification for soils with variable duration of rice cultivation history.

Two paddy soils that have been in rice cultivation for approximately 300 (P300) and 2000 years (P2000) in Cixi, Zhejiang Province, China were sampled. Fractionation of soil aggregates were achieved using a wet-sieving procedure. Results showed that rice cultivation history improved large-aggregate formation. Compared to P300, P2000 increased the proportion of large aggregates from 6.26% to 20.5% and decreased silt+clay fractions from 42% to 24.8%. The trends indicated that cultivation history integrated soil silt + clay fractions into large-aggregates in the soil. Soil TOC, TN, AOB and AOA were heterogeneously distributed within different sizes of aggregates. Highest TOC and TN contents were observed for micro-aggregates, while the lowest was associated with the silt + clay fraction. Nitrifers were found mainly associated with macroaggregates. The highest level of AOB amoA gene copies were observed in macro-aggregates (18.1 and 4.73 * 10^5 copies g^{-1} dry soil for P300 and P2000, respectively), while the lowest values were associated with large aggregates. The highest level of AOA amoA gene copies were observed in macro-aggregates (19.0 and 2.19 * 10^6 copies g^{-1} dry soil for P300 and P2000, respectively), while the lowest gene copies were associated with large aggregates and silt + clay fractions. AOA amoA gene copies were about one order of magnitude higher than AOB for all aggregates and whole soils, and their distribution patterns were similar between farming durations. Highest net nitrification was observed for macroaggregates. Nitrification patterns associated with various sizes of aggregates coincided with whole soil, but nitrification rates were significantly different for various aggregate sizes. The highest net nitrification occurred for macroaggregates and the least for large- aggregates, which coincided with nitrifier populations. For P300, net nitrification associated with macroaggregates was 10.6% and 26.6% higher than whole soil and large aggregates, respectively. For P2000, net nitrification associated with macroaggregates was 37.6% and 49.5% higher than for whole soil and large aggregates, respectively.

Rice cultivation history improved large-aggregate formation from silt + clay fractions. AOB and AOA were mainly associated with macroaggregates, and net nitrification was also higher for macroaggregates than large-aggregates and silt+clay fractions. The coinciding spatial distribution patterns for nitrifying microorganisms and net nitrification associated aggregates supported heterogeneous distribution patterns of nitrifying microorganisms in the present study.

Keywords：*soil structure, soil function, ammonia-oxidizing bacterial, ammonia oxidizing archaea, paddy soil, s*

P1-91

[DS2] Soil Development and Soil Properties and Functions

Soil-Lt: Automatic and Continuous Determination of Shrinkage Behavior of Soils

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The structure of soils is characterized by the spatial arrangement of particles within a given soil volume, which results in the formation of pore space. It is well known that changes in climatic and hydrological conditions but also cultivation in agriculture and forestry amongst other activities affect soil structure and result in intense changes of soil volume. As a consequence physical properties and functions of soils (e.g. accessible surface area, porosity, mechanical soil strength, and hydraulic conductivity) as well as the prerequisite of rigidity for e.g. hydraulic modeling are affected and result in variable and undefined soil conditions amongst others concerning gas and water household, modeling of coupled processes. Especially, swelling and shrinking induced by changes of matric potential respectively wetting and drying, strongly affect soil structure. In particular, soils with a high content of organic matter or clay and silt, tend to distinct swelling and shrinking processes, which can then result in a rearrangement of particles and thus in changes in flows and storage of water, gas and temperature.

Generally, it is well known that soils undergo intense short and long term alterations of their properties, which also require a well-defined strength or hydraulic stress range of rigidity that up to date was not defined but because of an easier data application for e.g. modeling was simply neglected in laboratory and in-situ measurements. However, viable tools are needed in order to quantify the effects of volume changes and pore structural changes on soil functions: the definition of pore rigidity as well as the kind of volume change: its isotropy and anisotropy, and intensity of volume changes, crack formation (flow paths) and surface area changes (accessible surfaces) are urgently needed and will be defined in the running project.

Sophisticated methods to measure volume and structural changes of soils like height change analysis (vernier caliper) or the volume replacement method with paraffin are well described in the literature. But these methods are not only time consuming, invasive and include some difficulties but they are also limited to a specific condition but do not quantify the total process. Thus, a new approach is the application of a laser based device for the investigation of soil samples via laser triangulation. This will allow the noninvasive investigation of samples, which will also be less time consuming and should provide a higher accuracy compared with the known methods. Furthermore, the analysis can be automatically processed and allows a continuous measurement of multiple replicates and the possibility to vary in sample size and orientation. In addition, it will be possible to couple this device with measurements of other soil properties, such as soil moisture, matric potential, soil mass and unsaturated hydraulic conductivity.

The device and the software are being developed in the framework of a project, facilitated by the BMWi (Federal Ministry of Economics and Technology, Germany), in cooperation between the UGT GmbH (Muncheberg, Germany) and the University of Kiel (Germany).

The process of development of the device will be combined with X-ray CT measurements of soil samples to validate the results of laser triangulation and to give information about the accuracy.

First tests show that it is possible to quantify crack characteristics as well as the displacement of soil material at the cylinder wall with a precision close to the findings from X-ray CT. Although the laser based device is limited to a three-dimensional surface analysis, we can also link these data with corresponding measurements with X-ray CT of the internal soil structure. We can proof that the differences (laser vs. X-ray CT) of the results for total soil volume and sample diameter are remarkably low (±1%), which emphasizes the sensitivity of the new laser method .

Keywords：*laser triangulation, image analysis, structure development*

P1-92

[DS2] Soil Development and Soil Properties and Functions

How to Identify the Important Organic Compounds from the Soil Matrix: Metabolomics and the Analyses of Soil Through Soil Water

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Introduction

Metabolomics is the study of the "metabolome", the identification of all metabolites in a biological system. Metabolomic techniques can identify compounds in complex matrices, find potential target compounds that change depending on sample conditions, and determine processes that change the identity or concentration of these compounds. Metabolomics has found success in areas such as medicine and plant science. We discuss how metabolomic techniques may be used in soil science. As a case study, we have used metabolomic techniques on soil water samples to identify important chemical compounds related to cultivation methods, pasture types, and physicochemical factors.

Methods

The sample site, a dairy farm in south east Victoria, Australia, was prepared with a series of treatments in a randomised complete block design:

1. Cultivation: Mouldboard cultivated to 150 mm; or left untilled.

2. Pasture: Ryegrass; or a mixed sward of ryegrass and clover.

3. Fertilizer: 10, 35 or 100 kg/Ha Phosphorus fertiliser annually.

Soil cores were extracted from all plots (0-2 cm) and soil water extracted from these cores using centrifugation. Soil water samples were processed for physicochemical analyses, gas chromatography mass spectrometry (GC-MS) and liquid chromatography mass spectrometry (LC-MS). The analyses consisted of:

1. Tandem LC-MS was used to identify compounds across the "metabolome" of the soil sample. Polar-GC-MS analyses was used with a combination of databases to identify compounds in the soil water.

2. LC-Triple quad-MS was used in a targeted study of phospholipids found in soil water. Phospholipids are important metabolites in microbial communities, plants, and animals. GC-MS was used to confirm the identity of the phospholipids by targeting fatty acid

3. breakdown products.

Univariate and multivariate statistical relationships in the data sets (physicochemical, LC-MS and GC-MS) were mined to identify significant correlations between the data and treatments. Principle Component Analysis (PCA), Partial Least Squares-Differential Analysis (PLS-DA) and Hierarchical Cluster Analysis (HCA) were used to find grouping of compounds depending on treatment type. Adjusted t-tests were used to identify which treatment was significantly important for each compound. Correlation heat maps identified how these compounds were related to physiochemical parameters.

Results

LC-MS was able to collect the most data, with over 2000 compounds detected. In comparison, GC-MS only detected 93 compounds, though these compounds were also able to be identified from their fragmentation pattern, something that requires further experiments using LC-MS.

Mining of the LC-MS untargeted analyses allowed for a focus on compounds that were significantly different between treatments. Adjusted t-tests identified 22 compounds different between cultivated versus uncultivated plots, and 30 compounds that were different between ryegrass versus mixed sward plots. PCA and PLS-DA confirmed these grouping with HCA also confirming phospholipid differences between cultivation treatments.

The significantly different untargeted compounds and targeted phospholipids were further assessed with other LC-MS techniques to confirm their identities (e.g. MS/MS lipid profiling). Tentative identification of the untargeted compounds revealed the majority were sugars with several phosphates also identified. The majority of the phospholipids were found to be possibly of microbial or fungal origin.

The GC-MS analyses identified four compounds that were significantly different between cultivated and uncultivated treatments. The correlation heat map showed that glucose and mannitol were likely from similar sources and/or pathways while glycerol-α-d-galactopyranoside was negatively correlated with pH, perhaps due to its function as an osmotic regulator. Scyllo-inositol was positively correlated with organic P, indicating that it may be a substrate or degradation product of an inositol phosphate.

Conclusion

Metabolomic techniques provide a wealth of data that can be overwhelming. However, a properly designed experiment can identify compounds in the soil matrix that can possibly be used to identify trends in soil processes, spot compounds that might be amenable to adaptation (e.g. increase organic P accessibility to plants by inoculation of roots with fungi), or find biomarkers of the biological consortium that are essential to soil health. Furthermore, the power of metabolomic analyses is that other analytical techniques can be added to further investigate processes occurring with the soil matrix. This includes NMR, which can identify the structure of compounds through their carbon, hydrogen or P atoms, and qPCR, which can give a measure of the type and concentration of microbes in the soil matrix.

Keywords：*Metabolomics, Soil Water, Cultivation, Pasture type, Dairy, Methodology*

P1-93

[DS2] Soil Development and Soil Properties and Functions

Effects of Straw Returning on Soil Enzyme Activity, Composition and Stability of Soil Aggregates of Flue-Cured Tobacco Field in Huanghuai Area

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A field experiment from 2009 to 2012 was conducted to study the effect of different amount of wheat straw and maize straw returning on soil enzyme activity, composition and stability of soil aggregates of Flue-cured tobacco field in Hua3nghuai area. The results showed that the different amount of straw returning could decrease the soil bulk density, but increase soil organic matter with increasing the amount of straw returning, compared with CK. Most soil nutrient of flue-cured tobacco field had highest values of soil nutrients in the treatment of 4500kg.ha-1 of maize straw returning. But the wheat straw returning could improve soil nutrient with the increasing amount of wheat straw returning. Maize straw returning had a better effect on soil organic matter and other soil nutrient than wheat straw returning using the same amount of straw. The maize straw returning could improve the soil enzyme activity with the increasing amount of maize straw except for the hydrogen Peroxidase activity. And the wheat straw returning could also improve the invertase activity and urease activity with the increasing amount of wheat straw returning. But the alkaline phosphatase activity was highest in the 4500kg.ha-1 wheat straw returning treatment. Maize straw also had a better effect on the soil enzyme activity than wheat straw returning using the same amount of straw. The correlations indicated that Alkaline phosphatase activity were significantly negative correlated with soil pH. Invertase activity and urease activity both were significantly positive correlated with soil available N. Furthermore, Hydrogen Peroxidase activity was only negative correlated with soil available K significantly.

Mean weight diameter (MWD) and geometric mean diameter（GMD）in different amount of maize and wheat straw returning treatments were higher than that in CK treatment. Straw returning could improve aggregation and its stability of soil aggregates. The dry and wet sieving results both showed that the more straw returning decreased the more fractal dimension of soil aggregates. The treatments of 7500kg.ha-1 of either maize or wheat straw returning both had the lowest fractal dimension in their treatments, and the more straw returning could enhance the formation of the wet stable aggregates from micro-aggregates to macro-aggregates. But the maize straw returning could increase the stability of soil aggregates and soil aggregate distribution better than those in wheat straw returning at the same amounts of straw. The correlations indicated that the MWD and GMD of dry sieving and GMD of wet sieving were all significantly positive correlated with soil organic matter. Organic matter was the main cementing and stabilizing agent of aggregate formation. Maize and wheat straw returning in tobacco field could increase the aggregation and the stability of soil aggregate. Therefore, this study had important theoretical meaning and practical value to choose rational straw returning to maintain and improve soil nutrient in tobacco field of Huanghuai area.

Keywords：*Straw returning; soil nutrient; Soil enzyme activity, Soil aggregate; Flue-cured tobacco field*

P1-94

[DS2] Soil Development and Soil Properties and Functions

Effect of Different Organic Nutrient Sources on Growth, Yield, Uptake and Economics of Groundnut

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Groundnut (Arachis hypogaea), is a species in the legume family (Fabaceae) native to South America, Mexico and Central America. It is an annual herbaceous plant growing to 30 to 50 cm tall. The flowers are a typical pea flower in shape, 2 to 4 cm (¾ to 1½ inch) across, yellow with reddish veining. The average productivity of groundnut in India is about 1341 kg/ha-1 as against the world's average yield of 1348 kg/ha-1. About 70 per cent of the crop is grown on black soils and the remaining on red soils. The field experiment was conducted during summer season of 2006-07 to 2011-12 at the Main Centre for Integrated Farming System Research located at Agricultural and Horticultural Research Station, Kathalagere; Davangere comes under the Southern Transitional Zone of Karnataka, India, under protective irrigation. Which is located in the Bhadra Command Area between 130 21 latitude and 760151 E longitude at an elevation of 561.6 m above the MSL. The soil of the experimental site was sandy clay loam with a pH 5.30 of 0.52 per cent organic carbon and 202.7, 12.0 and 233.6 kg/ha available N, P2O5 and K2O respectively. The experiment was laid out un replicated with eight treatments such as T1 -50% recommended NPK + 50% N as FYM + inorganic sources of micro-nutrients as per soil test (10 kg ZnSO4/ha), T2 - Different organic sources each equivalent to 1/3 of recommended N (FYM + vermicompost + non-edible oil cake), T3 - T2 + intercropping or trap crop (location specific in each season), T4 - T2 + agronomic practices for weed and pest control (No chemical. pesticides and herbicides), T5 - 50% N as FYM+ rock phosphate to substitute the P requirement of crops + phosphate solubalizing Bacterial culture, T6 - T2 + bio fertilizer containing N and P carriers, T7 100% NPK + secondary and micro-nutrients based on soil test (10 kg ZnSO4/ha) and T8- dummy plot. Before sowing of groundnut incorporation of all the nutrient sources to the soil has been done. In the month of February first fortnight the sowing of groundnut (TMV-2) using 60 kg kernels ha-1 was done at spacing of 30 cm X 10 cm row to row and plant to plant distance respectively. All agronomic practices followed as per the package of practices. Soil samples were collected and samples were analyzed for major nutrients using standard procedure.

The plant growth parameters at harvest were influenced with application of different nutrient sources. At harvest, application of 100% NPK + secondary and micro-nutrients based on soil test (10 kg ZnSO4/ha) has recorded higher plant height (57.86 cm), more number of branches/plant (7.20) and more number of nodules/plant (18.40) as compared to dummy plot (55.98cm, 5.90 and 16.80 respectively). However, it was closer with all the treatments except dummy plot. The maximum number of pods/plant (30.12), dry pod weight/plant (29.32 gm), 100 seed weight (28.50 gm) and shelling percentage (79.64) was produced with application of 100% NPK + secondary and micro-nutrients based on soil test (10 kg ZnSO4/ha) as compared to other treatments and dummy plot.

The dry pod yield (1953 kg/ha-1), kernel yield (1555 kg/ha-1), haulm yield (3617 kg ha-1) and Harvest Index (0.57) were higher at 100% NPK + secondary and micro-nutrients based on soil test (10 kg ZnSO4/ha) as compared to all other treatments (1692 kg/ha-1 to 1722 kg/ha-1, 1264 kg/ha-1 to 1318 kg/ha-1, 3163 kg/ha-1 to 3568 kg/ha-1, and 0.51 to 0.56, respectively) and dummy plot (1651 kg/ha-1, 1226 kg/ha-1, 3176 kg/ha-1 and 0.47, respectively).

Nutrient availability and uptake: Treatment receiving Different organic sources each equivalent to 1/3 of recommended N (FYM + vermicompost + non-edible oil cake) + bio fertilizer containing N and P carriers has recorded higher available N (363.91 kg/ha-1), available P2O5 (18.13 kg/ha-1) and available K2O (174.71 kg/ha-1), and also the same treatment recorded higher uptake of N (183.88 kg/ha-1), P (31.16 kg/ha-1) and (111.74 kg/ha-1) as compared to all other treatments.

Economic analysis: Application of 100% NPK + secondary and micro-nutrients based on soil test (10kg ZnSO4/ha) has recorded higher net return (Rs. 71,717/ha-1) and BCR (2.34) over other organic nutrient practices and dummy plot.

Keywords：*effect, different organic sources, soil properties, nutrient uptake, groundnut*

P1-95

[DS2] Soil Development and Soil Properties and Functions

Soil Organic Carbon Sequestration Affected by Revegetation on the Loess Plateau, China

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Revegetation has been reported as one of the most effective measures for reducing soil erosion on the Loess Plateau in China. In the framework of 'Grain for Green' vegetation rehabilitation project, soil organic storage in the comprehensive treatment watershed-Shanghuang was investigated by Geostatistics combined with GS+ and ArcGIS9.3, also soil organic carbon (OC), OC fractions, aggregate-associated OC and OC fractions were studied under both non-grazed grassland and afforestation area. Five OC fractions were studied: soil microbial biomass carbon (Cmic), particulate organic carbon (POC), humus (HS), humic acid (HA), fulvic acid (FA). Due to the difference of land uses and soil carbon density, the difference of soil carbon storage between comprehensive treatment watershed and non treatment watershed were obviously. In comprehensive watershed-Shanghuang, the main land use types are shrub land (22052.81 t、6525.12 t) and natural grassland (14573.14 t、3634.42t) which occupied 70.43 % of the total area. Soil carbon storage increased effectively with vegetation restoration conditions. Under non-grazed grassland revegetations, apart from Th.M. (Thymus mongolicus Ronnm), soil OC and OC fractions concentration increased with recovery time, whereas under afforestation revegetations, soil OC and OC fractions under N.G. (Natural grassland) was higher than C.K. (Caragana Korshinskii Kom) shrubland. Cmic, POC, HS, FA was more sensitive than total OC to vegetation types. Intermediate sized aggregates (2-5 mm, 1-2 mm, 0.25-1.0 mm)-associated OC was higher than other size aggregates. In this study area, soil mean weight diameter MWD decreased with increasing SOC above a certain C concentrations (18.13 g-kg-1). On the Loess Plateau, revegetation is efficient means of increasing soil OC concentration, also reasonable land use resulted in more soil OC storage.

Keywords：*Revegetation, SOC storage, SOC fraction, Loess Plateau*

P1-96

[DS2] Soil Development and Soil Properties and Functions

Application of Laser Triangulation for the Determination of Shrinkage Behavior of Soils in Laboratory Tests

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The structure of soils is characterized by the spatial arrangement of particles within a given soil volume, which results in the formation of pore space. It is well known that changes in climatic and hydrological conditions but also cultivation in agriculture and forestry amongst other activities affect soil structure and result in intense changes of soil volume. As a consequence physical properties and functions of soils (e.g. accessible surface area, porosity, mechanical soil strength, and hydraulic conductivity) as well as the prerequisite of rigidity for e.g. hydraulic modeling are affected and result in variable and undefined soil conditions amongst others concerning gas and water household, modeling of coupled processes. Especially, swelling and shrinking induced by changes of matric potential respectively wetting and drying, strongly affect soil structure. In particular, soils with a high content of organic matter or clay and silt, tend to distinct swelling and shrinking processes, which can then result in a rearrangement of particles and thus in changes in flows and storage of water, gas and temperature.

Generally, it is well known that soils undergo intense short and long term alterations of their properties, which also require a well-defined strength or hydraulic stress range of rigidity that up to date was not defined but because of an easier data application for e.g. modeling was simply neglected in laboratory and in-situ measurements. However, viable tools are needed in order to quantify the effects of volume changes and pore structural changes on soil functions: the definition of pore rigidity as well as the kind of volume change: its isotropy and anisotropy, and intensity of volume changes, crack formation (flow paths) and surface area changes (accessible surfaces) are urgently needed and will be defined in the running project.

Sophisticated methods to measure volume and structural changes of soils like height change analysis (vernier caliper) or the volume replacement method with paraffin are well described in the literature. But these methods are not only time consuming, invasive and include some difficulties but they are also limited to a specific condition but do not quantify the total process. In view of the above, a laser based device and the corresponding software for the investigation of soil samples via laser triangulation are being developed in the framework of a project, facilitated by the BMWi (Federal Ministry of Economics and Technology, Germany), in cooperation between the UGT GmbH (Muncheberg, Germany) and the University of Kiel (Germany). The process of development of the device will be combined with X-ray CT measurements of soil samples to validate the results of laser triangulation and to give information about the accuracy.

This new approach will allow the noninvasive investigation of samples, which will also be less time consuming and should provide a higher accuracy compared with the known methods. Furthermore, it is planned to present different technical designs for a multipurpose applicability of the device: (i) measuring of dynamic soil structure development via laser scanning for single samples, (ii) surveillance of the shrinkage for determination of the retention curve with the ku-pF apparatus by UGT GmbH, and (iii) monitoring of shrinkage experiments with multiple samples on sand-boxes or ceramic plates. As the analysis in all cases can be automatically processed, a continuous measurement of multiple replicates that may vary in sample size and orientation is possible, which will result in highly detailed quantification of crack characteristics considering the displacement of soil material at the cylinder wall.

Keywords：*Soil-LT, image analysis, structure development, ku-pF, soil shrinkage*

P1-97

[DS2] Soil Development and Soil Properties and Functions

Assessing Soil Erosion Intensity in the Klipriviersberg Nature Reserve

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To guarantee the sustainability of nature reserves in South Africa, there is need to pay attention to the threats faced by soils in these nature reserves. Soil is a major component of natural environment which needs to be protected. The continuous grazing and trampling on the soils by animals and humans coupled with the occasional forest fire may portend a great challenge to soils in these nature reserves. In addition, the nature of the terrain coupled with scanty vegetation on the soils may lead to the development of sheet and or gully erosion and other forms of soil erosion in this nature reserves. Early detection and quantification of the annual rate of soil loss in this nature reserves would provide the basis for sustainable management of the forest reserves and guarantee continuous revenue generation. This study therefore seeks to address the threat of soil erosion in one of the South African's nature reserve (Klipriviersberg Nature Reserve) with a view to ensure its long term sustainability. Revised Universal SOIL Loss Equation (RUSLE) model was applied in the estimation of the erosion potential within the Klipriviersberg Nature Reserve. The final results show erosion risk potential of the different parts of the nature reserve. Different mitigation approaches toward ameliorating the observed erosion were discussed.

Keywords：*Soil Erosion, Rusle, Sustainability Of Nature Reserves.*

P1-98

[DS2] Soil Development and Soil Properties and Functions

Characteristics of Soil Seed Bank in Different Ecological Environments on the Chinese Hill-Gully Loess Plateau

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On the Chinese Loess Plateau, serious slope and gully erosion have caused a decrease in soil water capacity and fertility, which has resulted in vegetation degradation and a reduction in agricultural productivity. Great efforts have been made to restore vegetation to control soil erosion, but the efficiency of artificial revegetation is not satisfactory. Natural revegetation is an alternative. The soil seed-banks are an essential source for natural revegetation. Its presence affects both ecosystem resistance and resilience. However, their composition and distribution in different ecological environments remains unknown. In addition, whether or not seed loss during soil erosion limits vegetation colonization is also unknown. In this work, soil seed bank composition and distribution were studied in four erosion zones (sheet erosion zone, rill erosion zone and ephemeral gully erosion zone located from top to bottom along hill slopes, and water and gravity erosion zone on gully slopes) and three microsites (fish-scale pits, under tussocks, and open areas) in four sits (a southern-aspect microcatchment with a short slope and a deep gully, an eastern-aspect microcatchment with a long slope and a shallow gully, a northern-aspect microcatchment with a artificial Caragana korshinskii slope and a deep gully, and a artificial Robinia pseudoacacia slope). Soil samples were collected at depths of 0-2cm, 2-5cm and 5-10cm in April, August and October in 2008 and 2009. The soil seed bank was identified using germination experiments. The results showed that:

Characteristics of the soil seed bank changed with the ecological environments and standing vegetation. The average soil seed bank density varied from 1188~22560 seed/m2. The soil seed bank density was 3937~22560 seed/m2 in natural restoration slope, 2031~5775 seed/m2 in artificial Caragana korshinskii slope, 1437~6355 seed/m2 in artificial Robinia pseudoacacia slope, 1395~7460 seed/m2 in natural gully slope, and 1188~10969 seed/m2 in the gully sludge. Species diversity and evenness indexes in artificial restoration slope, natural gully slope and gully sludge were significantly higher than in natural restoration slope. The soil seed bank mainly distributed in the top soil (0-2 cm) with obvious seasonal fluctuation, and the seed density was highest in spring, then reduced gradually form summer to autumn.

Compared with the eroded open areas, the fish-scale pits and tussocks retained a higher density of seeds and a larger number of species. This indicated that some seeds lost with soil erosion and deposited in sedimentation area. However, there was no significant seed loss with soil erosion intensity increasing in the hill and gully slopes. The soil seed bank is not the key factor limiting the colonization of natural vegetation.

91 species were recorded in the soil seed bank, including 30 annual/biennial herbs, 11 graminoids, 35 perennial forbs, 13 subshrubs and shrubs, and 2 trees. The dominant abandoned successional species distributed widely. The pioneer species Artemisia scoparia was abundant, especially in natural restoration slope with an average proportion more than 80%. With vegetation succession, the seed density of dominant later successional species, such as Lespedeza davurica, Artemisia giraldii, Artemisia gmelinii, Stipa bungeana, Bothriochloa ischcemum, and Sophora viciifolia increased in the soil seed bank, while the proportion of Artemisia scoparia decreased to less than 30%. Most of the dominant species had persistent soil seed bank which can enhance their recolonization in the eroded environments.

Keywords：*soil seed bank, revegetation, soil erosion, Loess Plateau*

P1-99

[DS2] Soil Development and Soil Properties and Functions

Soil Nutrient Dynamics in Major Agro-Ecologies and Implications for Proper Soil Fertility Management in Nigeria

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Replanting old cocoa plantations with improved seedlings have not been successive with deficient soil nutrients being implicated in Nigeria. To stem this, three farming villages - Osu, Idanre and Ajasspr respectively represents Atakumosa, Idanre and Etung districts, which cut across the three major cocoa producing agro-ecologies in Nigeria were selected as candidate areas for soil fertility evaluation toward better cocoa plantation rehabilitation management. A soil profile pit was dug at each location, the soil profile horizons were identified and described using soil munsel color chart. Soil samples were collected from each soil horizon, labeled, air dried and routine analysis carried out for soil pH, organic carbon, total N, available P, exchangeable K, Na, Ca and Mg, H+, Al+ , ECEC and doil particle size distribution. Results indicated that the soils had organic C contents pf 5.6-29.5 g/kg soil, total N content range of 0.52-2.80 g/kg soil, available P of 1.0-56.0 mg/kg soil. The soil K, Mg, Ca and ECEC value ranges were respectively 0.24-0.70, 4.84-4.60, 4.40-11.4 and 6.67-17.79 cmol/kg soil. The OC, N and P values generally decreased down the soil profile and suggest the need for constant supply of fertilizers both as organic and inorganic sources in order to have a sustainable cocoa cropping of the soils. The soils were acidic with pH value range of 4.13-6.05 which calls for corrective measures to reduce soil acidity so that the sol could support better cocoa growth and production. The soils were high in sand with silt+ clay contents generally below 320 g/kg, especially at the 0-15 cm soil depth. This indicated that cocoa seedlings establishment would be problematic without sufficient water supply through irrigation and mulching during dry spells. This is more pronounced for Idanre and Atakumosa district soils compared to Etung. Application of organic fertilizers at 1.0, 2.6 and 1.8 t ha-1 would be needed annually at Etung, Idanre and Atakumosa respectively for sustainable soil fertility maintenance on the plantations

Keywords：*Agro-ecologies, cocoa production, nutrient dynamocs, soil organic matter, soil fertility management*

P1-100

[DS2] Soil Development and Soil Properties and Functions

Effects of Undisturbed Soil Removal of Long-Term Located Experiment on the Combined Forms of Humus and the Organo-Mineral Complexes of Black Soil

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Effects on undisturbed soil removal on the status of organo-mineral complexes and combined forms of humus of black soil were studied on the basis of long-term located experiment. Results showed that the degree of organo-mineral complexes, the contents of combined forms of humus, the ratio of loosely to tightly combined humus and the ratio of loosely to stably combined humus between different fertilizer treatments did not change after soil removal. The organic manure plus chemical fertilizers treatment had the highest fertility before and after removal, the humus of this treatment was the most active and it also had the best degree of organo-mineral complexes. The change of soil organic carbon, organic carbon in heavy fraction, the quantity of organo-mineral complexes and the degree of organo-mineral complexes of different fertilizer treatments before and after the removal were not significant. The degree of additional organo-mineral complexes and quantity of additional organo-mineral complexes were increased at first and then decreased in the two years after the removal and the change is significant. The effect of soil removal on the contents of combined forms of humus, the ratio of loosely to tightly combined humus and the ratio of loosely to stably combined humus of 0~20cm layer were not significant, but it showed a large fluctuation in 20~40cm layer. In this layer, the contect of loosely combined humus and the ratio of loosely to tightly combined humus were decreased first and then increased, the content of tightly combined humus was increased first and then decreased, there was not distinct regularity changes of the content of stably combined humus and the ratio of loosely to stably combined humus.

Keywords：*long-term fertilization, black soil, combined forms of humus, degree of organo-mineral complexes*

P1-101

[DS2] Soil Development and Soil Properties and Functions

Arsenic Removal from Contaminated Soil Using Porous Carbon-Iron Oxide Functional Nanostructures

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Rice hull is an important agriculture residues, it was reported that the world's annual rice production is 5.71 billion tons, in which the rice hull available for using is 1.44 billion tons and the annual yield of China is about 40 millinon tons. However, most of rice hull is burned as wastes, it not only waste energy but also influences the quality of air. Thus, it is urgent to make use of rice hull. In recent years, nanostructured materials have attracted acomprehensive attention because of their novel physical,chemical, and biological properties and potential use in many applications, especially those of metallic nanoparticles and their corresponding metal oxides, such as iron oxide nanoparticles, zinc oxide, and titanium oxide.We report a fast and facile method to synthesize novel porous carbon-iron oxide functional nanostructures using rice hull as raw material. Iron oxide nanoparticles are decorated on porous carbon nanostructures. This structures are observed in SEM and TEM micrographs, indicating a unique 3D ensemble of 0D iron oxide nanoparticles distributed on porous carbon nanosheets. Raman spectra and XPS indicate the presence of iron moieties in mixed valence states of FeOOH and Fe2O3. The iron oxide nanostructured materials are not only magnetically active but can also provide a great functionality in the arsenic removal from contaminated soil. This unique nanostructure greatly absorbs arsenics from contaminated soil because of increased surface-to-volume ratio and open pore network.

Keywords：*Contaminated soil , porous carbon, nanostructures, rice hull, Arsenic removal*

P1-102

[DS2] Soil Development and Soil Properties and Functions

Role of Topography and Land Use on Magnetic Susceptibility of Soils of Southwestern Iran

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Magnetic susceptibility measurements can serve a variety of applications including the determination of changes in soil forming processes and the dominant ecological conditions, the study of parent material effects, understanding sedimentation processes, soil drainage conditions, soil pollution, and even the separation and identification of soil delineations. The magnetic susceptibility (χ) of soils varies with the slope position due to some factors such as texture, drainage class and land use. The technique is especially attractive since it is relatively rapid, nondestructive, and can be applied to both intact and disturbed samples of soils and rocks. Iron oxides are the most abundant of the metallic oxides in most soils; they are present in all climatic regions, in several mineral forms, and at variable concentrations. They range between a few percent for young to almost 100% for highly matured soils. Though the χ of incipient soils closely reflects that of the parent material, divergence occurs as pedogenesis proceeds. The soils of the Southwestern Iran (Beshar Plain) formed on the relatively same parent materials and are mainly affected by topography and land use (paddy soils or dryland soils). No previous studies have been done about the effect of these factors on magnetic susceptibility and Fe oxides distribution in the soils of the region. This study attempts to link χ and Fe oxides of the soils to landforms, soil characteristics and land use (paddy and dryland soils) on the same parent materials. Nine representative pedons were taken along a transect in different physiographic units in Beshar Plain. The results indicated that χ is determined mainly by topography and land use. In most pedons, the highest concentrations of poorly crystalline Fe (Feo) were observed in the top soil with different types of land use. Aquic condition in paddy soils seems the main cause for a significant decrease in the amount of Fed in the studied soils. Maximum concentration of pedogenic Fe (Fed) was noticed in more stable landforms with non-aquic moisture regime. Paddy soils exhibited higher Feo/Fed ratio values, suggesting that they have more poorly crystalline iron oxide phases than dryland soils. Magnetic measurements showed that the χ values of paddy soils were much lower than those of dryland soils. The highest value of χ was found in the pedons located on plateau and piedmont plains and the lowest value of χ belongs to those that are located on hill and river lower terraces. A positive correlation was found between the frequency dependence of χ (χfd) and χ in paddy and dryland soils. Higher values of χfd were observed at soil surface than at deeper levels, suggesting a greater proportion of ultrafine grains.

Keywords：*Fe oxides, Iran, land use, magnetic susceptibility, soil*

P1-103

[DS2] Soil Development and Soil Properties and Functions

Effect of Nh¯4+-Zeolite on Growth Characteristics of Wheat

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To evaluate the effect of two types of soil textures and zeolite enriched with ammonium on growth characteristics of wheat and water use efficiency, a factorial experiment based on completely randomized design with three replications in greenhouse of Shaid Chamran University, was conducted in the fall of 2011. Treatments were 5% and 10% of the raw zeolite, 5% and 10% zeolite enriched with ammonium, fertilizer treatment (100 kg ha-1) and soil textures were clay loam and sandy loam. The results showed that the soil texture significantly affected on all factors of growth characteristics of wheat and water use efficiency ($P<0.01$). The plant nitrogen percentage, 1000-seed weight and seed yield were higher in sandy loam soil than in clay loam. Water use efficiency in sandy loam, was more than clay loam. None of the zeolite treatments had no significant effect on water use efficiency. The highest percentage of plant nitrogen fertilizer plants treated with ammonium-rich zeolite and 10%, respectively. The highest percentage of plant nitrogen was observed in chemical fertilizer treatment and 10% NH4+-zeolite and the highest seed yield was obtained in 10% NH4+-zeolite treatment. The highest C / N ratio was measured in treated with 10% raw zeolite in a sandy loam soil. Therefore, the application of ammonium zeolite enriched can be improved wheat growth characteristics and using less chemical fertilizer and thereby also saving on fertilizers helped to reduce environmental pollution.

Keywords：*wheat, NH4+-zeolite, soil texture, growth characteristics, water use efficiency*

P1-104

[DS2] Soil Development and Soil Properties and Functions

Effects of Intercropping on Soil Nutrients and Enzyme Activities in Continuous Taro Cropping Fields

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Based on field trials, long-term experiments were carried out to test the feasibility alleviating Taro cropping obstacles by intercropping with corn, soybean in continuously Taro cropping fields. There were 4 treatments in this experiment: continuously cropping Taro treatment (T1), non continuous cropping (T2), intercropping with corn (T3) and intercropping with soybean (T4). Soil nutrient, soil enzyme activities and the quality and yield of Taro were detected to investigate the effect of intercropping on continuously Taro cropping fields. The results of the experiments suggested: (1) intercropping could balance soil nutrient in continuously cropping fields. Available nitrogen, available potassium and organic matter content under 2 intercropping treatments in average had been increased by 9.79%, 58.21% and 71.05%, respectively, and available phosphorus had been reduced by 64.08%. (2) Intercropping could improve soil enzyme activities. Soil catalase activity, urease activity and sucrase activity under 2 intercropping treatments in average had been increased by 23.75%, 38.15% and 129.61%, respectively. In the meanwhile, the influential factors of soil enzyme activity under intercropping treatments had been converted from continuously cropping to non continuous cropping. (3) Intercropping could effectively improve the yield and quality of Taro. Yield, starch content, crude protein content and crude fat content of Taro under 2 intercropping treatments in average had been increased by 39.97%, 26.08%, 36.94% and 35.44%. Intercropping could be effective in improving Taro cropping obstacles, but there was no significant difference between treatments of intercropping with corn and soybean. Mechanisms of intercropping improving continuously cropping soil and crop yield and quality still need further study to test.

Keywords：*Taro cropping obstacles, Intercropping, Soil nutrient, Soil enzyme activities, Yield and quality*

P1-105

[DS2] Soil Development and Soil Properties and Functions

Study of Digital Photogrammetric Observation Techniques and Methods in the Hillslope Soil Erosion Processes

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How to observe morphology evolution of underlying surface and physical characterization of soil erosion from two-dimensional space is a key issue in soil erosion process observations. It also restricts our understanding in soil erosion characterization, mechanism and model establishment studies. To address this issue, digital photogrammetric observation, computer vision and theories and methods in soil erosion studies were used in the present study. Based on the capture of high-resolution digital image of underlying surface during rainfall process, digital point cloud matching, digital elevation model (DEM) generation and measurement of soil erosion, digital photogrammetric observation techniques and methods in soil erosion process were explored and established. The results showed that, the established digital photogrammetric observation system could precisely calculate the three-dimensional digital point cloud and generate the DEM from the underlying surface with a time interval <3 minute and spatial density <2 mm. Furthermore, the amount of soil erosion and geometry of underlying surface that describes the physical characterization of soil erosions could be calculated. This study can portray the evolution of the underlying surface soil erosion accurately, and it is of great importance in understanding of the mechanism of soil erosion. It also provides new methods and technique for basic researches in soil erosion.

Keywords：*Soil erosion, underlying surface, digital photogrammetric observation, digital point cloud, observat*

P1-106

[DS2] Soil Development and Soil Properties and Functions

Effects of Two-Point-Source Overlap Sewage Trickle Irrigation on the Distributions of Soil Water Content, Soil Salt Content and Wdpt

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Water and salt distributions of hydrophobic soils have important influence on the crop growth. Laboratory two-point-source overlap sewage trickle irrigation experiments were conducted to assess the effects of sewage irrigation rates on soil water repellency, water movement and salt transport. Three typical soils were selected from different regions in China. Four application rates (i.e., 1.08, 2.17, 5.0 and 10.0 ml/min-1） were calibrated. The characteristics including soil water repellency denoted by water drop penetration time (WDPT below), wetting patterns and soil salt content distributions were analyzed. The results showed that: (1) After short-term (shorter than half a day) sewage irrigation and redistribution, WDPT increased evidently. The WDPT increments for sand were the smallest, and for saline-alkali soil were the most significant. The larger the dripper discharges, the longer the WDPTs. (2) The wetting fronts for sand and Lou were both smooth. Large discharge such as 5 to 10 ml/min-1 was suitable irrigation rates for such soils. Infiltration rate of saline-alkali soil was slow and the shape of wetted zones was irregular. Low application rate (i.e. 1.08 ml/min-1 or smaller) was recommended for saline-alkali soil. (3) Power functions were good for quantifying the relationship of horizontal and vertical wetting fronts with respect to infiltration time. (4) The distributions of soil salt content and WDPT in horizontal and vertical planes were in high consistence with those of soil moisture. High soil moisture generally led to high WDPT. Saline-alkali soil with low salt content was found more hydrophobic. In conclusion, short-term sewage trickle irrigation affected distributions of soil water, soil salt and WDPT.

Keywords：*trickle irrigation, two-source overlap, hydrophobicity, soil water and soil salt distributions, cont*

P1-107

[DS2] Soil Development and Soil Properties and Functions

Improving the Productivity of Acidic Sulfate Soils of Malaysia by Using Soil Amendments for Increased Rice Yield

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Rice production in Malaysia faces many constraints. In some areas of Malaysia, rice production is limited by the presence of degraded soils (low pH, high Al and Fe(II), low organic matter) and poor inherent fertility (sandy, low cation exchange capacity, etc.). The self-sufficiency level of rice in Malaysia right now is 72% and it needs to be increased for the food reason of security. Rice production can be enhanced by increasing the area planted to rice or by increasing the yield per unit area. With no expansion in area to be expected and the slowing down in yield increase, the growth of rice production has fallen below market demand. Farmers have to depend partly on the productivity of marginal soils for their rice supply. One of the soils targeted for rice cultivation in Peninsular Malaysia is acid sulfate soil. This soil occurs exclusively in the coastal plains of the peninsula. The soil is characterized by the presence of pyrite (FeS2), which produces high acidity when the areas having the soils open up for development. Acid sulfate soils are normally not suitable for crop production unless they are effectively ameliorated. Many of this soil have nutrient deficiency, especially phosphorus which causes poor plant growth. Their pH is low (<3.5) and contain toxic amounts of Al and/or Fe. Aluminum toxicity is one of the major factors influencing plant root growth. In acid sulfate soils, Al3+ restricts the growth of roots either by inhibition of cell division, cell elongation or due to both. Rice can be grown well at soil pH above 5. This soil fertility restriction can be improved efficiently by applying amendments, such as dolomitic limestone (GML), basalt and organic materials (bio-fertilizer). A field experiment has been conducted to improve the productivity of acid sulfate rice soils using lime, basalt and bio-fertilizer. The results showed that incorporation of these amendments had increased soil pH and subsequently reduced Al toxicity. It is believed that the bio-fertilizer had produced organic acids that were able to chelate the Al, thereby reduced its toxicity. At rice harvest, higher plant height, tiller numbers, panicle numbers, leaf chlorophyll content, plant biomass and grain yield were obtained for amended soils compared to those of the control treatment. The average farmer's yield on these soils is 1.4 to 2.5 t ha-1 season-1. After incorporation of the amendments, rice yield had increased to 4-6 t ha-1 season-1. These experiments are still ongoing at this area.

Keywords：*Biofertilizer, Ground magnesium limestone, Basalt, Soil pH, Yield*

P1-108

[DS2] Soil Development and Soil Properties and Functions

The Uptake of Intact Soluble Organic N by Two Forest Species in Subtropics

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Growing evidences of direct uptake of intact soluble organic nitrogen (such as amino acids) by plants have been acquired from studies on plant types under various ecosystems. These ecosystems included not only plants under low temperature conditions, but also some temperate areas, even hot arid and tropical ecosystems. These observations indicate that the uptake of soluble organic N is related not only to the environmental factors, such as environmental temperature and inorganic N availability, but also the plant species. Furthermore, the transporters which mediate the uptake of organic N have been identified both in mycorrhizal fungi and in plant roots. It is inferred that uptake of organic N is likely to be a widespread adaptation strategy in natural ecosystems. In this study, a pot experiment was carried out on two main forest species, Cinnamomum camphora (broad-leaved forest) and Pinus massoniana (coniferous forest), in subtropics to investigate if they have the capacity and difference to uptake intact organic N and what is their preference N source. Three forms of ^{15}N-labeled N [^{15}N-$(NH_4)_2SO_4$, ^{15}N-KNO_3 and 2-^{13}C-^{15}N-glycine] were separately injected into soils (red earth) in which half a year-old Cinnamomum camphora and Pinus massoniana seedlings were planted, the shoots and roots were then harvested 2h, 6h and 72h after injection. The ^{15}N and ^{13}C excess of forest shoot and root samples were analyzed by Isotope ratio mass spectrometer. The objectives of this study were to test (1) if Cinnamomum camphora and Pinus massoniana have the capacity to uptake organic N, (2) if they do, which form of N sources is preferred by these two species, and (3) what difference to uptake organic N exists between these two species. The results showed as follows:
1. The ^{13}C abundance values after 2h, 6h and 72h injection of ^{15}N-$(NH_4)_2SO_4$, ^{15}N-KNO_3 and distilled water (CK) in Cinnamomum camphora and Pinus massoniana roots, which were in the range of -29.2‰ to -29.8‰ and -28.8‰ to -30.1‰ respectively, showed no significant difference. Those in the roots after the injection of 2-^{13}C-^{15}N-glycine, which were range of -20.4‰ to -26.7‰ and -17.5‰ to -27.1‰ respectively, raised obviously with increasing of injection time, and were significantly higher than those among treatments of ^{15}N-$(NH_4)_2SO_4$, ^{15}N-KNO_3 and distilled water, which indicated that Cinnamomum camphora and Pinus massoniana can directly absorb intact glycine molecule from the soil.
2. The ^{15}N excess values in the treatments of ^{15}N-$(NH_4)_2SO_4$, ^{15}N-KNO_3 and 2-^{13}C-^{15}N-glycine after 72h injection in Cinnamomum camphora roots were 274.62, 413.61 and 26.43 $\mu mol\ g^{-1}dw^{-1}$ higher than those in Pinus massoniana roots, indicating Cinnamomum camphora had a higher capacity to uptake ammonium, nitrate and glycine nitrogen than Pinus massoniana. The absorptive amounts of ammonium nitrogen in Cinnamomum camphora were lower than those of nitrate nitrogen, but significantly higher than those of glycine nitrogen, however, those of ammonium nitrogen in Pinus massoniana was much higher than those of nitrate and glycine nitrogen. The results suggested that the capacity to uptake soluble nitrogen from soil varied significantly with forest species.
3. With increasing of injection time, the absorptive rates of ^{15}N by both Cinnamomum camphora and Pinus massoniana roots declined gradually in ^{15}N-$(NH_4)_2SO_4$ treatment, and those by Cinnamomum camphora roots increased first and then decreased but those by Pinus massoniana roots gradually declined in ^{15}N-KNO_3 treatment, and those by roots of Cinnamomum camphora and Pinus massoniana raised first and then decreased in 2-^{13}C-^{15}N-glycine treatment. The results suggested that the absorptive amounts of soluble nitrogen by both Cinnamomum camphora and Pinus massoniana from soil decreased after a period of injection time.
4. After 72h injection in 2-^{13}C-^{15}N-glycine treatment, the excess value of ^{13}C in the shoots of Cinnamomum camphora and Pinus massoniana were significantly higher than those in the roots, and those in the shoots of Cinnamomum camphora was 2.31 times of that in Pinus massoniana shoots, but those in Pinus massoniana roots was much lower than that in Pinus massoniana roots, which indicated that Cinnamomum camphora had higher transport capacity of glycine nitrogen than Pinus massoniana. The absorptive rates of ^{13}C by the roots of Cinnamomum camphora and Pinus massoniana decreased with increasing of injection time in 2-^{13}C-^{15}N-glycine treatment, but those of Cinnamomum camphora were much higher than those of Pinus massoniana.

Keywords：*glycine, organic N uptake, Cinnamomum camphora, Pinus massoniana, subtropics*

P1-109

[DS2] Soil Development and Soil Properties and Functions

Effects of Nitrogen Deposition Rates and Frequencies on the Abundance of Soil Nitrogen Functional Genes in a Typical Steppe of Northern China

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Nitrogen (N) deposition is a commonly recognized threat which aroused concerns for negative impacts on ecosystems and dramatically increasing amount. Microbial processes driving N cycling are hot topics in wide ranges under N deposition, abundances of nitrogen functional genes (NFGs) were usually used to represent N transformation rates, nevertheless field experimental N depositions were mostly conducted through applying N plentifully once or twice which may cause substantially different predictions on ecosystems compared with natural deposition. In order to close to true effects of N deposition and test potential mis-estimate of conventional N application on N turnover, 6 N addition rates (0-50g N m2yr-1) were used to represent variability of N deposition in diverse patterns, and applied into field monthly and half-yearly to simulate natural atmospheric N deposition and to act as conventional N application respectively to quantify abundance shift of nitrogen functional genes (NFGs) involved in N transformation, including nifH for nitrogen fixation, amoA of bacterial (AOB) and archaeal (AOA) for ammonia oxidation, narG for nitrate reduction; nirS and nirK for nitrite reduction, and nosZ for nitrous oxide reduction, after 3 years' experimental N deposition. The N application amended soil available N and consequently created incremental acidity resulting from ammoxidation especially at high N rates. NFGs showed distinct sensitivities to N addition rates, excluding narG; abundances of nifH and AOB-amoA appeared more abundant when N was applied monthly and half-yearly, respectively. Sharp reduction of chiA abundances but without differences in all rates meant its extreme sensitivity to improved available N. Obviously, AOB-amoA was more responsive, however, AOA-amoA appeared to be weak indicator to N addition but dominated in absolute numbers over AOB-amoA. Abundance increases of nifH, AOA-amoA, nirK, nirS and nosZ showed at rates 10 - 20 g N m2yr-1 due to improved available N conditions; abundant decreases in relative high rates mainly resulted from pH suppression. Our findings indicate that observed changes of NFGs abundances demonstrated variable levels of chronic atmospheric N deposition and altered N cycling process diversely. The existed differences of NFGs abundances between two frequencies highlight that conventional experimental N deposition may lead to biased estimate which can not provide accurate basis for N management under the experimental condition. Optimum N addition rate for each NFG abundance should be furtherly discussed to facilitate N management.

Keywords：*Typical steppe - Nitrogen transformation -Nitrogen functional genes - Experimental N deposition*

P1-110

[DS2] Soil Development and Soil Properties and Functions

Effects of Potassium on Growth, Photosynthetic Characteristics and Yield of Camellia Oleifera Abel

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INTRODUCTION

Camellia oleifera Abel is one of the four major woody edible oil plant in the world, it is the most important edible oil tree also in low hilly area of South China. Potassium is widespread deficiency in south china, it has become the limit factors of C. oleifera Abel yield. So, different potassium level experiment was designed to search for the suitable application amount of potassium in mature C. oleifera Abel. The results of this research can provide the scientific basis for getting high yield of C. oleifera Abel.

METHODS

The trial was established in Xingzi County, Jiangxi province where a subtropical monsoon humid climate exists. Seven-year old clones of C. oleifera Abel were used in the trials. There were six fertilized treatments with 180 g N and 80 g P2O5 per plant, and their K2O levels were designed as 0 g, 60 g, 120 g,180 g, 240 g,300 g per plant. A total of 7 treatment with CK(no fertilizer). The spring-shoot length, diameter, leaf area, SPAD levels, photosynthetic characteristics and fruit yield of C. oleifera Abel were measured after one year.

RESULTS AND DISCUSSION

when the nitrogen and phosphorus are in the same level, the spring-shoot length, diameter and SPAD levels were obviously better than CK. All increased firstly and then decreased with potassium level increasing, and all of the three were better when K2O was 120 g per plant, but there were no significant differences on SPAD between six fertilized treatments. Net photosynthetic rate, stomatal conductance, transpiration rate and intercellular CO2 concentration of fertilized treatments were higher than these of CK. Net-photosynthetic rate, stomatal conductance and transpiration rate increased firstly and reached to maximum when K2O was 120 g per plant, then decreased with potassium level increasing. They were significant higher than these of other treatments. Intercellucar CO2 concentration was relatively stable no matter the potassium content was lower or higher. The proper application of fertilizer could increase the yield of C. oleifera Abel fruit. The yield was the highest when K2O was 120 g per plant, and 3449 g fruit was picked up from one plant. It was higher by 147% than that of no potassium fertilizer.The ratio of output to input was higest at potassium level, it decreased with the potassium content increasing.

CONCLUSIONS

Appropriate amount of potassium fertilizer can promote C. oleifera Abel to grow and improve its photosynthesis, increase its yield to some extent. But it was not the more the better, when K2O was 120 g per plant, C. oleifera Abel grow best, its photosynthetic effect was the strongest, and the fruid yield was highest.

Acknowledgement: This study has been supported by IPNI(Jiangxi-29) and the National Natural Science Foundation of China (31260194）

Keywords：*Camellia oleifera Abel；potassium；growth；photosynthetic characteristics；yield*

P1-111

[DS2] Soil Development and Soil Properties and Functions

Sedimentation Processes of Phosphorus in the Catena in Dam Reservoirs in the Mekong River Basin

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Introduction

In the backdrop of rapid economic growth, the Mekong River Basin now faces an increasing demand for electricity. This demand has led to a number of proposals for the construction hydroelectric dams. However, there are many unanswered questions about the genesis and nutrient cycles of the bottom environment in a dam reservoir in the tropical zone. The environments within dam reservoirs are thought to be different from that of natural lakes owing to factors such as the artificial formation of lakeshores, strong influences from past land use, and the main inflow of the tributary stream. The objective of this study is to clarify the following issues regarding bottom environments in dam reservoirs in the Mekong River Basin: 1) sedimentation process and 2) functional evaluation of reaction states for nutrient cycles such as phosphorus.

Sampling sites and analytical methods

Sediment core samples were collected from several dam reservoirs in Thailand and Laos. To investigate the sedimentation processes, the cores were sampled from the following locations within the same catena: inland, lakeshore, and the center of the reservoir. In addition to the samples from these reservoirs, samples from a natural lake, the Tonle Sap in Cambodia, were also obtained for reference.

After the morphology of the core sample was examined, the core samples were sliced vertically and the sliced samples were freeze-dried. Freeze-dried subsamples were used for the determination of total carbon and nitrogen contents, total and inorganic phosphorus contents, particle distributions, and selective dissolutions of Fe by using acid-oxalate for amorphous and dithionite-citric acid solution for crystalline oxides.

Results

The relationship between the phosphorus and iron oxide contents of surface sediments at the lakeshore in the dam reservoirs of Thailand and in the Tonle Sap in Cambodia was investigated. Iron oxide plays an important role in the phosphorus cycle in lakes owing to phosphate adsorption. Our results show that both the phosphorus and iron contents varied in each region, and a positive correlation was found between inorganic phosphorus content and iron oxide content, except for the sediments at the dam reservoirs in Laos. These results suggest that iron oxides in sediments play an important role in the retention of phosphorus in dam reservoirs and natural lakes, even in the tropics. The origin of phosphorus was not apparent but there were some areas where the phosphorus content might be increasing, probably due to human activities. This was particularly observed at the lakeshore of Tonle Sap in Cambodia.

Ratios of organic phosphorus to total phosphorus in sediments collected from the lakeshores of dam reservoirs in Thailand and Laos were higher than those from Tonle Sap. This is because a lot of organic matter is derived from plant debris and soil organic matter near land. In addition, although the origin of the phosphorus was not apparent, considerable inorganic phosphorus might be increasing owing to the activities of people on the floating villages in Tonle Sap. However, the ratios in sediments collected from the center of each of the reservoirs and the lake were not very different. It may be that accumulation processes are different at the lakeshores and at the centers in dam reservoirs and natural lakes.

In addition, vertical differences in the components of sediment cores were observed.

Keywords：*sediment, Mekong River Basin, phosphorus, dam reservoir, catena*

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[DS2] Soil Development and Soil Properties and Functions

Just a Matter of Time: Fungi and Roots Significantly and Rapidly Aggregate Soil over Four Decades in Fiume Tagliamento, Ne Italy

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Fluvial island is an emergent landform in a floodplain that is surrounded by stream-channel branches or waterways as a result of interaction between riparian vegetation, wood debris and physical system. These highly dynamical systems are therefore ideal to study soil structure development in the short to medium term, a process where soil biota and plants may play a great role. We investigated the soil structure development along a 40 year chronosequence in Flagogna reach, along a pristine river system, Fiume Tagliamento, Northeastern Italy. We quantified soil structure using several parameters, which capture different aspect of structure, and measured biotic (e.g., fungal and plant root parameters) and abiotic (e.g. organic carbon) factors expected to determine soil structure. In order to confer statistical robustness to our conclusions, the models relating soil structure to its determinants for the first time explicitly took into account spatial autocorrelation, which is here due to the space for time substitution inherent in the study of chronosequence and which could have confounded results of previous studies. We found that, despite the eroding forces from the hydrological and geomorphological dynamics subjected to the system, all soil structure variables significantly and in some case greatly increased with site age, which, given results of multivariate analyses, we interpreted as a macroscopic proxy for the major direct and indirect binding effects exerted by root variables and AMF extraradical hyphae. Key soil structure parameters such as percentage of water stable aggregates (WSA) can double from the time the land emerges (mean WSA = 30 %) to the 40 years (mean WSA = 64 %) covered by our chronosequences. This study therefore demonstrates the fundamental role of soil biota and plant roots in aggregating soils even in system where intense short to medium term eroding forces of physical nature could in principle contrast and nullify that medium to long term stabilizing effects of the biotic components.

Keywords：*river, fluvial island, soil structure, chronosequence, arbuscular mycorrhizal fungi, root*

P1-113

[DS2] Soil Development and Soil Properties and Functions

Assessing Soil Structural Quality Using Visual Examinations and Classical Tests

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Soil structure is usually evaluated by classical tests, which refer in this study to those soil properties measured in the laboratory and field such as soil organic carbon (SOC), bulk density (BD), porosity, soil resistance to root growth, hydraulic conductivity, and infiltration rate. Despite the many instruments or techniques available to measure properties related to soil structure, there are many circumstances where such tests cannot be conducted. Facing those limitations, the visual evaluation of morphological structural properties in the field is a possible alternative. The visual examination methods are not competing with but rather complementary to classical tests. Visual examination methods are now being used in several countries and showed value in explaining differences in crop performance and yield resulting from soil management and type. To provide similar information through other soil physical properties, requires several measurements and can be costly and time consuming. There is therefore a need to extend the use of visual examinations for assessing the condition of soils in the sense of soil quality and soil degradation.

This study evaluates the use and the ability of visual examinations for assessing soil structural quality (SSQ) in soils with contrasting textures and under different land uses. SSQ was visually evaluated in terms of soil morphology and a limited number of physical and chemical soil properties, was determined in the laboratory and field. The study searched for similarities in SSQ class between visual examinations [visual evaluation of soil structure method (VESS), visual soil assessment method (VSA), the type of aggregates and the visual evaluation of the degree of fragmentation and dispersion of aggregates] and classical tests [SOC, aggregate stability, BD, porosity, plant available water capacity (PAWC), and unsaturated (Kh) and saturated (Ks) hydraulic conductivity], as well as the statistical relationships between them. Samples were taken on a sandy loam and a silt loam soil, both under cereal monoculture and permanent pasture, with conventional tillage and no tillage, respectively.

Results from visual examination methods indicated significant differences between land uses and soil structure condition of the soils ($0.01 < P < 0.05$), which were confirmed by soil porosity, PAWC, wet sieving and the hydraulic conductivity at different pressure heads. Besides searching for the similarities found between the morphological evaluations and the classical tests in classifying the soil structural condition of the soil, we also sought at statistical relationships between them. A relationship between VSA and BD was observed in sandy loam soil, with $R2 = 0.50$. Relationships between VSA and SOC, porosity, PAWC and mean weight diameter (MWD) were observed in the silt loam soil, with R2 values ranging from 0.35 to 0.50. VESS was also related to SOC ($R2= 0.51$), porosity ($R2= 0.47$), PAWC ($R2= 0.35$) and MWD ($R2= 0.47$) in the silt loam soil. In the sandy loam soil, VESS was only related to K(h) at different pressure heads (0, -1, -3 and -10 cm), with R2 values ranging from 0.37 to 0.43. The type of aggregates was only related to Ks estimated from tension infiltrometer measurements ($R2= 0.40$) in the sandy soil, and with K(h) at -10 cm ($R2= 0.56$) in the silt loam soil. With regards to the visual score of the aggregate stability, in the silt loam soil, there were significant relationships with SOC ($R2= 0.89$), air capacity (AC) ($R2= 0.80$), PAWC ($R2= 0.91$) and MWD ($R2= 0.94$). For the sandy loam soil relationships were evidenced with AC ($R2= 0.65$) and MWD ($R2= 0.59$), and with K(h) at different pressure heads ($0.33 < R2 < 0.43$).

In conclusion, the present study demonstrated that visual examinations are reliable semi-quantitative methods to assess SSQ and could be considered as dependable morphological data for predicting other soil properties. Statistically significant relationships between physical and chemical soil properties on the one hand and visually evaluated SSQ on the other are promising in demonstrating the soil structural condition requested for thresholds of different predicting variables, rather than general ranges of a sole variable. Dissimilarities in terms of soil quality found between the visual examination and SOC, suggest that SOC should be used cautiously as a sole indicator for soil quality as has been proposed in literature, because SOC per se is not always well related to the soil structural condition.

Keywords: *visual soil evaluation, type of aggregate, soil hydraulic conductivity, aggregate stability*

P1-114

[DS2] Soil Development and Soil Properties and Functions

The Effect of 13c and 15n-Labelled Green Manures on the Dynamic Changes of the Soil Microbial Biomass C and N

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Three 13C and 15N-labelled green manures were cultivated by solution in advance. A certain proportion of above dried green manures and dried soil were incorporated into culture bottles. The results showed that threen green manures could increase the soil microbial biomass C and N. The effect of astragalus sinicus on the soil microbial biomass C was most significant while the effect of Lolium perenne on the soil microbial biomass N was most significant. Meanwhile, as the time of incubation advanced, the dynamic trend of soil microbial C and N showed a single peak curve. And it was at the four weeks that the soil microbial carbon was up to the highest while the soil microbial biomass nitrogen reached a peak in the first or second week. In addition, the contribution rate of green manures to the microbial biomass N was up to 0.2%-7.4%, and the microbial biomass C was up to 1.5%-21.6%. Therefore, it meaned the original soil C and N was still the main sources of energy and nutrient for soil microorganisms. However, different green manures still had different contribution to the soil microbial biomass C and N.

Keywords：*13C and 15N-labelled; Green manures; Soil microbial biomass C and N; Contribution rate*

P1-115

[DS2] Soil Development and Soil Properties and Functions

Changes in Geochemistry of Soils Induced by Foreign Soil Reconstruction Project in the Three Gorges Reservoir Area, China: Implication to Anthropogenic Pedogenetic Process

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Apart from natural soil-forming factors, human activities also play a significant role in the pedogenic process. Changes of geochemical compositions, chemical weathering features, and weathering trends of purple soils both before and after foreign soil reconstruction project in the Three Gorges Reservoir area, China were discussed in this study to reveal the influence of anthropogenic activities on pedogenic process and its role in soil taxonomy. The results showed that although origin topsoil A1, origin subsoil B/C/BC, foreign topsoil A2 and newly constructed topsoil A3 had close geochemical compositions regardless of soil types, the foreign soil reconstruction project did slightly change the major elements content of the topsoil. The distribution of major elements in each soil horizon was nearly close to that in UCC except the lower content of P and Na, and A3 was more similar to UCC than the other soil layers. Chemical index of alteration (CIA), weathering index of Parker (WIP), Na2O/K2O ratio, together with A-CN-K ternary diagrams could be applicable to identify the weathering intensity and the weathering trend of natural purple soils and disturbed soils affected by anthropogenic activities. The CIA and the WIP values, the two most commonly applied indices, were compared in this study and the outcome suggested that the CIA worked more effective than the WIP on the purple soil. Most of soil samples were in moderate chemical weathering and the degree of newly constructed topsoil A3 was higher than that of natural origin topsoil A1 and lower than that of foreign topsoil A2, which demonstrated the influence of foreign soil reconstruction project on soil chemical weathering. The foreign soil reconstruction project actually was a kind of soil anthropogenic mellowing activity, which promoted the forming of the anthropic soil. The project transformed the geochemical compositions, chemical weathering rate and soil-forming process of the purple soil. Consequently, anthropogenic activities could thicken the soil depth, change the soil weathering status, and bring more consideration into soil taxonomy.

Keywords：*Three Gorges Reservoir area; Chemical weathering; Foreign soil reconstruction project; Anthropogenic*

P1-116

[DS2] Soil Development and Soil Properties and Functions

Depth Profiling of Soil Organic Matter and Minerals Distribution Using Fourier Transform Mid-Infrared Photoacoustic Spectroscopy

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Soil organic matter (SOM) and minerals are the major solid components of soils. A major process for SOM preservation is sorption to mineral surfaces, and the sorption processes would lead to formation of heterogeneous coatings of SOM on mineral surfaces. The traditional methods for analyzing SOM will cause the destruction of SOM chemical and physical properties; moreover, heterogeneous profile information as a function of distance into SOM coatings on mineral surfaces would be lost. Thus, it is important to evaluate SOM properties with whole soil samples at different distances from the soil surface to inter in situ. In this study, fourier transform infrared photoacoustic spectroscopy (FTIR-PAS), which is widely used for convenient qualitative identification and nondestructive depth profiling of a variety of samples, are used for the challenging. The results suggest that non-destructive depth profiling of SOM and minerals were heterogeneous as a function of distance (μm) from surface. Three different layers were identified and the main compositions were: (1) 0-6 μm with O-H and C-H; (2) 7-18 μm with Si-O-H and C=O; (3) 18-25 μm with C=C.

Keywords：*Soil Organic Matter, Minerals, Fourier Transform Mid-infrared Photoacoustic Spectroscopy*

P1-117

[DS2] Soil Development and Soil Properties and Functions

A New Technology for a Controlled Tension Gradient in Lysimeters in Accordance with the Surrounding Soil

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Field lysimeters are used to gain information on the natural water balance and the substance conversion at selected soil sites. Especially the real evapotranspiration can only be measured by direct weighing of a specified soil volume. Therefore the soil volume is cut off from the surrounding soil and all the processes influencing the water balance. This might lead to unnatural water gradients in the soil column and hence to influenced data that don`t show the natural water balance. So far lysimeters have been built very long to minimize the influence of the wrong tension at the bottom of the lysimeter and simulate a free drainage into a deeper aquifer. But this approach works only for some measurement sites and is completely wrong for others. And the longer a lysimeter is built the more cost-intensive and time-consuming it is.

A newly developed control system enables to control the tension at the lower boundary of the lysimeter according to the conditions of the surrounding soil. Porous ceramic cups connected to a control system and a pump are installed between soil and gravel filter at the bottom of the monolith. The ceramic cups are water filled and the water inside the ceramic cups is connected to the soil water through the pores of the ceramic transmitting the pressure. Therefore by controlling the pressure inside the ceramic cups the water pressure in the surrounding soil can be controlled.

A tensiometer in the undisturbed soil outside the lysimeter station provides the reference value for the tension to be adjusted at the bottom of the monolith. If the outside tension is higher than the inside tension in the same depth the pump adjusts a negative pressure to the water inside the ceramic cups which is then transferred to the soil. Hereby water is sucked out of the soil. To be able to account for that water in the water balance it is recorded with a tipping counter before being discharged or being collected for further analysis. If the outside tension is lower than the inside tension the pressure inside the ceramic cups is raised and water from a water reservoir is pushed back into the soil lowering the tension at the bottom of the monolith.

This way the tension at the bottom of the lysimeter as lower boundary condition always accords the present tension in the surrounding soil and both systems have the atmosphere as upper boundary condition in common which causes the same tension in the soil close to the surface. This leads to a natural tension gradient inside the lysimeter.

Data from a test site in Müncheberg (Germany) show that this system controls the tension to an accuracy of 0,5 kPa and has a response time of less than 30 min. To get an even faster response time and higher accuracy graded ceramic cups with different pore sizes (and different air entry points) can be used and switched on and off by an additional control panel according to the flow rate that is needed to adjust the tension. Thus the controllable flow rate at the lower boundary of the lysimeter can be fitted to the ku-function of the surrounding soil.

Keywords：*Lysimeter, Tension, Tension control, Boundary condition*

P1-118

[DS2] Soil Development and Soil Properties and Functions

Forest Soils and Vegetation of the Mediterranean Region of Croatia

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The study of the relationship between soils and vegetation of forest habitats in Croatia was started in 1948, and complex investigations of forest habitats, with the aim of establishing the most suitable stand form for specific habitats, have been carried out since 1963. On the basis of comprehensive scientific research material, resulting from the above investigations, a survey was produced of the main members of the pedological-vegetational sequence for the region of Croatia, and specific soil was associated with each vegetational unit.

In the region of Croatia Euro-Siberian-North American and Mediterranean forest regions are in close contact. The whole of the Adriatic coast and Croatian islands are dominated by the Mediterranean region, which is vertically divided into two belts: coastal and montane. The coastal belt (Mediterranean-littoral) comprises three forest zones: stenomediterranean – forests of Aleppo Pine, eumediterranean – forests of Holm Oak and submediterranean – forests of Oriental Hornbeam and Pubescent Oak, and the montane belt (Mediterranean-montane) comprises two zones: hemimediterranean – forests of Dalmatian Black Pine with Holm Oak, forests of Holm Oak and Hop Hornbeam and epimediterranean – forests of Pubescent Oak and Hop Hornbeam. Between the Euro-Siberian-North American and Mediterranean region stretches an area of littoral Beech forest (Seslerio autumnalis-Fagetum sylvaticae) which spreads over almost the whole of the southern slopes of the Dinaric massif, above forests of Pubescent Oak and Hop Hornbeam.

The largest part of the Mediterranean region of Croatia has a basic Mediterranean type climate (Csa according to Köppen) with dry, hot summers and mild, rainy winters. A smaller part belongs to the peri-Mediterranean transitional belt, which has stronger continental climatic influence, due to its contact with montane Croatia.

The geological parent material of this region is mainly formed of limestone of Mesozoic and Palaeogenic age, and less of dolomites and deposited layers of flysch. The most frequent types of soil in the forest zones of the coastal belt are: skeletic, eutric, rhodic, chromic Cambisols, colluvic, eutric, skeletic Regosols, rendzic Leptosols and to a lesser extent rhodic, chromic Luvisols. In the zones of the montane belt, at higher altitudes and steeper sites, the most frequent types of soil are: molic Leptosols and leptic, colluvic Cambisols, while at lower altitudes rhodic, chromic Cambisols are most common.

Keywords：*Soils, vegetation, Mediterranean Croatia*

P1-119

[DS2] Soil Development and Soil Properties and Functions

Long-Term Monitoring of Technogenically Eroded Soils in Primorsky Krai (russia)

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A detailed investigation of territory being subject to the impacts of the lead smelter emissions since 1929 was carried out in the 1975-77s. The study area is located on the Sea of Japan coast. The key sites located at different distances from the emitter and differing in intensity of the technogenous impact were selected on the basis of the spatial distribution in the soil cover of major pollutants (lead, cadmium and zinc). The first key site was situated within a zone of maximum impact of technogenous emissions on the territory adjacent to the lead smelter. Here, the vegetation and upper humic soil horizons are fully destroyed. The surface looks like the technogenic desert. The second and third key sites were chosen within zones of the moderate and weak impacts. Morphological characteristics of all landscape components within these zones are satisfactorily expressed.

The first investigation of key sites was made in 1977 while the second one in 1989. Within this time interval, the smelter has operated with increasing volumes of production. The third study of key sites was performed in 1998. This time period is characterized by progressing stagnation of production. The fourth investigation was accomplished in 2012 after the enterprise operation was terminated some years ago. Differences in the enterprise operation resulted in differences in intensities of impacts of the technogenous emissions on the environment. In order to reveal the response of soils to dynamics of the impact in each key site, the randomized collection of soil samples was carried out. The samples were taken at points of the square grid with the square side length of 4 m. In each key site, 30 samples were taken. Within zones of the weak and moderate technogenic impact of the third and second key sites, the samples of humic horizon of 0-2.5 cm thick were collected. Within a zone of maximum technogenic press of the first key site, the layer-by-layer, at depths of 0-2.5; 2.5-5.0 and 5-10 cm, sampling of eroded soils was performed. For all samples, the acidity of soil, organic carbon content, total content of heavy metals and content of two mobile species of metals were determined.

In the report, the statistically processed quantitative estimates of the dynamics of actual acidity of eroded soils obtained over the whole period of investigations (1977-2012) will be presented.

Keywords：*eroded soils, long-term monitoring, soil acidity*

P1-120

[DS2] Soil Development and Soil Properties and Functions

Changes in Properties of Different Soils Exposed to Paddy Management

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Cultivation of rice under submerged conditions results in distinct soils (paddy soils). Paddy soils may originate from many different parent soil types. Management includes artificial submergence, ploughing, and puddling and cause a dense plough pan and redox-related transformation and re-distribution of minerals and soil organic matter (SOM) with depth.

The Research Unit “Biogeochemistry of Paddy Soil Evolution” aims at identifying the major processes in paddy soil development. First, we studied a chronosequence in the coastal region of the Zhejiang Province (PR China). Soils were either used as rice paddies, or, adjacently, for a variety of non-inundated cultivation of other crops. This unique chronosequence allowed for quantifying rates of paddy soil formation in direct comparison with soils under non-paddy management. Our data indicate three fundamental phases of paddy soil development: During the first decades after land embankment (initial phase), soil formation is driven by short-term biogeochemical processes such as desalinisation, establishment of paddy-specific microbial communities, and the development of a dense plough pan, which partly decoupled topsoil from subsoil processes. During the next two centuries (intermediate phase), dissolution of carbonates prevails. Frequent flooding and drainage accelerated decalcification as compared to soils under non-paddy agricultural management. Soil organic matter contents constantly increase in paddy topsoils. Within the paddy soil profile, we identified two time domains above and below the plough pan: while processes in the regularly flooded topsoil are much faster compared to non-paddy topsoils, decalcification and related processes in the subsoil are only slightly accelerated due to the decoupling impact of the plough pan. After decalcification of the entire soil profile, long-term mineral transformations (final phase) begins. Mn and Fe oxides become dissolved upon reduction in the topsoil, pass the plough pan and re-form in the subsoil, mainly within in the interiors of the aggregates.

However, it is unclear to what extent parent soils – often differing strongly in mineral assemblage and organic matter – control the development of paddy soils. Thus, the second part of the study aims at investigating the impact of paddy management on mineral

assemblage, SOM, and other soil properties as compared with agricultural soils not used for paddy rice production. We focus on major soil types typically used for rice cultivation in Asia, including Acrisols (sub-tropical monsoon climate, PR China) as well as Andosols, Vertisols, and Ferralsols (tropical climate, Java, Indonesia). Paddy soils as well as adjacent agricultural soils not used for paddy rice production (non-paddy soils) were sampled by horizon. Samples were analysed for bulk density, pH, electrical conductivity, organic carbon (OC) and total nitrogen, oxalate- as well as dithionite–citrate–bicarbonate-extractable Fe, and the mineral assemblage of the fine earth (<2 mm).

Paddy soils derived from Acrisols (PR China) are characterised by larger OC concentrations in the puddled topsoil horizons, resulting in larger cumulative OC stocks in paddy soils than in the respective non-paddy soils. Other soil types do not show an increased OC sequestration under paddy management. Paddy soils derived from Ferralsols and Vertisols of Java have similar OC concentrations and stocks as the respective non-paddy soils. Even paddy and non-paddy soils derived from Andosols (Java) show similar OC concentrations and depth distributions. Other properties differ significantly between paddy and non-paddy soils at all investigated sites. Paddy management always causes significant depletion of crystalline Fe oxides in the topsoils (puddled horizon and plough pan), often followed by an accumulation of crystalline oxides in deeper horizons. The share of short range-ordered Fe oxides, in turn, depends much on the original share. In soils with little short range-ordered Fe oxides (Ferralsol & Acrisol), their share increases. In the Andosol, where short-range ordered Fe oxides are more dominant, their concentration decreases. But the crystalline Fe oxides decrease at the same rate so that the share of the short-range ordered Fe oxides remains nearly unchanged. To summarise, rice production under submerged conditions alters redox-sensitive constituents such as iron oxides. Parts of the changes are linked to the properties of the original soil type. Also, paddy management does not always increase carbon sequestration. Thus, the original soil types control direction and extent of the development of paddy soils.

Keywords：*Phases of pedogenesis; paddy soils; parent soil type; soil organic matter; soil mineralogy*

P1-121

[DS2] Soil Development and Soil Properties and Functions

Examination of Background Variables During Soil Ph Determination by Remote Sensing

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Determining soil heterogenity is an important part of the precision farming that is supported by geoinformatic systems. Our working group is focusing on the development of optical methods to determine the physical and chemical soil parameters. Soil pH is a basic determinant of soil nutrient supply capacity. The detection of the soil acidity is not easy because only the indirect effects of surface pH can be analyzed through reflected spectra. It is important to consider that optical effects which were generated by the pH change can mix with the effects of the organic matter or clay content. Experiments of Seilera et al. (2007) has proved that the pH change is caused by the concentration change of OH group. This can be measured by the evaluation of the reflection spectrum. The quantity of the OH group is in relation with the quantity of acid groups in the soil.

Our research focuses on the indirect determination of soil acidity. The examinations were carried out by ASD Fieldspec R3 Max equipment of the Hungarian Institute of Agricultural Engineering, Godoll?. The equipment is a portable hyperspectral spectroradiometer, by which reflection spectra can be detected on 350-2500 nm. The detections were carried out under precisely set conditions in the laboratory. Our long-term objectives are first to understand and clarify the relationships and then to utilize our experiences by the application of AISA DUAL airborne sensors under field conditions.

We examined the hyperspectral reflection spectra of a calcareous sandy soil. We changed the pH and the calcium carbonate content of the soil samples with different amount of hydrochloric acid treatments. Reflection spectra were detected of the air-dried soil samples, and the absorbance peaks were detected within the wavelength range specific for water.

Within the 1900-2000 nm wavelength range, the height of the peaks specific for OH group and the pH values of the soil samples showed strong quadratic correlation (R2=0.95). The question arises whether the pH change is indeed influencing directly the infrared (IR) absorbance? We examined the relationship between some other soil parameters of our samples and the peak heights of certain absorbance. The CaCO3 content of the originally calcareous soil samples decreased according to the acidifying treatment. We examined the relationship between the calculated CaCO3 content and the obtained IR absorbance peak heights within the previously mentioned wavelength on the original and the treated soil samples. In this case, we obtained strong quadratic correlation (R2=0.97) as well. This result is not accidental at all, since it is widely known that the CaCO3 content of soils and its pH shows strong correlation. Based on our experiments we obtained strong quadratic correlation in this case as well (R2=0.97). It can be assumed that there is such a background variable behind the relationship between the IR absorbance and the pH value that shows strong correlation with both parameters. Based on our examined samples, this background variable can be the soil moisture content. We measure this component directly by IR absorbance on the given wavelength range. Since we acidified our soil samples with hydrochloric acid, the CaCO3 formed calcium chloride based on the treatment. The calcium chloride is strongly hygroscopic, thus under the same humidity conditions, the soil samples treated with hydrochloric acid have higher water content after reaching the equilibrium. The pH values of the soil samples and the moisture content of the air-dried soil samples showed strong linear correlation (R2=0.87). The different soil moisture content of the soil samples was measured by weight differences. To determine soil moisture by weighing in the laboratory is easy to carry out, however, if we want to develop a method that can be used in precision farming, then the soil moisture content has to be determined by remote sensing. Hyperspectral spectroradiometer can be utilized for such a purpose. However, the differences in soil moisture content result in the change of absorption peak height that can be evaluated well within several wavelength ranges. The most intensive and the most evaluable peak is within the range of 1900-2000 nm.

Keywords：*hyperspectral technology, soil acidity, humidity*

P1-122

[DS2] Soil Development and Soil Properties and Functions

Estimation of Soil Texture Using Observed Soil Moisture in an Oasis of the Heihe River Basin, Northwest China

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In the past few years, progress has been made in estimating soil texture using remote sensing based on the relationship between soil moisture and soil physical properties. Previous studies have shown that the spatial and temporal changes of soil moisture are significantly related to soil physical and hydraulic properties during the drying phase. This relationship can be used to estimate soil particle size distribution and thus soil texture classification especially in low-relief areas where topographic co-variables related to soil texture do not vary greatly.

The 25-km2 area considered in this study is an oasis of the Heihe River Basin, northwestern China. It seemingly exhibits homogeneous soil forming factors, so it is difficult to predict soil properties using traditional covariates supposed to represent soil forming factors. Therefore a time series of field-observed soil moisture variations was used as a covariate with the aim of estimating soil surface texture at a local scale. The soil moisture was recorded for 132 hours beginning at the end of irrigation when the surface soil was saturated. We used ordinary kriging based on 96 field-observed soil moisture points to map the soil moisture spatial distribution. We found that the variation of soil moisture increased with increasing clay and silt content, and so decreased with increasing sand content. The spatial distribution of soil moisture changed during the entire drying phase. We hypothesize that these changes are caused by soil texture. Therefore, the spatial correlation between two time-adjacent soil moisture conditions was used to select cluster factors. As soil moisture decreased, the changing spatial variability pattern, assumed to be caused by soil texture variation, was represented by the moisture content difference between the two adjacent time periods. This index of soil moisture difference was then used as input in fuzzy c-means clustering method. Ten classes were generated. In each class, the soil sample with the maximum fuzzy membership was taken as the typical one. Finally, a linearly weighted average function was used to infer soil texture from the typical values.

Accuracy assessment was carried out based on 64 independent field samples. The validation root mean squared error values of clay, silt and sand were 1.63%, 2.81% and 3.71% respectively; and the prediction total accuracy was 90.43%, 96.23 and 87.17% for clay, silt and sand, respectively. With these experiments and results, we show that it is possible to reliably estimate soil texture from observed soil moisture data in the plain oasis region.

Acknowledgement: This work was supported by the Natural Science Foundation of China (No.41130530, 91325301).

Keywords：*Digital soil mapping, Soil moisture, Soil texture, Fuzzy c-means clustering*

P1-123

[DS2] Soil Development and Soil Properties and Functions

Measuring Cadmium in Soils and Leachate Water Using Double Mixed Layer DGT in a Sandy Soil

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P fertilizers are added to the soil to maintain soil fertility and high crop production. Some P fertilizers may be naturally contain Cd or be contaminated with it. The relation between the application of phosphate fertilizers as part of agriculture process and the accumulation of Cd in soil and plants has been studied broadly over several decades for health risk assessment and to preserve healthy agricultural production. Labile Cd is bio accessible to plants, therefore increasing of labile Cd in soil from P fertilizers application may cause the accumulation of Cd in plants. A diffusion gradient in thin film (DGT) is a diffusive passive sampling device developed for quantitative determination of labile metals. DGT has been used to measure different kinds of elements in water, soil and sediments. Recently, DGT has been developed by using titanium dioxide–based adsorbent (Metsorb- DGT) mixed with the chelex to obtain the mixed binding layer which is called Metsorb- chelex DGT (MC- DGT). This paper reports on the results of this techniques being applied to soil for measuring the concentration of Cd added to soil via P fertilizer application. A large flume experiment (8m long x 30cm wide x 80cm deep) was carried out to evaluate the performance of DGT, with Metsorb Chelex mixed binding layer gel, in detecting and adsorbing Cd in a sandy loam soil put into the flume to the depth of 60cm. The flume was set at 1% slop for all experiment. Drainage tubes were installed at 1 meter intervals along the length of the flume at 15 cm and 45 cm depth below soil surface The MC-DGTs were deployed in two depths of 15cm and 45cm in the soil. P fertilizer was added to the soil by dissolving the Single Super Phosphate (SSP) fertiliser in tab water in three concentrations (0.01, 0.1, and 0.5) mg/l The DGTs were removed from the soil after three deployment times of 4 days, 7 days and 14 days. At each deployment period 2 DGTs were removed for P and Cd measurements. Phosphorus measurements were performed spectrophotometrically, utilizing the standard molybdenum blue method. Cadmium was measured by inductively coupled plasma mass spectrometry (ICP-MS). The leachate water samples were collected daily for 14 days. The results show that MC-DGT is capable of accurately detecting the labile specie of Cd and P in the soil and leachate water even at very low concentrations. There was highly significant correlation between deployment time and the accumulation of labile Cd and P adsorbed on the Metsorb-chelex adsorbent layer. MC- DGT adsorption increased with increasing the SSP fertilizer dose and there was highly significant relation between fertiliser dose and the concentration of P and Cd adsorbed on the Metsorb Chelex mixed adsorbent layer. In addition the MC - DGT has proved its ability to function effectively for fourteen days of deployment in the soil.

Keywords：*DGT, Cadmium measurement, Phosphorus measurement, P fertilizers, Cd transport in soil*

P1-124

[DS2] Soil Development and Soil Properties and Functions

Soils and Land Use Potential in Central Province of Png

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Knowledge of soil morphology and chemical fertility at key agricultural research and demonstrations sites is fundamental to the development and extension of agricultural production systems. Developing countries are often challenged by incomplete and/or sparse spatial data that does not capture the variability in soil type, fertility and other key limitations to productive and sustainable use. While it is not possible to overcome all land use limitations in a short term project, a strategic approach that targets areas that have potential for intensive agricultural development can be used to best focus limited resources. This approach has been used in Central Province of Papua New Guinea. This province consists of lowland and elevated areas with vastly differing soil types and land use limitations. Here we report on profile characteristics and soil fertility of potentially productive soil and site combinations identified at research stations and from organised farming cooperatives in the district. The data show some of the wide diversity in soil physical and chemical characteristics in the province. The implications of these soil data for agricultural development and productivity are discussed.

Over all in PNG the understanding of the quality of soil resources is fundamental to development of sustainable agricultural production systems. In many developing countries, soil resources are described at an aggregated level, as in Bleeker (1983) and Hanson et al. (2001) for Papua New Guinea (PNG), but this is usually inadequate for decision making on cropping practices for long term sustainability. In this study, existing information on soils and land capability in Central Province PNG has been further supported by profile examinations of soils identified as having potential for sustainable agricultural development. Soil types in PNG are highly variable due to the landscape being affected by active geological processes, significant climatic gradients and variable topographic features in a high relief terrain. Land capability and land use potential is also highly variable (Hanson et al. 2001). This paper reports on profile characteristics and chemical fertility of soils identified as having potential for intensified vegetable production in coastal and elevated regions of Central Province, and identifies practices needed for sustainable production.

We found the variation in chemical soil fertility means that assessment of soil fertility and thus the need for fertiliser inputs or other soil and crop management strategies will be needed on a site-specific basis. We also found soil physical conditions were variable, however, the overriding interpretation is that careful management will be needed to maintain favourable conditions at all sites, though some are more susceptible to degradation than others.

Keywords：*soil, PNG, land, vegetables, nutrients, chemistry*

P1-125

[DS2] Soil Development and Soil Properties and Functions

Spatial-Temporal Distribution of Soil Salt Crusts in the Taklimakan Desert Highway Shelterbelt of Northwest China

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The Taklimakan Desert Highway Shelterbelt is well-known as “Great Green Wall”, which borders a 436 km length and 72-78 m width of the highway. As a result of drip-irrigation with high salinity groundwater (2.8~29.7 g L-1) coupled with high evaporative demands, solute salt have accumulated and soil salt crust (SSC) have widely distributed on soil surfaces in the shelterbelt. Because of high soluble salt content, SSC is one potential threaten to the shelterbelt plants. Especially, soluble salt could leach into plant roots zone and destroy the plant growth under unexpected strong rainfall. Thicknesses and electronic conductivities (EC) are two main characteristics of SSC. By sampling and analyzing, in this study, we examined the development process and spatial-temporal distribution of SSC on soil surface of the shelterbelt under high saline groundwater drip-irrigation in hinterland of the Taklimakan Desert. The results showed that: (i) EC of irrigated area and wetting front increased over time within the irrigation times, whereas EC of outside of the irrigated area remained stable; (ii) EC of SSC increased firstly then decreased as departing from the dripper horizontally; The thickness of SSC changed greatly within the range of 40 cm from the dripper with the maximum of thickness at 40 cm, and changed slightly out of this range; (iii) Topography has a great effect on the spatial distribution of salt crust. The thickness and EC of SSC on upslope position of dripper were larger than downslope position; and (iv) The thickness of SSC increased with formation age in the early development stage of shelter-forest, but gradually tended to a constant. EC of SSC increased in the early planting stage of shelterbelt, and then decreased gradually with the shelterbelt age. Our finding reveals SSC development and spatial-temporal distribution in the Taklimakan Desert Highway Shelterbelt under high saline groundwater drip-irrigation that can contribute to salt injury prevention in this region.

Keywords：*Taklimakan Desert, Sandy soil, Saline water, Drip-irrigation, Soil salt crusts, Spatial-temporal dis*

P1-126

[DS2] Soil Development and Soil Properties and Functions

Variability of Soil Properties along Selected Toposequences in Mt. Makiling Forest Reserve, Philippines

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Topography affects soil properties, especially in mountainous areas where slope steepness, curvature, and length varies. Soil-landscape relationship or toposequence study is important in conservation of mountainous areas. In the Philippines, several forests, even those classified as protected areas, are in danger because of the increasing rate of migration brought about by the increasing population in low-lying areas. The Mt. Makiling Forest Reserve (MMFR) is no exception. The forest reserve covers the municipalities of Los Baños, Bay, and Calamba in the province of Laguna, and the municipality of Sto. Tomas in the province of Batangas. It has a total area of about 4,224 hectares. Mount Makiling Forest Reserve not only serves as an educational and research resource but also an important watershed reserve. It has an exceptional diversity of flora and fauna. Residents around and within the forest reserve view it as an excellent economic resource. There are about 1,000 people currently living inside the reserve boundaries. Urbanization along the fringes of MMFR has also become a problem. This study was conducted to determine the effect of landscape position on soil properties in geologically young soils of Mt. Makiling. Transects were made on the north and south facing slope of the mountain. Samples were taken from 13 pedons at different elevations ranging from 200 meters to 1100 meters. The pedons were located at the interfluve, convex creep slope, transportational midslope, and colluvial footslope. Pedon were characterized based on their morphological, physical, chemical, and mineralogical properties. Soil pH(w) ranged from 4.6 to 6.2. Soils located at elevations of 600 meters and above (pedons 8-13) have pH values of more than 9.8 in 1M NaF. Pedons 8 to 13 had higher organic carbon content than those pedons sampled below 600 meters. Bulk density and particle size distribution of the soils were also determined. Soils were also analysed for chemical properties such as CEC, exchangeable bases, and available phosphorus. Clay mineralogy of the soils were determined using X-ray diffraction. The soils were also characterized using the Soil Taxonomy framework. Results of the analyses showed variations in terms of soil profile development at different landscape positions.

Keywords：*toposequence, soil-landscape relationships, Mt. Makiling Forest Reserve*

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[DS2] Soil Development and Soil Properties and Functions

Soil Chemical Properties of Selected two Herbs Intercropped With Paraserianthes Falcataria at Degraded Forest Area in Tangkulap Forest Reserve, Telupid, Sabah

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A study on Cymbopogon nardus (Serai wangi) and Ocimum basilicum (Selasih) inter-cropped with Paraserinathes falcataria has been carried out at FMU 17B, Tangkulap Forest Reserve, Telupid, Sabah. This area managed by Maxland Forest Plantation Sdn Bhd. The main objectives of this study were to determine the soil chemical properties of C. nardus and O. basilicum using organic fertilizer and to determine the relationship of growth performance of herbs between the soil chemical properties. Randomized Completely block Design (RCBD) was used with four treatments (T1=20 g, T2=40 g, T3=60 g, T4=control) for C. nardus while (T1=30 g, T2=60 g, T3=90 g, T4=control) for O. basilicum. The results showed that there were significant different among the mean values for C. nardus and O. basilicum such as total N (%), available P (cmol+/kg), exchangeable K (cmol+/kg), exchangeable Mg (cmol+/kg), exchangeable Ca (cmol+/kg) and exchangeable CEC (cmol+/kg). To sum up, the macronutrients play a crucial role in affecting the growth performance of selected herbs under the degraded soil condition and potentially to be applied in such disturbed forest.

Keywords：*degraded soil, intercropping, macronutrients*

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[DS2] Soil Development and Soil Properties and Functions

Soil Nitrogen and Phosphorus Availabilty Under Hypersaline Conditions

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Prediction of soil nitrogen (N) and phosphorus (P) availability in highly saline-submerged soils is crucial to optimize the growth of algae and to sustain Artemia cyst production in the solar saltwork in coastal areas of the Mekong Delta. This study was carried out to aim at revealing the effects of hypersaline conditions on soil N and P availability and finding the correlation between the amounts of dissolved N and P released from the pond sediment and the pools of these nutrients present in soil.

Our results from laboratory incubation experiments showed that the hypersaline conditions existing in Artemia ponds have an effect on both N and P availability. Increasing salinity to 80 g L-1 (EC 108 dS m-1) resulted in less mineral N accumulation at the early stage of submergence. However, adverse effects of high salinity on N mineralization are short-lived. In the later stages of submergence, the rate of net N mineralization recovered. On another hand, extremely high salinity enhanced P availability and mobility. At saline concentration of 70 g L-1 (EC 84-94 dS m-1), the concentrations of dissolved reactive P (DRP) present in the water column were 1.5 to 2 fold above the concentrations of DRP in the extracts with lower salinity (EC 11-23 dS m-1). Disturbing soil by daily raking of the pond bottom sediment to feed Artemia offered favorable conditions for the release and maintenance of available N and P. Under these conditions, the availability of N and P to algae utilization can be reliably predicted based on some soil chemical properties: the presence of available inorganic N (DIN) after submergence can be predicted from the fractions of soil labile organic N extractable by hot KCl; whereas the pools of Olsen-P and/or 24-h DRP in equilibrium can be used as indicators to estimate the availability of P.

Keywords：*nitrogen, phosphorus, hypersaline, saline-submerged soils*

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[DS2] Soil Development and Soil Properties and Functions

Feedbacks Between Litter Decomposition and Weathering in Young Sandy Soils

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Within the framework of studying initial ecosystem develoipment at the constructed catchment Chicken Creek (Elmer et al. 2013), soil development and the function of initial soils in the transformation and cycling of nutrients are of high relevance (Schaaf et al. 2011). We studied the effect of litter decompositon on soil properties and functions in a microcosm experiment under controlled conditions. Two types of parent material used for the construction of the aquifer at Chicken Creek were filled into soil columns. The substrates differed in physical and geochemical properties. Litter from two dominating plant species found at the catchment (Calamagrostis epigejos and Lotus corniculatus) was added to the soil columns and irrigated for 80 weeks at constant temperature and water flux. Controls with litter only and substrates only were included and all treatments werde carried out in four replicates each.

Decalcification was higher in the loamy sand columns compared the pure sand columns despite lower initial carbonate contents. Decomposition rate differed between the two litter types depending on C/N ratio. Lotus litter decomposed faster and mineralized nitrogen was nitrified resulting in increased carbonate dissolution and calcium leaching from the columns. Potassium released by decompositon was highly retained in the soils exept for the pure sand + Lotus treatment which showed high potassium leaching after 80 days.

By integrating litter from two types of plant species reflecting grass and herbs with wide distribution within the catchment and two soil substrates representing the main textural and geochemical variation of the sediments used for catchment construction we were able to characterize the general function of these sub-patches within the catchment with respect to litter decomposition, soil solution composition, nutrient leaching, and effects on the soil mineral phase. Overall, the results suggest that initial differences in substrate composition in combination with invading vegetation may lead to the development of patterns with different biogeochemical process intensities within the catchment. These patterns are not mere additive effects of substrates plus litter, but reflect feedback mechanisms in element transformation and cycling and could result in an increasing heterogeneity of soil properties, nutrient availability and element fluxes with time.

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Keywords：*soil development, soil function, decalcification, nitrification, nutrient leaching*

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[DS2] Soil Development and Soil Properties and Functions

Influence of Organo-Mineral Composts on Agrochemical Properties Serozem Soils of Uzbekistan

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Optimizing soil fertility and agro-chemical soil properties are currently of great importance, since the content of humus and nutrients from year to year decreases. The reason for decline of soil fertility is the lack of organic fertilizers and use of crop rotation involving leguminous perennial herb. On the other hand a source of organic fertilizer can be municipal solid waste. Currently in the cities of Uzbekistan accumulated huge amount of solid waste whose disposal is an environmental necessity (Alikhanov, 2003; Kholikulov, Pardaev, 2003). In this regard, great importance is the disposal of household waste from organic urban agriculture and provide organic fertilizer

Introduction.

According to the Committee for Nature Protection of the Republic of Uzbekistan waste used as organic fertilizer, municipal solid household waste are 30 million m3, cattle-breeding complexes, more than 25 mln.m3 manure. In recent decades the tendency to reduce the stock of organic fertilizers and the increase of urban waste. Therefore there is a need for joint use of organic and urban waste as fertilizer to add nutrients to the soil and improve the ecological situation. The criterion for the use and removal of organic fertilizer from urban household waste is the content of heavy elements such as Zn, Cu, Ni, Mn, Cr and others, as well as humus acids. The focus is on the content of heavy elements found from the composition of urban waste, as some of which is micro. Composted manure urban household waste meets the demand of the soil at the macro and micro elements. Without a scientifically sound study can not be the application of urban waste. Since they are composed of substances that adversely affect the environment and soil fertility. Therefore, we must first learn how to pre-disposal waste and wagging on the environment and soil fertility. To this end, studied the possibilities of composting of municipal solid waste, the floor rotted manure, wheat straw and sludge ponds, as well as the impact of these composts on the agro-chemical characteristics of the typical serozem soil Zarafshan Valley.

Methods.

For these purposes, were studied by means of composting, recycling them. Composts prepared different ratios of carbon to nitrogen, which strongly affects the maturation and chemical composition of the digest. Composts were prepared in the field of urban waste, manure, mud and straw in different ratio (by mass). making compost and manure is applied at doses of 30, 60 t/ha and those with a dose of mineral fertilizers repeated. The method of conducting field experiments and laboratory analysis of general acceptance (Radov, 1978; Petukhov, 1985).

Results.

Chemical analysis shows that the studied organogenesis wastes differ significantly in chemical composition. When making compost narrow ratio of C:N in the soil increases microbial processes, including decomposition of humus, and increases the content of ammonium nitrate and potassium. When making compost wide ratio of carbon to nitrogen increases the processes of immobilization of mineral nitrogen, which reduced the content of mineral nitrogen in the soil at the beginning of the experiment.

However, the average growing season of cotton under the action of the compost increases the content of ammonium and nitrate nitrogen. Application of composts in three consecutive years in one plot increased the humus content in serozems, especially when making compost with a wide carbon to nitrogen. Introduction of composts against the background of complete fertilizer has contributed to increasing the mineralization in the soil, leading to higher content of available plant nutrients serozems. These processes were particularly noticeable in making nitrogen fertilizers in composting options. In the application of composts in a dose of 30 t/ha in three years not had an increase of heavy metals in soil for up to maximum allowable concentrations. The application of compost, humus content increases. Compost, which dominates the manure has an advantage in its influence on the content of organic matter. Since stocks of organic matter in the 0-50 cm layer so the option has increased by 4.8 t/ha, and the remaining compost only 3.9-2.7 t/ha. The combination of compost fertilizers provide additional accumulation of organic matter in soil. Making compost positively affect the amount of absorbed bases, especially by divalent cations and the enrichment of the soil organic matter. To increase the effectiveness of composts to increase in their share of manure.Investigation of the content of total and mobile forms of trace elements and heavy metals have shown that the introduction of compost had no significant effect on the change in their content. Consequently, the introduction of composts significantly affect the nutrient status serozems. Conclusion.

Thus, recycling of municipal solid wastes by composting with manure, straw and mud is a viable and environmentally safe and to make these composts in a dose of 30 t/ha within three years significantly increases the content of mobile nutrients in the soil and improves agrochemical properties serozems.

Composting of them considered the most important and acceptable way of disposal of hazardous and hazardous household solid waste. Thereby we solve two problems, waste disposal and lack of organic fertilizers.

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Keywords：*City hard domestic waste, serozem soil, humus, fertilizers, mineral, organic, soil type, cotton.*

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[DS2] Soil Development and Soil Properties and Functions

Physicochemical Impact of Irrigation with Treated Wastewater on Soil: Case Study of Cebala Borj Touil Perimeter (tunisia)

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A growing demand for water for agricultural irrigation has produced a marked increase in the reuse of treated wastewater worldwide. Wastewater has been widely used for agricultural irrigation in countries located in arid or semi-arid areas. A study was carried out at Cebala Borj Touil, Tunisia, to test the feasibility of using secondary treatment wastewater and to determine whether the water quality would then meet the recommended irrigation norm. The area was irrigated with treated wastewater (TWW) since 1989. Physical and chemical variation properties of the soil were measured after and before an irrigation cycle, eventually pH, salinity, ionic composition and heavy metals (Pb, Cu, Zn, Ni, Co and Cr). It has been shown that soil pH is basic, an increase of salinity in depth a dominance of sodium (Na> Ca> Mg >> K) and an increase in salinity in depth. All heavy metals concentrations are below the maximum allowable. Compared to the average total content, some exceedances are observed for the Pb, Cu and Zinc. Overtaking is lightweight for Ni.

Keywords：*irrigation, treated wastewater (TTW), soil*

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[DS2] Soil Development and Soil Properties and Functions

Fertility of Soils of Zarafshan Valley of Uzbekistan and its Change Under the Influence of Natural and Anthropogenic Factors

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Introduction. The current state of fertility of soils of Zarafshan valley of Uzbekistan, and also formation and change of fertility of soil under the influence of various natural and anthropogenic factors is discussed. As a result of recent research and field experiments, the estimation of a role of alternation of agricultural practices (, applications of fertilizers, irrigation and ground waters, processing of soil, type of soils, mechanical structure, , relief) the effect on fertility of cultivated soils is given. Now, in connection with an intensification of use of the earths appreciable decrease in fertility and deterioration of properties of soil, dehumification and desertification is shown. All it, basically, is connected with maintenance or decrease of humus content at the expense of strengthening of its mineralization. In this connection studying of fertility of various types and subtypes of soils of the mechanism of formation and decrease in fertility of soils is of great importance.

Methods. Expeditionary study the relief, a bias of fields, type, a subtype and a soil kind, of ground waters, mechanical structure, alternation of cultures, the agricultural technician of cultivation, cultivate fields, application of fertilizers and other indicators are studied. On genetic horizons chemical and agrochemical properties of soil are defined. In different conditions the Zarafshan valley with different cultures by methods cotton Institute and the Institute of Soil Science and Agricultural studied humus mode and agrochemical soil properties. Field experiments, on studying of influence of mineral, organic fertilizers, alternations of cultures on agrophysical, agrochemical and microbiological properties of soils are spent. Biometric accounts, phenological supervision and laboratory analyses are spent by the standard techniques.

Results. In the conditions of the Zarafshan valley of Uzbekistan, with increase in an arrangement of fields above sea level, the climate changes and the quantity of an atmospheric precipitation increases that positively influences vegetation and their biomass. At low height of district above sea level basically deserted soils are formed: takyr soil, the grey-brown, meadow deserted. In them contains water soluble salts much, in it is soil – an absorbing complex much cation sodium, however the maintenance humus in most cases low. With transition in a valley, there is a zone serozem soils where with height increase passes with light on typical, with typical to a dark serozem soil. In mountain conditions brown, brown soils are extended. The highest maintenance humus is observed in mountain soils, and the lowest – in deserted. But in a deserted zone in flood-lands and I and II terraces of the river Zarafshan are extended such meadow soils where age and a thickness of soil very high, the maintenance humus from top to down on a soil profile does not vary almost because of formation powerful humus horizon. These soils highly cultured also are used by the person since very old time. However, in a deserted zone there are new irrigated soils where the thickness of soil at all does not reach 50-70 fertility of these soils very low, the maintenance humus about 0.5% see. From the point of view of agriculture serozem soils have great value. They are formed on loessial parent breeds and the thickness of these soils reaches to 3 meters. Of ground waters too is of great importance in formation of not salted soils and their fertility. At close of ground waters meadow processes develop, the soil is well provided with a moisture that is important in the conditions of an arid zone and field agriculture. Thus basically meadow soils are formed. In them it is a lot of humus, in comparison with serozem soils and consequently they are more

fertile, than other soils. Meadow soils of the Zarafshan valley, basically are formed in alluvial adjournment. On mechanical structure meadow and deserted soils easier, than serozem soils. Mechanical structure of serozem soils – middling and heavy loam and clay, meadow soil and other soils of a deserted zone – sandy, sandy loamy and easily loamy. With weighting of mechanical structure of soil its fertility and the maintenance humus raises. Sandy loamy and sandy soils are most low fertile. With degree increase cultivate – fertility of soil, its thickness, maintenance humus raises that favorably operates on cultivation of agricultural crops. From anthropogenesis factors a kind of cultivated cultures, their alternation, a crop rotation, mineral and organic fertilizers, soil processing, an irrigation and the agricultural technician of cultivated cultures, technogenic pollution of soil are of great importance in formation of fertility of soil. Forwarding researches show that at cultivation of fruit crops and lucernes the maintenance humus raises. Cultivation cultivated cultures, such as a cotton, tobacco and corn leads to maintenance decrease humus. So, at cultivation of tobacco and after it wheat the maintenance humus was in arable horizon of 0.86%, in under arable horizon – 0.84%, and at 2 summer cultivation of a lucerne, accordingly 1.08 and 1.07%, and under an orchard (apple-tree) – 1.34 and 1.10% that it is possible to see for example soils of Urgut region. Now the world has witnessed the deterioration of soil fertility by reducing the quality and content of humus. These processes go many long years everywhere in many countries. So, according to Rozanov, Targulan & Orlov (1989) if average annual loss of carbon in a kind humus in last was 1000 years 31.3 tons for last 300 years – 300 million tons, and over the last 50 years – 760 million tons. In Uzbekistan too last 50-80 years the maintenance humus is lowered on 50% (Tursunhodzhaev et al., 1977; Muhamedjanov, 1978; Sattarov, 1990). Application cotton-lucerne crop rotation slows down processes dehumification and mineralization of organic substance. The long stationary experiences spent in Samarkand and Tashkent where influence of a monoculture and cotton-lucerne a crop rotation on fertility and humus a condition of soils and efficiency of fertilizers in these conditions (Tursunhodjaev & Bolkunov, 1987; Geltser & Lasukova, 1934; Khashimov et al., 1990). Comparison of fertility and humus conditions of virgin soils with the arable show that soil processing promotes a fast mineralization humus at the expense of aeration strengthening. The maintenance testifies to it humus under cultivate cultures. But long agriculture on irrigation at processing of soil with application grassland agriculture systems of a crop rotation and organic fertilizers promotes preservation of fertility of soils that it is possible to see in old irrigated highly cultured soils. Conclusion. Field experiments show that the mineral fertilizers brought in high doses promote mineralization strengthening humus and to factor decrease humification organic weights, is thus formed «extra» nitrogen. Organic fertilizers increase the maintenance and qualitative structure humus. Agrophysical, agrochemical and microbiological properties of soil thus improve. Fertility of soils of the Zarafshan valley is formed under the influence of various natural and anthropogenesis factors, change, their combinations, parities and quantities leads to change of fertility of soil.

Keywords：*Fertility, soil, the factors natural, anthropogenesis, properties, humus, fertilizers, mineral, orga*

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[DS2] Soil Development and Soil Properties and Functions

Change of Temperature and Humidity of Soil at its Regulation

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Introduction. It is studied influences mulching soils by a polyethylene film on temperature and water modes of irrigated typical grey soils of a foothill zone of Samarkand region of Uzbekistan. It is established that mulching soils a polyethylene film promotes essential rise in temperature of soil especially in the spring when weather is still cool. Besides mulching raises humidity of soil in comparison with the control, safe a moisture in soil. Regulation of a temperature and water mode of soil is of great importance. As moisture preservation in soil in the conditions of irrigated agriculture is actual. Intensive evaporation in arid zones leads to an exhaustion of soil moisture and to the over-expenditure of irrigation water that is the big problem at shortage of irrigated water. On the other hand in the conditions of a foothill zone the spring and warm days favorable for vegetation of plants of tobacco come much later, than in other areas of region. It leads to late crops of tobacco and truncation of the vegetative period of plants. Therefore rise in temperature and humidity of soil has great value in creation of an optimum thermal and water mode of soil for growth and development of plants. These purposes studying are mulching soils a polyethylene film is actual. For influence research mulching a polyethylene film on temperatures and humidity of soil put field experiments.

Results. Results of the spent researches show that mulching soils a transparent polyethylene film essentially raises soil temperatures, especially its top layers, with transition in the bottom horizons the difference between the control and mulching a variant in soil temperature decreases. After 30 cm horizon influence mulching soils a polyethylene film on soil temperatures sharply decreases. Mulching raised temperatures of soil depending on time of days, horizon and supervision terms on 1,9-5,50C in an arable layer and on 0,8-1,60C – in arable under soil a layer. The highest difference in soil temperature between the control and mulching a variant was observed 1500 hours days. Evening, night and early morning hours rise in temperature at the expense of use of a polyethylene film was observed less considerably. Mulching soils with a polyethylene film most of all operates on temperatures of soil of second half of day. The reason of it is accumulation and solar energy preservation under the polyethylene film, got there in first half of day. In the evening and at night in soil the solar energy does not collect, and is spent. Therefore the evening a difference in soil temperature between these variants gradually decreases. Mulching polyethylene film most of all raises temperatures of soil in the spring, when cool weather. According to other authors, the polyethylene film well passes the infra-red beams, playing the basic a role in soil heating. On the other hand the polyethylene film does not release through itself heat and beams in outside. At mulching soils a polyethylene film the expense of heat on evaporation of moisture from soil decreases two times, returns of turbulent heat in atmosphere is reduced to 17 %, heat stream coming to soil increases by 25 % (D.B. Sipris, V.I.Revut, 1974). Condensation of pair water under a film does not promote leaving reflected by the earth of solar radiation.

esults of it, mulching with a polyethylene film of soil positively operates on a thermal mode of soil raising its temperatures. Study of average daily temperature show that the polyethylene film with mulch increases soil temperature in spring and early summer from day to day until June 20. This pattern is observed and compared with the control and respect in the past days. After June 20, raising the temperature of the soil by mulching it is significantly reduced. In all periods of observation and measurement of soil

temperature increase this figure by mulching the soil with polyethylene film was more substantial in the upper soil horizon. When you go to these lower horizons of the difference in soil temperature between the control and mulching option is gradually reduced. Thus, in 5 cm soil depth the difference in temperature in different phases of plant growth was 2,5-4,50C at 10 cm depth-2,1-4,20C, 20 cm depth-2,3-4,00C, depth of 30 cm-1,9-3,00C, 40 cm depth -1,4-2,50C, 50 cm depth -1,0-1,60C. Thus, after 50 cm depth soil temperature in both variants become almost the same form that is the influence of mulching on soil temperature in these horizons do not wake observed. Mulching considerably operates and on humidity of soil. At mulching humidity of soil, a stock of a moisture to a meter layer raises. It is especially appreciable before next irrigation. After the termination irrigation the difference in humidity of soil gradually increases and reaches to the maximum before next irrigation. Increase of humidity of soil at mulching is observed all vegetative period. It creates an optimum water mode of soil for plants. So, before the first irrigation in the control in a layer of 0-30 cm humidity of soil was 12,5 %, in horizon of 30-50 cm – 15 %, in 50-100 cm a layer – 16,9 %, in mulching a polyethylene film of soil accordingly – 15,5; 17,2; 18,0 %. Before the second irrigation in the control humidity of soil on horizons accordingly was 10,5; 13,4; 15,6 %, in mulching variant – 14,6; 15,7; 17,2 % (tab. 1). The reason of increase in humidity of soil at mulching polyethylene film is the delay of pair water and reduction moisture evaporation under a film. Besides, at mulching the volume weight decreased, the soil structure that promotes decrease in evaporation of water and an effective utilization of a soil moisture more remained. Increased soil moisture under polyethylene film mulching has led to an increased supply of moisture in all soil horizons. In the transition to the lower horizon of the soil profile moisture reserve increases. During the irrigation in the control and mulching variant aligned supply of moisture. However, a week after watering is the difference between these options in the stock of moisture increases substantially. Then, this difference increases gradually until the next watering. The difference in moisture reserves remain at the end of the growing season. Mulching changing volume weight of soil, porosity, structures positively influenced water penetrations of soil. At mulching soils a polyethylene film speed absorption waters during the first hours experience about 64,0 mm/hour to 94,5 mm/hour essentially increases. The same data is received by other authors in the conditions of Uzbekistan at cotton cultivation (Sh.Kholikulov, 1976; K.Ochilov, 1992; I.Turopov, 1994; Kholikulov Sh.T., Goziev T.2004; Goziev T, 2006).Optimization of temperature and humidity of soil at mulching its polyethylene film have created good a condition for growth and development of plants of tobacco. Thus growth of plants, and quantity of leaves total it essentially increased has led to increase of productivity of tobacco on 6,2 t/h at mulching soils in comparison with the control.

Conclusion. Thus mulching irrigated serozem soils at tobacco cultivation in foothill zones increases temperature and humidity of soil, its water penetration, especially in the top horizons that positively influences growth, development and productivity of plants tobacco.

Keywords：*Temperature, humidity, mode, soil, regulation, mulching, polyethylene film, tobacco, productivity.*

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[DS2] Soil Development and Soil Properties and Functions

Electrostatic Properties of Permanent Charge and Variable Charge Soil Inorganic Colloids

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Variable charge of inorganic colloid for four types of soil with variable or permanent charge in China under different pH values was measured by using back-titration method. Results show that: (1) There exists one peak on the curve of variable charge amount-pH value (Qv~pH) for every testing soil sample while the pH value of the system is about 5. Maybe it relates with different behaviors of Fe, Al etc between sample titration solution and reference titration solution. Normally, the negative variable charge amount of inorganic colloid in permanent charge soil is higher than that in variable charge soil. The main reason is probably that the content of kaolinite and Fe, Al oxides in former soil is much less than those in later soil whereas the content of 2:1 type clay minerals in them is opposite. (2) The shapes of Qv~pH curve of inorganic colloid in variable charge soil and permanent charge soil are similar. The amount of variable charge in inorganic colloid of soils tested is various with different kinds and content of clay minerals and Fe, Al oxides. For example, goethite is possibly the source of variable negative charge at pH 3~4; gibbsite, pH 4~5; hematite, magnetite, pH 5~7 and Al-OH, pH 8~10. For the same clay mineral or Fe, Al oxides, the amount of variable charge is changed with the pH value in the system. The higher pH value, the higher of variable negative charge derived from H+ dissociation of Si-OH in tested soil inorganic colloids.

Keywords：*Back-titration, Electrostatic properties, Variable negative charge, Inorganic soil colloids*

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[DS2] Soil Development and Soil Properties and Functions

Capability of Tuff and Tuff Derived Soils in Carbon Stabilization

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This study had been carried out in order to evaluate the capability of tuff and tuff derived soils in carbon storage. The capability of pyroclastic rocks (volcanic ash) in development of Andic property the roles of organic matter, mineralogy and physico- chemical properties in carbon storage were investigated. The Rock were crashed and passed through 10 mesh sieve. Six Soil and four rock samples were selected for treatment with for levels of organic matter (0, 3, 6 and 10 percent) with three iterations: totally 48 rock and 72 soil samples were incubated in laboratory condition (at 23-250C and 0.8 field capacity). Evaluation of the results showed All of the studied soil have andic properties such as (¬pH NaF > 10.3, phosphate retention48-60 percent, Alo+1/2Feo>0.54 %. Similar trends were observed about the effects of organic matter on carbon storage between the studied rocks and soils samples (0.9-6 percent in soils) and (1.2-5 percent rocks). Also the effects of organic matter on total Fe in soil samples (2.29-5.35 percent) were more than rocks (1.16-3.85 percent). Physical properties such as ¬(saturation, Field capacity and, wilting point moisture), mean weight diameter of aggregates by wet sieving, soil texture and clay mineralogy were determined. Microscopic properties such as (glass content, size, color and limpidity of volcanic glass) on thin sections of rock were determined. Finally, this study showed that studied pyroclastic rocks have capability organic carbon storage with high speed and the supply of enough organic matter can quickly lead to andisol formation.

Keywords：*Tuff, Volcanic Ash, Organic Matter, X-ray diffraction*

P1-136

[DS2] Soil Development and Soil Properties and Functions

Water Holding Capacity of Agricultural Soils

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Water holding capacity of soils belongs to the important soil properties and determines the extent to which the soil is able to hold water in its profile for longer time. This ability of soil is not stable and depends strongly on textural composition. Total amount of retained water depends also on soil depth and the type of bedrock. Soil ecological units represent a set of codes characterizing the soil and the other environmental properties. They are grouped in a comprehensive database (BPEJ database) and have map output. Given the above and the fact that soil ecological units contain information directly applicable in the evaluation of water holding capacity, they have been used to create a database of water holding capacity for each soil ecological unit. Water holding capacity of soil was determined on the basis of pedotransfer rules and represents typical values of this soil property in individual soil ecological units. The aforesaid does not mean that the real value of water holding capacity is not different from the characteristic values of this parameter derived using pedotransfer rules. This fact may reflect the impact of external factors on soil, which may significantly affect water holding capacity.

Keywords：*water holding capacity of soil, pedo-ecological units, soil texture, soil depth, pedotransfer rules*

P1-137

[DS2] Soil Development and Soil Properties and Functions

Silver Transport in Soils: Infuence of Zinc

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The focus of this study was to quantify the transport of silver (Ag) in soils having distinctly different properties. Miscible displacement experiments were carried out where a pulse of Ag in the form of Ag(NO3)2 in a background solution 0.005 M Ca(NO3)2 was applied to a uniformly packed soil column where steady flow in soil columns was maintained. Olivier loam, Webster loam, and Windsor sandy soils were used in this study. Batch experiments were carried out to quantify Ag and Zn sorption isotherms for each soil using batch methods after 24 equilibration. All isotherms were nonlinear in nature where a Freundlich model well described the adsorption results. The exponent Freundlich parameter b was less than 1 for soils which is indicative of the extent of heterogeneity of Ag ad Zn in all soil. Webster soil, with highest clay content, exhibited highest sorption for both Ag and Z whereas Windsor soil exhibited higher affinity for Ag than for Zn.

Miscible displacement results from the soil columns indicated that Ag was highly mobile with low affinity and limited retardation of the breakthrough curves (BTCs). The extent of Ag trartport varied among soils and was consistent with results adsorption isotherms results. A high maximum (peak) concentration in the effluent solutions was observed and is a characteristic of limited Ag retention reactions with soil matrix surfaces. Moreover, the BTCs for Ag indicated little tailing during leaching or release which indicate that fast retention reactions are dominant. For all soils, silver recovery in the effluent solution ranged from 65% to 84% of that applied.

The presence of Zn in the applied pulse solution (in the form of Zn(NO3)2) resulted in enhanced Ag transport with lower affinity of Ag for all soil. Earlier arrival of the BTCs for Ag was observed in the presence of Zn. The difference in Ag arrival in the effluent ranged from 2 to 10 pore volumes. In addition, enhanced Ag recovery was observed in the presence of Zn for all soils. The range of recovery Ag was 77% to 96%. In fact, for Olivier soil, complete recovery of Ag was attained in the presence of Zn. These results suggest strong competitive sorption of Ag-Zn in soils

Keywords：*Transport, silver, zinc, retetntion, miscible displacement*

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[DS2] Soil Development and Soil Properties and Functions

Structure and Function Relationships in Microbial Communities: a Heat Shock Experiment

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Over the past 50 years, there has been intense research and debate in the field of ecology about the significance of biodiversity in ecosystem function. Among this biodiversity, microorganisms living in soil are abundant and highly diverse, with estimates of up to 109 cells (Gans et al., 2005) and 104 species (Curtis et al ., 2002) per gram of soil. These microorganisms are the key player of many soil functions such as biochemical cycling (Weedon et al., 2011). Highly diversified and functionally redundant (Torsvik and Øvreås, 2002; Allison and Martiny, 2008), microbial communities are one of the major soil components that ensure the sustainability of ecosystem services (Coleman and Whitman, 2005). In this work, the soil functions and community structure relationship was evaluated by heat shock stress in microcosm. It was expected that decreasing the overall diversity by this treatment would also cause a decrease in functional redundancy, especially for those functions associated with more specialized microbial groups. We selected two plots with well known soil management practices, including a long-term arable cropping plot (>10 yr) and a permanent grassland (>25 years). The conventional crop (CC) had a history of long-term cropping (wheat, maize, flax or beet). Soil functions were evaluated by measuring enzyme activities: cellulase (CEL), N-acetyl glucosaminidase (NAG), β-glucosidase (GLU), xylanase (XYL) and Dehydrogenase (DES). The total microbial biomass has been assayed by the quantification of total DNA extracted from soil. Abundance of bacterial and fungal communities and the relative abundance of targeted bacteria taxa were measured by q PCR RNA genes. For both soils, in most cases, results showed immediate effects following warming treatment. All enzymes were inhibited except the xylanase activity for which the effect of temperature was transient for crop soil whereas it has been stimulated by 140% in grassland soil. Soil warming significantly reduced total microbial biomass and fungal abundance in both soils. Abundance of total bacterial community was not affected by heat shock. In both soils, the dominant taxa were Actinobacteria (13–40%) and Bacteroidetes (14–32%), while the Planctomycetes and Gammaproteobacteria had lower abundance (0-3%) and the abundance of all other groups ranged between 0.1 and 14%. The difference in enzymatic activities response may be related to differences in the soil microbial community composition. As stress reflects agronomic reality or is away from natural conditions, it changes the microbial community structure and can lead to changes in biological functions. These changes may have important consequences in soil ecosystem services or ecosystem resilience.

Keywords：*enzymatic activities, soil microbial community, heat stress*

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[DS2] Soil Development and Soil Properties and Functions

Chemical Attributes of a Degraded Soil by Mining in the Mine Serra Da Onca, Amazona Basin, Brazil, Under Reclamation

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The exploration of mineral resources promotes soil and environment degradation because it needs the natural vegetation removal. The soil organic matter is destroyed and the soil fertility decreases. The tin mining in Serra da Onça, located in the Jamari National Forest, State of Rondônia, Brazil, caused hard physical, chemical and biological changes in the soil. In 1997, the area was split in plots and it was initiated a recovery program, which consisted in the modeling of land, erosion control, liming, green manure, mineral fertilization and the planting of native species . In the next years, new plots were set to be recovered, to which it was applied the same retrieval program. Annually the plots received a score from 1 to 10 according to the soil coverture and the plants status and soil was sampled (0-20 cm) for chemical analysis.. The objective of this work was to evaluate soil chemical properties in twelve plots in that mine that were submitted to reclamation by this program. The experiment was installed in a randomized blocks design with three replications. The data were compared among them and with samples collected around the mine in area with the soil under native vegetation or coppice. Visual observation of the aspect of the plots let us to give a score 7 for all them. The data showed that the chemical attributes of the plots under reclamation were very similar to those of the coppice, then considering that they were auto-sustainable.

Keywords：*mineral resources, environment degradation , Amazona Basin*

P1-140

[DS2] Soil Development and Soil Properties and Functions

Biological Tillage Effect on Macropore Network and its Consequences for Gas Diffusion

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Crop sequences are commonly suggested as an alternative to improve subsoil structure without the intervention of machinery. A better structure can be used by future crops to take advantage by reaching better growing substrate. Our hypothesis was, that due to the root systems of specific crops, an enhanced macropore network will be created, consisting of wide biopores and inter-aggregate pores (cracks) which significantly influences gas transport.

We analyzed three preceding crops with shallow roots (Festuca arundinacea, fescue), taproot-herringbone (Cichorium intybus, chicory) and taproot-multibranch (Medicago sativa, alfalfa). The crops where cultivated for one, two and three years. Undisturbed soil cores were taken for gas diffusion, air permeability and air-filled porosity measurements. A double chamber experiment allowed the monitoring of oxygen diffusion through a soil core for determination of the relative diffusion coefficient under transient conditions. The change in oxygen concentration in both chambers (in a logarithmic scale) against time gave a measure for the initial gas transport mainly occurring in the more organized coarse macropores, which were associated with biological drilling (root activity creating macropores). In this way, the existing macropores could be separated into high and low functional for gas transport. Furthermore, the cores (equilibrated at -15 kPa matric potential) were scanned to visualize the existing pore network with X-Ray computer tomography. By means of 3D image analysis, geometrical features as pore size distribution, tortuosity and connectivity of the pore network were assessed and compared to commonly used empirical approaches.

The diffusion measurements showed an increased relative coefficient for the taprooted cultivations (alfalfa and chicory). A better soil structure (related to shrink-swell processes) under alfalfa was interpreted from the calculated tortuosity index, which was confirmed by the measured mean tortuosity by image analysis. A break point in the diffusion/time curve was clearly visible under alfalfa and chicory cultivation, which means that an exponentially higher gas diffusion took place in the high functional macropore network (mainly root paths, earthworm channels and shrinking cracks). The presence of these high functional coarse macropore networks was also confirmed by results from 3D image analysis. Under chicory, higher connectivity and lower tortuosity of pores positively influenced the gas transport, although the amount of this macroporosity was significantly lower than under alfalfa, which lead to a lower relative diffusion coefficient. Significant differences between the three treatments on diffusion and pore network geometries were only observed after three years of cultivation.

Keywords：*oxygen, diffusion, functionality, macropore,*

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[DS2] Soil Development and Soil Properties and Functions

Effect of Different Pastures Improvement Strategies on the Functional Resistance and Resilience of the Porous System of an Andisol Under Sheep Grazing

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INTRODUCTION

Most of grasslands in southern Chile have some degradation level, therefore, different improvement strategies, such as fertilization of degraded grasslands and establishment of new pastures are carried out to increase production levels. As grazing is carried out all year round, the soil is under both mechanical and hydraulic stress (Dec et al., 2012).

This may change physical quality of soil, which can be tested by resistence and resilience of pore system (Gregory et al., 2009). Hypothesis states that pore system of soil under pastures with lower intensification management level, would have greater resistance and resilience both in mechanical and hydraulic stresses. The aim of this study was to assess effect of different improvement strategies for degraded naturalized pastures with sheep grazing on the resistence and resilience of an Andisol under laboratory mechanical and hydraulic stresses.

MATERIALS AND METHODS

The study site was the Agricultural Experiment Station (39º48' S, 73º15' E, 12 m.a.s.l) Universidad Austral de Chile, Valdivia and it was carried out in September 2011. Undisturbed soil samples (n=9 collected in cylinders of 230 cm3) were taken in different pastures as Lolium perenne and Trifolium repens (T1) and multispecies (T2) of Lolium perenne, Dactylis glomerata, Bromus valdivianus and Trifolium repens. On the other hand, the same was repeated in a naturalized pasture without fertilization (T3), naturalized with fertilization (T4) and naturalized without fertilization and without grazing (T5), all of them with Agrostis capillaris, Hypochaeris radicata, Anthoxathum odoratum and Rumex acetocella as prevailing species. Furthermore, cylinders were done with sieved soil T3 (T6) to simulate the structure absence effect. All treatments were subjected to an equivalent mechanical and hydraulic stress (80 kPa).

Two water retention curves were determined at matric potentials of 0, -1, -2, -3, -6, -15, -30 and-50kPa, before and after stress conditions. Capacity parameters were established, such as, air capacity (AC) and plant available water (PAW) and intensity parameters, such as air permeability (ka), and two pore continuity index (C2 and C3) of macropores. Furthermore, unidimensional soil deformation was measured in every tension in order to determine coefficient of linear extensibility (COLE) and pore shrinkage index (PSI).

RESULTS AND DISCUSSION

Mechanical stress decreased AC favoring PAW, whereas the opposite occurred with hydraulic stress, due to cracking which allows soil structure formation (Dorner et al., 2011). ka, C2 and C3 shows a level decrease tendency after compaction, but no clear trend appears after hydraulic stress for same parameters. In every condition, soils under different pastures maintained capacity and intensity functions. All treatments for both kind of stresses didn't reach critical level proposed by literature. COLE in macropores increased after mechanical stress, however, hydraulic stress improved soil structure by COLE decrease. PSI increased after compaction, but no major differences where found because compaction does not have significant influence in shrinkage capacity of macropores. By improving structure, hydraulic stress decreased PSI since macropores are more stable in this kind of stresses.

CONCLUSIONS

Comparing different improvement strategies of degraded pastures, no great differences were observed both in resistance and resilience, taking into consideration the capacity and intensity parameters as well as the soil mechanical strength. Still, there is a tilling effect when comparing pastures with completely homogenized soil, which simulates a strong and recent tillage. Finally, stresses can occur both at the same time and space but bringing different consequences on the soil: while the mechanical stress destroy the structure by soil compaction, the hydraulic one improve the structure by cracking.

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Keywords：*Resistance and functional resilience porous system, Andisol, prairie improvement.*

P1-142

[DS2] Soil Development and Soil Properties and Functions

Total Applied Energy Versus Cavitation Intensity: How Soil Aggregate Stability Can be Accessed Using Ultrasound?

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The soil aggregate stability has been intensively studied in Soil Science, because soil aggregation is closely related to important soil attributes and processes, such as: soil porosity, water infiltration, soil aeration, hydraulic conductivity, surface sealing, compressibility, soil erodibility and carbon stabilization. Using ultrasonic energy to assessing the soil aggregate stability, the energy level needed for breaking and dispersing the aggregates is easily determined. Moreover, it is possible to have an overview of the soil aggregate hierarchy. Expressing the ultrasonic energy in J mL-1 of soil-water suspension or J g-1 is the main way the applied energy has been shown. We hypothesized that this is not a suitable way, since the same total applied energy can be obtained from different combinations of sonication time and power level [E(Joules) = P(Watts).t(seconds)]. Thus, this work aimed to evaluate the effect of interaction between time and ultrasound output power on the stability of soil aggregates. It was used a sonicator probe-type insert (2.5 cm) in a soil suspension (10 g oven dry-basis of aggregate sized between 4 and 8 mm in 250 mL of distilled water). The soil aggregates were obtained from an Oxisol (0-5 cm layer) under coffee production in Brazilian Savanna and submitted to ultrasonic irradiation under different output power levels and times: (i) 20 W during 500 s; (ii) 30 W during 333.33 s; (iii) 40 W during 250 s and (iv) 50 W during 200 s. In all these conditions the total applied energy was 10,000 J (40 J mL-1 or 1,000 J g-1). After each sonication, the soil aggregates were wet-sieved (2 mm, 1 mm, 0.5 mm and 0.25 mm sieves), the mass of aggregates and or particles that were retained in each sieve was oven-dried (105° C) for 48 hours, weighted and finally calculated the amount of aggregates in each size fraction (4-2 mm; 2-1 mm; 1-0.5 mm; 0.5-0.25 mm; and < 0.25 mm). Our results show that despite the total applied energy was the same, different responses on soil aggregate stability were obtained. The cavitation intensity seems to be more efficient or has more effect on soil aggregate breakdown and dispersion. This statement is true once that the binomial “high output power and short-time” had more effect that “low output power and length of time”, although the combination of these conditions had produced the same amount of energy.

Keywords：*ultrasonic energy, soil aggregates, soil disruption*

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[DS2] Soil Development and Soil Properties and Functions

Effect of Variation in Parent Material on Growth and Yield of Hevea Brasiliensis (para Rubber)

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Soils suffer a considerable depletion of fertility as a result of monoculture of industrial and economic tree crop species. This is exemplified by Hevea brasiliensis (para rubber) tree in its growing cycle and yield of latex. On the basis of the premise that soil nutrients influence the growth and yield of para rubber and that the age of the para rubber tree has an impact on the fertility status of soils, a study was conducted in April to November, 2010 to evaluate soils developed over predominantly granite and phyllite deposits in the rain forest ecological zone of Ghana, West Africa.

The area experiences a bi-modal rainfall pattern with about 1700 mm. The main rainy season is from April to July with a peak in June and a minor rainy season from September to November with a peak in October. Relative humidity is very high averaging between 75 % to 85 % in the rainy season and 70 % to 80 % in the dry season. The highest mean temperature of the district is 34 °C which is recorded between March and April, while the lowest mean temperature of 20 °C is experienced in August. The field had been cultivated to rubber since 1960. The topography is generally undulating, except certain portions within the plantation where gentle and few steep slopes occasionally occur. The field is approximately 260 hectares and was divided into upper, middle and lower slope segments using random sampling technique. A reconnaissance survey was conducted to randomly select soil catenae at both locations. Soil catenae of 7, 17, 40, 48 years of rubber cultivation on the granite and 13, 15, 36, 38, 52 years of rubber plantation on the phyllite were selected for the purpose of evaluating the influence of soil parent materials and ages of rubber plantation on the physical and the chemical properties of soils. These two parent materials served as the basis for blocking the field. Each catena was divided into three slope segments being the summit, the middle slope and the valley bottom. Twenty nine soil profiles were dug, described and classified as per the guidelines of World Reference Base for Soil Resources, following from the Ghana Soil Classification System. Each location had five replicates. Geographical Positioning System points were picked from the selected spots where profile pits were dug. Soil profile pits measured 1 m x 2 m x 2 m deep. Three different spots were randomly sampled within each genetic horizon and bulked. A composite soil together with a duplicate were analyzed for particle size density, bulk density, moisture content, pH, organic carbon, total nitrogen, available phosphorus, available potassium, exchangeable acidity, percentage base saturation, cation exchange capacity, micronutrients (zinc, iron, manganese and copper). The data were subjected to statistical analysis, mainly summary statistics, principal component analysis and analysis of variance, using the Genstat statistical software.

Nkwanta series was identified on the summit of both parent materials and classified differently as Xanthic, Plinthic and Haplic Ferralsols due to different formative elements present at different physiographic units. The middle slope segments had Eutric Cambisol (Asume), Ferralic Cambisol (Atewa) and Plinthic Ferralsols (Asikuma). Gleyic Arenosol (Temang) and Eutric Gleysol (Kakum) occupied the lowlands. The Land capability sub-classes identified were: IVtf, IVef, IVtwf, VIsf, IVwsf, Vsf, Vf on the granite and IVetf, IVstf, IVsf, IVwf, VIwf, Vwf and VIswf on the phyllite, based on USDA Soil Survey Manual. With the use of Maximum Limitation Method, Xanthic, Plinthic and Haplic Ferralsols were marginally suitable while the Eutric Gleysol and Gleyic Arenosol were not suitable mainly for rubber. Principal components, PC1 and PC2 isolated per cent sand, per cent silt, cation exchange capacity, percentage base saturation, organic carbon, total nitrogen and available phosphorus as the key soil attributes influencing growth and yield of rubber and impact of age of rubber on soil properties.

Integrated nutrient management system is recommended for the management of the soils.

Keywords：*Granite, Phyllite, Hevea brasiliensis, Land Evaluation, Catena*

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[DS2] Soil Development and Soil Properties and Functions

Preparation of Polyvinylpyrrolidone-Stabilized Fe0 Nanoparticles for Remediation of Cr(vi)-Spiked Soil

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In this study, laboratory batch experiments were conducted on a hexavalent chromium Cr(VI)-spiked soil to evaluate the effectiveness of synthesized polyvinylpyrrolidone (PVP)-stabilized iron (Fe0) nanoparticles. Batch experiments were performed to investigate the effects of the initial concentration of Cr(VI), the dosage of PVP-stabilized Fe0 nanoparticles and pH of solution on the removal efficiency of Cr(VI). PVP-stabilized Fe0 nanoparticles were synthesized by reduction of ferrous sulfate using sodium borohydride by applying polyvinylpyrrolidone (PVP) as a stabilizer. TEM and XRD examinations were applied for determination of particle size and characterization of produced nanoparticles. At a dose of 0.15 g/L, CMC-stabilized Fe0 nanoparticles were able to reduce 97% of 7.5 mg/L Cr(VI) in 3h at the pH valve was 5. The results showed that the removal efficiency decreased with the initial concentration of Cr(VI) and pH of solution and increased with PVP-stabilized Fe0 nanoparticles dosage. Our study suggested that the introduction of polyvinylpyrrolidone (PVP) could significantly improve the performance of Fe0 nanoparticles for environmental remediation applications.

Keywords：*Hexavalent chromium, Iron nanoparticles, Polyvinylpyrrolidone, Remediation, soil*

P1-145

[DS2] Soil Development and Soil Properties and Functions

Effect of Imazethapyr and Pendimethalin on Nitrogen Fixing Ability and Plant Growth Parameters in Groundnut (arachis Hypogaea L.)

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The experiment was conducted during the kharif, 2011 at College Farm, College of Agriculture, Rajendranagar, Hyderabad, India. Main objectives of the experiment were to study the effect of different doses Pendimethalin and Imazethapyr application on plant growth parameters, nodulation and crop yield in groundnut. Persistence of these herbicides in the plant and soil matrices was also studied in this experiment. The experiment consisted of two main plots and five sub-plots replicated thrice in split-plot design. Rhizobium inoculation and un-inoculation as main treatments and five sub treatments viz., no herbicide treatment (weedy check), Pendimethalin at recommended dosage (750g ha-1), Pendimethalin at double the recommended dosage (1500g ha-1), Imazethapyr at recommended dosage (75g ha-1), and double the recommended dosage (150 g ha-1). Soil physical parameters such as texture viz., BD, PD, %PS and MWHC, physico chemical and fertility properties viz., pH, EC, CEC, OC, Available P2O5 and K2O were studied at initial and harvest time of groundnut crop. Available soil N and plant N content were analyzed at different intervals such as 8, 15, 30, 60 DAA and at harvest. Plant parameters such as plant height, root length, number of nodules, and number of active nodules were recorded at 15, 30, 45, 60 and 90 DAS. Similarly, data on visual toxicity symptoms and chlorophyll content was collected at 1, 3, 5, 8, 15 and 30 DAS. Residue of both Pendimethalin and Imazethapyr herbicides were analyzed at 0, 15, 30 DAA in soil and plant. Similarly, grain samples were also analyzed for residue of herbicides. Pod yield and grain yields were recorded at harvest of the crop. Nitrogenase activity was also studied by Acetylene reduction assay at 30, 45, 60 DAS and Harvest. Results of the study indicated that, usage of Pendimethalin and Imazethapyr at recommended and double the recommended doses did not adversely affect the soil physical, physicochemical and fertility properties. Application of Imazethapyr at double the recommended dose (150g a.i ha-1) resulted in phyto-toxicity (yellowing in 15 % plants) which persisted up to 8 DAA. However, no phyto-toxicity symptoms were observed in Pendimethalin sprayed plots. Seed treatment with Rhizobium in groundnut significantly influenced the total nodule number up to 45 DAS and active nodules throughout the crop growth period. Application of Pendimethalin doses did not adversely affect the number of total nodules or active nodule count. But, application Imazethapyr at double dosage resulted in significantly lower total nodule and active nodule up to 45 DAS. Non-significant changes in the plant N content even in the treatment which reduced nodulation indicate removal of nutrient from the soil reserves. Nitrogenase activity in groundnut increased up to 60 DAA and thereafter decreased gradually. Imazethapyr double dose adversely affected the nitrogenase activity up to 45 DAA which later on recovered from 60 DAA. Despite better weed control achieved in Imazethapyr double dose treatment, highest pod yield was recorded in Imazethapyr at recommended dose where seed inoculation was done (2285 kg ha-1compared to Imazethapyr double dose (2160 kg ha-1). Absence of the Pendimethalin and Imazethapyr residues in the plant, kernel or post-harvest soil samples indicated that these herbicides are safe for usage in groundnut crop.

Keywords：*PENDIMETHALIN, IMAZETHAPYR, NITROGEN FIXING ABILITY, GROUNDNUT*

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[DS2] Soil Development and Soil Properties and Functions

Driving Factor Behind Spatial Variability of Carbon Stocks and Fluxes in Urban Soils of Central European Russia

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Urbanization is among the most rapid land-use change trend. Land conversion to urban result in considerable and usually irreversible changes in vegetation, soil cover, stocks and fluxes of energy and matter. Biogeochemical carbon cycle has the main impact on the global processes and mainly in climate change, thus knowledge of carbon stocks and fluxes in different biomes has high relevance. So far, most of our understanding of C cycle comes from investigation of natural and agricultural ecosystems, whereas much less in known about urban ones.

Globally urban areas occupy less than 3%; however, their contribution to carbon cycle can be considerable. Urban soils can store considerable amount of carbon resulted from adding of organic composts, wastes, intensive growth of root biomass and "cultural layers" formed in result of historical residential activity. At the same time, urban topsoil has high potential to emit CO2 through intensive mineralization of turf-based soil mixtures widely used in greenery, but rather non-stable in urban conditions. Urban areas are represented by combinations of contrast functional zones, sealed and impervious territories. As a result, urban soils are very heterogeneous and carbon stocks and especially fluxes are very variable in time and space. Spatial variability of carbon stocks and fluxes in urban areas can be influenced by both conventional (climatic, vegetation) and urban-specific (soil sealing functional zoning, soil pollution and physical disturbance). It is critical to understand driving factors influencing carbon balance in urban soils under various bioclimatic and management conditions to be able to model urban carbon and to analyze contribution of urban soils to regional and global carbon balance.

Central European Russia (CER) is rather variable in bioclimatic conditions, including boreal, sub-boreal and steppe conditions. Besides CER is the most populated territories in Russia with as percentage occupied by urban areas up to 7-10% in some regions. The aim of the study was to analyze driving factors behind spatial variability urban soils' carbon stocks and fluxes under different bioclimatic conditions in CER.

We analyzed two cities, contrast in bioclimatic conditions: Moscow (south-taiga zone, reference soddy-podzolic soils) and Kursk (forest-steppe zone, reference grey forest soils and chernozems). In each city three functional zones (industrial, residential and recreational) were observed. For each plot, we measured coil CO2 emission in situ (Li-820, May-November, 15 replicas, 10 days' time step), soil temperature and moisture, carbon stocks (annually sampling by augering from 0-10, 10-30, 30-50 and 50-100 cm layers; 10 replicas), soil acidity (pHKCl) nutrient content (Ntot; P2O5; K2O) and contamination (Pb, Cd, Zn and Cu). In both regions, we found average CO2 outflow, but also carbon stocks higher than in referenced natural sites. Moreover, CO2 emission was increasing in a row recreational residential< recreational < industrial areas, following intensification of anthropogenic pressure. The highest spatial variability in CO2 emission (CV up to 60%), and in carbon stocks (CV up to 40%) was found for the industrial areas, whereas the lowest – for residential and recreational. Profile distribution of soil organic carbon also varied between the functional zones with linear decrease with depth in recreational areas and more uniform distribution for residential ones. Both bioclimatic conditions and functional zooming had a significant influence on spatial variability of C stocks and fluxes and explained up to 15-20% of total variability.

Keywords: *urban soils, soil organic carbon, GHG emission, spatial variability, urban-specific factors*

P1-147

[DS2] Soil Development and Soil Properties and Functions

Evaluation of Some Fertility Parameters of Lowland Rice Growing Soils under Different Fertilizer Managements

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Majority of rice growing soils in Sri Lanka have low level of organic matter (<1%), available phosphorous (<10 mg kg-1) exchangeable potassium (<78 mg kg-1) and exchangeable Zn (<1 mg kg-1) even with the application of chemical fertilizer. Average farmer yields of rice are close to 4.5 t ha-1 which is far below to potential yield of 10 t ha-1. Therefore, incorporation of green manure, rice straw and rice stubble of the previous crop has been emphasized by the Department of Agriculture irrespective of the application of chemical fertilizer to overcome the nutrient deficiencies. Effect of such materials on soil fertility and grain yield in long run has not been critically evaluated so far under Sri Lankan conditions to educate farmers and extension officers on the importance of such practices. Therefore, the present survey was conducted to uncover the effect of application of organic manure and chemical fertilizer in diverse combinations on fertility status of low land rice growing soils cultivated for long in the low country intermediate zone of Sri Lanka.

Long term experimental plots maintained with four fertilizer treatments namely no organic manure or chemical fertilizer (Control), only organic manure, only chemical fertilizer and organic manure plus chemical fertilizer for twenty two consecutive seasons were selected for this fertility survey. Application rates of organic manure and chemical fertilizer for respective treatments were 5 t ha-1 rice straw, 1t ha-1 green manure, 4t ha-1 cow dung, 120 kg N ha-1, 35 kg P2O5 ha-1, 30 kg K2O ha-1 and 1 kg Zn ha-1. N, P, K and Zn were given in the form of Urea, triple super phosphate (TSP), muriate of potash (MOP) and ZnSO4 respectively. Four soil samples were collected randomly from each plot and samples were analyzed for pH (1:2.5), electrical conductivity (1: 5), organic matter, total nitrogen, available P, exchangeable and non exchangeable K and exchangeable Zn.

During the last five seasons, the highest grain yields were recorded from the plots treated with organic manure plus chemical fertilizer and followed by chemical fertilizer, only organic manure and Control. A significant variation in pH values among four treatments was not observed and Soil pH was lying between 6 and 7. Significantly higher electrical conductivity values were observed in organic manure treated plots (0.07 dS m-1). The highest level of organic matter as well as total nitrogen is recorded in organic manure treated plots. Total nitrogen content in paddy soils has reached to the lowest level of 0.02% in the control. Organic manure alone reached the highest level (0.07%) of total nitrogen in the soil. The highest level of available P recorded as 5 mg kg-1 in the plots treated with organic manure alone. Even with the application of phosphorus fertilizer at the rate of 45 kg P2O5 ha-1 for more than twenty two seasons, there are no differences in available P in paddy soils applied with chemical fertilizer only and not applied. Comparatively higher exchangeable K content of 18.7 mg kg-1appeared in organic manure treated plots while lower exchangeable K content of 11.1 mg kg-1 appeared in plots treated with chemical fertilizer only. Continuous application of K fertilizer is necessary in paddy cultivation. Zn levels of all treatments were in a lower range of below 1 mg kg-1.

Significant differences were observed in electrical conductivity, organic matter, total nitrogen, available P, exchangeable and non exchangeable K and exchangeable Zn when plots were treated with different combination of organic manure and chemical fertilizer. Seasonal application of both sources is necessary to improve crop yields and to maintain soil fertility. Present study proved the superiority of organic manure application in paddy soil with the purposes of sustaining soil fertility. Application of chemical fertilizer alone continuously causes decline in soil fertility. Exchangeable Zn and exchangeable K are significantly high in organic manure treated plots but significantly low in chemical fertilizer treated plots. Even after twenty two consecutive seasons continues application of chemical fertilizer and organic manure has not increased soil K and Zn levels. Levels of P, organic matter and Zn are still at the level below the critical level reported for optimum rice production. As such, seasonal application of fertilizer and manure is needed to maintain higher crop yields with higher soil fertility.

Keywords：*Fertilizer, Organic manure, Rice, Soil fertility*

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[DS2] Soil Development and Soil Properties and Functions

Distribution of Rain Fed Paddy Fields And Variation of Ph And Ec in Three Major Climatic Zones of Kurunegala District in Sri Lanka

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Rice is the major agricultural crop grown in Sri Lanka and majority of the area is under rainfed lowlands. At present lowland rainfed system contributes 1/5th to the national rice production. Distribution of rainfed paddy fields are diverse in three climatic zones of wet, intermediate and dry zones having annual rainfall more than 2500mm, between 1750mm and 2500mm, and less than 1750mm respectively. Rainfed paddy cultivation is done by poor farmers and less attention has so far been given to rainfed system due to lower grain yields (less than 3.5 t ha-1). Since demand for rice is increasing annually, lowland rainfed paddy production should be improved to feed the nation in the future. Remedial measures should be introduced to overcome constrains in rainfed paddy farming in order to achieve the above target. As studying the basic soil parameters for proper rice growing environment, this study was conducted to study the variation of soil pH and EC in three major climatic zones and their relationship to low productivity in the Kurunegala district

Three agrarian service areas (Mahananeriya, Ibbagamuwa and Alawwa) in Kurunegala district representing dry, intermediate and wet zone respectively were selected as study sites. Rainfed paddy fields were separated from the existing paddy map of the areas using Geographic Information System (GIS) capabilities and with the help of field survey. Soil samples (138 from Mahananeriya, 257 from Ibbagamuwa and 430 from Alawwa) were collected randomly along the paddy tract representing whole rainfed paddy fields and sampling points were demarcated by Global Positioning System (GPS). Soils were analyzed for soil pH (1:25) and Electrical Conductivity (1:5). Thematic maps were prepared for pH (1:25) and Electrical Conductivity (1:5) using GIS and extracted to rainfed paddy areas.

According to paddy area maps of the study sites, paddy growing areas of Mahananeriya, Ibbagamuwa and Alawwa is 14%, 28%, 18% respectively. The extent of rainfed paddy fields of the total extent of paddy fields in the study sites are 7% in Mahananeriya, 36% in Ibbagamuwa and 80% in Alawwa which represent dry, intermediate and wet zones respectively. Distribution of soil pH and electrical conductivity of rainfed paddy fields in Mahananeriya, Ibbagamuwa and Alawwa were shown in maps. Tthe most suitable pH range for paddy cultivation is 5.5 – 6.5. Result shows that soil pH of Mahananeriya and Ibbagamuwa varies from 3.5 to 7.5. Only 5 % of area in Mahananeriya and 25% of area in Ibbagamuwa are having pH between 5.5 and 6.5 while whole paddy extent in Alawwa having pH ranging from 3.0 to 5.5. Therefore, majority of the area in Alwwa and Mahannaeriya is unsuitable for paddy cultivation in terms of soil pH. Paddy plants in these low pH areas are vulnerable to iron toxicity and as a result give lower paddy yields. The most suitable electrical conductivity levels for rice is below 0.1 dS m-1 and 85% of area in Mahananeriya, 75% of area in Ibbagamuwa and 97% of area in Alawwa having electrical conductivity levels below this critical level. As such, majority of the areas are suitable for rice cultivation in terms of electrical conductivity. The maximum electrical conductivity values of Mahananeriya, Ibbagamuwa and Alawwa is 0.5, 0.75 and 0.25 ds m-1 respectively.

Soil pH in major rain fed paddy areas of wet and intermediate zones in the Kurunegala district is below the optimum level for paddy cultivation. Therefore introduction of remedial measure to overcome soil acidity is important to obtain the maximum rice production from these paddy fields.

Keywords：*Climatic zones, EC, pH, Rain-fed paddy fields*

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[DS2] Soil Development and Soil Properties and Functions

The Possibility of Anabaena Flos-Aquae Spontaneously Form Humus

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In the study of humus formation, scientists found that some autotrophic organisms could use inorganic carbon source to synthesize humus. There was record showed that peat had originated from algae in geological literature. It was also found microbes could synthesize humus by algae residue. Before the original soil formed on earth, photoautotrophic cyanobacteria had been common present in original water environment, so whether the formation of initial humus had relationship with cyanobacteria or not was an interesting question. It was important but seldom investigated. The paper explored whether the cyanobacteria could spontaneously form humus in its growth cycle with the absence of organic matter. The Anabaena flos-aquae was inoculated into the sterilized BG-11 medium, and cultivated in light shaker with temperature of 25~30 ℃, light of 1000~1500 lx and rotate speed of 120~150 rpm. Samples were respectively collected from phases of lag, logarithmic, stable and decline. The clear liquid (extracellular metabolites) and precipitation (Anabaena flos-aquae thallus) were obtained after high speed centrifugation. TOC, differential thermal and infrared spectrum analysis were used to analyze total organic carbon, thermal properties and functional groups structure of metabolites and thallus.

Results showed that: (1) with the growth of Anabaena flos-aquae, organic carbon in the system reached maximum value in stable phase, then began to decline in its death phase. It was caused by the change of organic matters through photosynthesis and decomposing metabolism. The carbon content of extracellular metabolites was ever-increasing, which suggested that some organic materials were released into the medium. (2) The calorie and weightlessness high/medium ratios of metabolic liquid increased with the growth of cyanobacteria, but they were still lower than that of the thallus. It showed that the aromatic/aliphatic ratio of metabolites gradually increased, and the aromatic degree was elevated soon afterwards, but they could not catch up with the thallus. Even if the metabolites could eventually form complex organic substances, they were just humus precursors with low molecular weight. (3) The infrared spectrograms displayed that the spectral features of Anabaena flos-aquae samples were much closer to that of fuvic acid. But the absent 1720 cm-1 and strengthened 1650 cm-1 and 1530 cm-1 characteristic peaks of cyanobacteria samples proved that algae organic matter had rich organic nitrogen and less organic carbon than natural humus. With the growth of Anabaena flos-aquae, the (2926+2860)/1650 and (2926+2860)/1530 ratios of metabolites decreased, which means the aromatic degree of metabolites gradually improved. In a word, the aromaticity of Anabaena flos-aquae samples was insufficient to natural humus in its normal growth cycle under the moderate cultivated condition. The growth and metabolism of cyanobacteria may be only as an original organic carbon accumulation. But the increased amide materials in metabolites may synthesize humus as precursor substances under certain conditions, the thallus could probably form humus in chemical and microbial polymerization after their decline. It will be investigated in further research.

This research was performed based on the financial support by National Basic Research Program of China (973 Program) (2011CB100503), National Natural Science Foundation of China (41171188).

Keywords：*possibility, Anabaena flos-aquae, humification, humic-like substances, formation*

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[DS2] Soil Development and Soil Properties and Functions

Estimating of Soil-Water Characteristic Curve Using Air Permeability

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Soil water characteristic curve (SWC) is a fundamental soil physical property that shows the functional relationship between moisture content and, matric potential and indirectly reflects the soil pore size distribution. It is shown that pore size distribution function can be described by air permeability (Ka) and gas diffusion (DP) which their measurements are much easier and faster than that of SWC. Using of the measured Ka and DP, the equivalent pore radius of the empty pores (r) at each moisture (or matric pressure) was computed and were transformed to the equivalent water filled pores at the corresponding moisture content. The latters were converted to matric potential (ψ) using the capillary equation. The resulted SWC for all examined soils were well matched with the experimental curves. The accuracy of the method was examined by evaluating of R2, RRMSE, GMER and GSDER statistics. The method used in this study showed very high accuracy to estimate SWC in most soil texture (average of RRMSE=17.362 % and average of GMER=1.035). Moreover the proposed method is rapid and inexpensive because there is no need to pressure plate or suction plate apparatus. The accuracy of the proposed method was also compared to that of van Genuchten model. The results showed that the proposed method was especially accurate in predicting soil matric potential from the soil moisture contents as compared with the above mentioned model (average of RRMSE= 821290 %!).

Keywords：*Air permeability, gas diffusion, Matric potential, Pore size distribution, Soil water characteristic*

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[DS2] Soil Development and Soil Properties and Functions

Soil Digital Mapping: Carbon Organic Maps of Brazil

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Soil is an important resource in the human life because it is the support to produce food in the agricultural activities. By the importance of this resource, it must be well known to better exploration and mainly preservation in a real Sustainable Development. But the reality is different, in the Brazilian case soil mapping is only near 70% of the country at 1:250000 scale. With this level of soil mapping Sustainable Development and with the premise “To know to preserve” there is a lack of soil knowledge. But this situation is not a exclusive case of Brazil and many countries are in the same situation and in any cases worst.

To improve this situation, Scientific Community created a global consortium, the “Global Soil Partnership”, to develop new digital soil maps in the World (GlobalSoilMap.nep). Similarly in 2013, the United Nations created the Intergovernmental Technical Panel on Soils as a group to contribute with provision of scientific guidance to Sustainable Development Goals related to soil thematic. Other actions at different levels are in development to overcome the lack of information about this resource.

In this context, Embrapa Soils and FAO implemented an agreement to offer training in Digital Soil Mapping to Latin American technicians. In Rio de Janeiro were trained 20 technicians and 60 in on-line training. Each group of technicians of Latin American countries developed their maps according their resources and limitations.

Brazilian technicians applying digital soil mapping techniques developed the Carbon Organic maps at layers of deeps 0-5 cm, 5-15cm and 15-30cm (this approach is recommended but Global Soil Partnership). The work was initially to get different sources of soil samples (near 15000) and to analysis the quality of this information resulting near of 10000 samples with geographic coordinates (but many attributes of them are lack). Also it was gathered covariate information: soil mapping, digital elevation models (SRTM), Landsat images, and others. SRTM was processed to extract mainly morphological variables. It was selected appropriate variables (covariates) that were related with the Carbon Organic applying statistical methods: data exploratory analysis, modeling and finally to analysis of the quality of results.

Results showed that Carbon Organic of Brazil at 0-5cm deep is 19.43g/kg. An analysis by biomes are: Amazon (Amazonia) 21.44g/kg, Savanna (Cerrado) 17.424g/kg, Atlantic Forest (Mata Atlantica) 22.71g/kg, Arid Land (Caatinga) 9.956g/kg and Wetland (Pantanal) 11.8g/kg.

Carbon Organic of Brazil at 5-15cm deep is 17.21g/kg. An analysis by biomes are: Amazon (Amazonia) 17.8g/kg, Savanna (Cerrado) 17.12g/kg, Atlantic Forest (Mata Atlantica) 22.18g/kg, Arid Land (Caatinga) 9.463g/kg and Wetland (Pantanal) 10.82g/kg.

At 5-15cm deep Carbon Organic of Brazil is 12.65g/kg. By biomes are: Amazon (Amazonia) 11.61g/kg, Savanna (Cerrado) 13.89g/kg, Atlantic Forest (Mata Atlantica) 19.169g/kg, Arid Land (Caatinga) 7.517g/kg and Wetland (Pantanal) 8.383g/kg.

These 3 layers show that Carbon Organic decreasing with deep, but this process is not linear and different biomes has different decreasing showing the dynamic of this attribute. Savanna and Arid land have a relatively more stable behavior and it will be understanding by the lack or less vegetation in relation to other biomes. Maps show this spatial dynamic and more easily to understand that only values.

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[DS2] Soil Development and Soil Properties and Functions

Soil Organic Carbon Maps of Brazil Using Digital Soil Modeling

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Soil information is essential to support sustainable development, especially in agricultural countries. In Brazil, the demand for soil maps is evident, since only near 70% of the country is mapped at the 1:250,000 scale. The lack of soil information is not exclusive of Brazil, and there must be many countries in worse situations.

Global initiatives including the Global Soil Partnership, GlobalSoilMap.net, and the Intergovernmental Technical Panel on Soils promote the inclusion of soils in the global sustainable development agenda, and foster the improvement of global soil resource information to alleviate this soil data crisis.

In this context, Embrapa Soils and FAO implemented an agreement to offer on-the-job training in Digital Soil Mapping (DSM) to soil scientists from Latin America and the Caribbean (LAC). More than 20 people from many LAC countries received in-class DSM training in Rio de Janeiro and more than 60 people were trained using distance education tools. Soil scientists from LAC countries developed their own maps according to the availability of soil and covariate data.

At Embrapa Soils, we developed preliminary soil organic carbon (SOC) maps for Brazil at three depths (0-5, 5-15, and 15-30 cm). We compiled soil data from different sources, which were submitted to quality checking analyses. We ended up with nearly 10,000 soil sites with available SOC and geographic coordinates. We gathered covariate information, including a soil map, a digital elevation model (DEM; SRTM), MODIS images, and others, and further processed the DEM to derive terrain attributes. We applied a DSM framework including data exploratory analysis, multivariate modeling of soil-landscape relationships, and independent validation of derived maps.

Mean SOC at 0-5 cm was 19.43 g/kg, and it varies considerably by biome, with: 21.44 g/kg at Amazônia (Amazon rainforest), 17.42 g/kg at Cerrado (savannas), 22.71 g/kg at Mata Atlântica (coastal forests), 9.96 g/kg at Caatinga (arid lands), and 11.80 g/kg at Pantanal (wetlands).

At 5-15 cm, SOC had a mean of 17.21 g/kg, which also varied by biome, with 17.80, 17.12, 22.18, 9.46, and 10.82 g/kg at Amazônia, Cerrado, Mata Atlântica, Caatinga, and Pantanal, respectively.

At 15-30 cm, mean SOC was 12.65 g/kg, and its distribution by biome kept the same general trends of the other layers, except that SOC was higher in Amazônia compared to Cerrado. The following SOC were observed: Amazônia – 11.61 g/kg; Cerrado – 13.89 g/kg; Mata Atlântica – 19.17 g/kg; Caatinga – 7.52 g/kg; and Pantanal – 8.38 g/kg.

Overall, SOC decreased with depth, but this process was not linear across biomes, indicating differences in carbon dynamics by biome. Final SOC maps portray these trends and must be interpreted in light of the different soil forming processes that govern in each type of ecosystem. These maps are preliminary and will be further improved by testing other DSM methods. Nevertheless, they represent a first and important step towards Brazil's contribution to the global soil attribute mapping.

Keywords: *Digital Soil Mapping, soil organic carbon, soil mapping*

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[DS2] Soil Development and Soil Properties and Functions

Partition of Nitrogen Between Microbial Biomass Nitrogen and Plant Nitrogen Uptake Influenced By Dicyandiamide, Hydroquinone and Carbon Addition

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Soil microbes are considered to be an important nitrogen (N) pool in dryland farming. Consequently, it has been recognized that the dynamic of microbial biomass N (MBN) was important in agricultural production. The dicyandiamide (DCD) and hydroquinone (HQ) were widely used as the nitrification inhibitor and urease inhibitor, respectively, to increase N use efficiency. Moreover, straw returning to the field is a common agricultural practice in the study region. The soil microbes must be affected by the inhibitors and straw input. To evaluate the effects of inhibitors and straw application on the contribution of MBN to plant N uptake in a dry cropland, we conducted a spring wheat pot experiment in Northeast China using different land management treatments (control, N, N+S, N+DCD, N+HQ, N+DCD+S, N+HQ+S, N+DCD+HQ, and N+DCD+HQ+S). During the experiment, we periodically measured the soil MBN and inorganic N (NH4+-N, NO3--N). Wheat yield and plant N uptake were measured when wheat was harvested. The results showed that yield increased significantly with fertilizer N application, and the yields were numerically higher in the treatments with combination of fertilizer N and DCD or HQ than in treatment N. However, compared to treatment N, the yield markedly increased by 19.8% in the treatment N+DCD+HQ. Generally, straw returning decreased wheat yield, and the greatest yield reduction was observed in the treatment N+DCD+HQ+S. This can be attributed to the soil microbe growth were promoted with carbon addition, resulting in the greater N immobilization. It can be evidenced that MBN was consistently higher in the treatments with carbon addition than in the corresponding treatments without carbon input across the experimental period. The inhibitors significantly influenced urea N release and ammonium nitrification, and the temporal partition of inorganic N obviously changed. Subsequently, nitrogen immobilization by microbes was improved when the concentration of ammonium increased, leading to less N for plant and the lower yield. The magnitude of yield reduction was higher when the carbon and inhibitor combined. It can be concluded that strong competition for N occurred between soil microbes and plant over the experiment period and microbial growth prevented N uptake by plants, especially in treatments with carbon input. Therefore, the amount and season of straw returning to field had to be paid more attention to avoid the negative effect on crop growth in current season.

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[DS2] Soil Development and Soil Properties and Functions

Stoichiometric Indicators of Saline Soil in Desert and Oasis Ecotone of Manas River Watershed, Northwest China

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Stoichiometry of soil ion composition is critical for salt soil management in desert and oasis ecotone. Previous efforts have been made to develop efficient stoichiometric indicators but few progresses were achieved. The objective of this study is to reveal horizontal distribution of salt soil chemical and physical characteristics as potential ecological indicators in typical desert-oasis ecotone of Manas River watershed in Xinjiang Province of northwest China. Total 186 topsoil samples were systematically taken in 0-30 cm depth along with watershed altitudes. Total salt concentration, 8 major salt ions concentration and other soil physical-chemical traits were measured and recorded. The data indicated that total salt concentrations in topsoil tended to increase from 3.405 g/kg to 17.37 g/kg from upstream to downstream. Topsoil pH values ranged from 8.59, 8.92 to 8.53 respectively, and its average particle sizes smaller than 2um varied from 1.28%, 3.54% to 4.15% respectively; its average particle sizes range from 2um to 50um varied from 72.26%, 69.64% to 58.78% respectively; its average particle sizes bigger than 2000um varied from 26.45%, 26.83% to 37% respectively. Importantly, equivalence ratios between Cl- and SO42- were observed to increase from 0.36, 2.11 to 3.76 over upstream, midstream to downstream zones, which reflected the change in soil apparent color shifted from white to black and thereafter to brown. Furthermore, quantitative proportion among positive ions was transformed from dominant Na+, Ca2+ and Mg2+ ions in upstream to Na+-led situation in mid- and down-streams. Among four major negative ions, the upstream is mainly characterized by dominant SO42- and the mid- / down- streams by Cl- and SO42-. Systematic cluster analysis showed that HCO3- and K+ had a similar feature of movement and other ions varied spatially. In addition, analysis of the charge balance on positive and negative salt ions indicated that the horizontal movement and selective sequestration of ions were likely the driving factors affecting formation of salt soil types. Our study demonstrated that spatial distribution of salt soil type may be featured by increasing equivalence ratio between Cl- and SO42-, increasing Na+, Cl- and SO42- proportion, and lessening soil particle size via apparent color reflection of topsoil in desert and oasis ecotone.

Keywords：*Stoichiometric indicator, Salt soil, Desert and oasis ecotone, Manas River watershed*

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[DS2] Soil Development and Soil Properties and Functions

Effect of Overseeded Forage Radish for Improving Soil Properties and Recovering Excessive Nitrogen in Southern Pastureland

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Overseeding cool-season forages on perennial warm-season pasture is a commonly practiced management to improve quality forage during the winter and spring season in the southern US. Utilization of tillage radish would be an aid in improving soil physical properties of perennial grass dominant pastures without soil nutrient loss or soil erosion caused by tillage. Field studies were conducted to evaluate the effect of overseeding forage radish in low productive permanent pastures on soil physical properties and forage production. Forage radish overseeded pasture was planted in the participating farms using a no-till drill planter in comparison with annual ryegrass overseeded or zero-winter crop overseeded pastures as two control pastures. Water infiltration rate and soil bilk density were performed in the filed pre-planting, mid-season and post growing season. Soil samples were also collected at the same time for chemical and physical analysis. Ground cover, forage production, and nutrient value of forage were monitored on a regular basis.

Keywords：*Forage radish, water infiltration rate, pasture, soil nitrogen*

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[DS2] Soil Development and Soil Properties and Functions

The Characters and Differences of Soil Organic C Fractions in Leymus Chinensis Grassland Applied N and P Fertilizers for 5 Years in Inner Mongolia

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The differences of soil organic C fractions were examined after 5-year application of N and P fertilizer in Leymus chinensis grassland of Inner Mongolia, China. Soil samples in 0-15 cm layer were collected from the long-term fertilization experiment: control (no fertilizer), N fertilizer (N 52.5, 105, 175 and 280 kg hm-2 yr-1) and P fertilizer (P 9, 37 and 75 kg hm-2 yr-1), which were established in 2000. The results showed that the applications of N and P fertilizer although didn't significantly affect soil organic C content, but different dosage of N and P fertilizer significantly affect soil organic C fractions. The application of N fertilizer increased the dry weight of free particulate organic matter (FPOM) by 13.2%-46.8%, while P improved that of occulate POM (OPOM), especially when the dosage of P > 37 kg hm-2yr-1, < 20μm POM content was increased by 90.6%-150.0%. Both N and P fertilizers application decreased the content of soil microbial biomass, up by 45.5%, but significantly increased the C and N content in soil POM and the proportion of FPOC to soil organic C (FPOC/SOC ratio), particularly under the application of N fertilizer, which was enhanced by 34.3%-69.4%. No significant effects of N and P fertilizer on soil mineral-associated organic C were found in this study, however, both P fertilizer and large dosage of N fertilizer application significantly enhanced the C content of 20-63μm silt sand, while decreased the C content of 0.2-2μm clay. It is obvious that long-term application of N and P fertilizer can significantly change the content and distribution of soil organic C fractions in L. chinensis grassland, and this change exist differences due to the dosage and type of fertilizer applied. Soil organic C fractions, particular soil microbial biomass C and FPOM, are much more sensitive to fertilization than soil total organic C.

Keywords：*Leymus chinensis grassland, N and P fertilizer, microbial biomass C, particulate organic C , mineral-associated organic C*

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[DS2] Soil Development and Soil Properties and Functions

Soil Organic Carbon and Total Nitrogen Stocks Under Different Land Uses in Tigray, Northern Ethiopia

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Soil organic carbon (SOC) quantity and quality are crucial to soil quality. Thus, SOC and total nitrogen (TN) concentrations and stocks were estimated in 0–5, 5-10, 10-20 and 20-30 cm soil layers for five land uses; rainfed crop production (RF), agroforestry based crop production (AF), open communal pasture (OP), silvopasture (SP) and irrigation based fruit production (IR) each with five replications within a watershed in Ethiopia. Generally, both magnitude and difference in SOC and TN concentrations showed a decreasing trend with depth within and among most land uses. SOC and TN concentrations were highly correlated in all land uses and depths. Total stocks in 0-30 cm layer were 25.8, 16.1, 52.6, 24.4 and 39.1 Mg ha-1 for SOC compared with 2.7, 1.6, 4.9, 1.9 and 3.5 Mg ha-1 for TN in AF, RF, OP, IR and SP land uses, respectively. With RF as baseline and the duration of 50 years since land use conversion, the average rate of accumulation was 0.73, 0.46, and 0.19 Mg C ha-1yr-1 in comparison with 0.065, 0.038, and 0.022 Mg N ha-1yr-1 for OP, SP and AF, respectively. Soils under IR also accumulated 0.56 Mg C ha-1 yr-1 and 0.019 Mg TN ha-1yr-1 in the 0-30 cm layer and in comparison with the RF land use system on an average of 15 years. The results of this study revealed that conversion of RF into grass and tree-based land uses has large technical potential of SOC and TN sequestration in the area.

Keywords：*Land use change, Carbon sequestration, Soil Organic Carbon or Total Nitrogen concentrations, Soil Or*

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[DS2] Soil Development and Soil Properties and Functions

Evaluating Soil Fertility Parameters in Maize Growing Smallholder Agricultural Systems of West Bengal, India Using Wet Chemistry and Diffuse Reflectance Spectroscopy Technique

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Poor soil fertility is one of the chief factors limiting productivity of smallholder maize systems in Eastern India. Synthesizing information to build up a better understanding of the relative significance of soil and crop management factors is important for targeting site-specific nutrient management. However, determination of soil properties is always a challenge for smallholder farming systems of south Asia, due to absence of adequate soil testing infrastructure. Visible near infrared (350-2500 nm) diffuse reflectance spectroscopy is a promising way out in this regard as the process is much faster.

The present study investigates the soil quality and fertility parameters in smallholder maize farm fields of West Bengal in Eastern India by using wet chemistry and diffuse reflectance spectroscopy technique. The study area included red and lateritic soils of Bankura district and old alluvial soils of Malda districts of West Bengal. Small and marginal farmers, cultivating farms that are usually less than 1 ha in size, typically characterize the study area. Consequently, spatial variability in soil physic-chemical properties and nutrient availability are very high as there are large management differences among farmers.

The soil physico-chemical properties of the soils were determined using both wet chemistry and rapid spectral analysis methods. A total of 179 composite surface soil samples, mixing eight subsamples from each field, were collected from farmers' fields with varying soil qualities and maize yield levels.

Considerable district wise variation in soil properties was apparent, with finer textured soils with higher OC, EC, and pH in Malda as compared to Bankura. On the contrary, box plots revealed that both districts had similar median available N (160 kg ha-1), but larger inter-quartile range in Malda. The statistical moments of all measured soil variables for pooled data revealed that except for plant available S, considerable variability in pH (4.8-10), EC (0.0-0.8 dS m-1), available N (77-308 kg ha-1), available P (4.9-21.7 kg ha-1), clay (10.8-44.8 %), sand (17.2-83.2%), and silt (4-42%) can be seen in the study area. Previous studies have shown high variability in soil physico-chemical properties and nutrient availability in smallholder systems as each individual farmer cultivates

small pieces of lands that increases the complexity of existing spatial variability caused by long-term effects of genesis, topography and climate.

Percent OC, analyzed by wet chemistry, was significantly correlated with all parameters except available N, P, and S. The soil samples were also scanned via Visible near infrared (350-2500 nm) diffuse reflectance spectroscopy and subsequent modeling analysis was done for rapid prediction of soil properties. Results indicated that spectral modeling was reasonably sensitive to capture the variation in soil organic carbon (r2=0.9, RPD= 3.1). Besides, maize yield was modeled using soil spectral data to examine whether soil spectra had any explanatory power in predicting maize production for smallholder maize systems. The model yielded a cross-validated r2 of 0.51 (RPD=1.12), exhibiting considerable prediction potential of maize productivity using soil quality parameters, as measured by soil reflectance, despite the presence of agronomic management and other socio-economic factors.

Significant advances have been made in prediction of soil parameters using soil reflectance spectroscopy. The technique allows non-invasive in-situ analysis of soil parameters that are critical for several important issues namely, soil survey, fertilizer recommendation etc. The current study shows that soil phsico-chemical properties and nutrient availability can be predicted by spectral analysis that correlates well with wet chemical analysis. Once popularized, this method will shorten the run time of soil analysis by wet chemistry methods while giving reasonably accurate predictions to cater to several needs.

Keywords：*Soil fertility, wet chemistry, diffuse reflectance spectroscopy technique*

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[DS2] Soil Development and Soil Properties and Functions

Recultivation of Minespoil Soils on the Jos Plateau, Nigeria

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One of the environmental issues associated with large scale commercial tin mining on the Jos Plateau is agricultural land loss because the areas affected are predominantly situated in places with intensive agriculture. Certainly, tin mining has had adverse effects on the agricultural potential of the area. With increase in population and the widespread desire to produce more food, land shortage has become a severe problem. Some farmers have extended their holdings to both reclaimed and un-reclaimed mine lands for rainfed and irrigated farming. So far, no detailed analysis of the agricultural activities taking place on the mine spoils has been done so as to determine the appropriate technologies for their sustained productivity. The objectives of this study are: to carry out an analysis of the agricultural activities to which the mine spoils are subjected and also determine the effects of such agricultural activities on some of the spoil soils properties. Field observations and measurements, as well as administration of well structured questionnaires were employed in capturing qualitative land use and soil management data while standard procedures were applied in spoil soil data gathering. The results show that rainfed crops cultivated comprise maize, guinea corn, Hungary rice (acha), potato, yams, cassava, tomato and sweet pepper, among others, while irrigated crops include tomato, green pepper, hot pepper, sweet pepper, cabbage, lettuce, potato, green beans, maize, carrots, and garden eggs, among others. Soil management practices include application of inorganic and organic (cow, poultry and town waste manure) fertilizers as well as cultural practices like mixed cropping, crop rotation, monoculture, mixed farming and bush fallow, ridging across slopes, strip farming and mulching are used to check erosion. All these practices have improved the levels of some spoil soil variables like soil pH, organic matter, total nitrogen, available phosphorus and exchangeable bases, indicating that appropriate land husbandry can enhance the conditions of the mine spoil soils and so contribute to meaningful agricultural ventures and environmental restoration in the mine land area.

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[DS2] Soil Development and Soil Properties and Functions

Effects of Biochar and Vermicompost Amendments on Phytoavailability of Cadmium in a Calcareous Soil

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Biochars are shown to be effective in the adsorption of heavy metals. A pot experiment was conducted to investigate the comparison of biochar and vermicompost on the availability of cadmium (Cd) to maize. Treatments were manure biochar and vermicompost which were applied at three rates (0, 5 and 10 g/kg) with three rates (0, 10 and 50 mg/kg) of Cd to a calcareous soil. After 75 days of growth, crop was harvested and dry matter yield and concentration of Cd were determined. Both biochar and vermicompost application, decreased the concentration of Cd in maize shoots. However, reduction in the concentration of cadmium in biochar treatment was higher than vermicompost treatment. The results also showed that the addition of biochar to soil did not have any significant effect on the dry matter yield of maize shoot. Unlike biochar, the addition of vermicompost, increased dry matter yield of maize shoot. The results revealed that biochar and vermicompost application can significantly reduce the phytoavailability of heavy metals to plants and may have potential for remediating contaminated calcareous soils.

Keywords：*Biochar, vermicompost, cadmium, phytoavailability, maize, calcareous soil*

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[DS2] Soil Development and Soil Properties and Functions

Rotation Soil Effects on Soil Profile: Organic Carbon and Nitrogen in a Semiarid Zone of Argentina

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In the semi-arid northwestern of Argentina, soil organic matter (SOM) research have been intensified in the last 10 years due to agricultural frontier advance. This process is associated with the expansion of croplands to produce soybean. Long-term studies on sustainable management practices are considered high priority. The aim of this study was to evaluate the effect of ten cropping systems on organic carbon (OC), total nitrogen (Nt) and stock of CO, during 6 years. The experimental area was located in the irrigation area of Rio Dulce (Santiago del Estero, Argentina). The soil of the study was a torriorthentic Haplustolls. The rotations involved 5 crops: cotton (=Ct; Gossypium hirsutum); soybean (=Sb; Glycine max); corn (=Cr; Zea mays); sorghum (=Sg; Sorghum bicolor) and wheat (=W; triticum aestivum). The treatments were: T1-monoculture (Ct/Ct)*, T2-monoculture (Sb/Sb), T3-(W-Sb)*, T4-(Cr-Sb), T5-(Ct/Cr); T6-(Sg/Ct); T7-(Sb/Ct); T8-(Cr-Sb/Ct) T9-(W-Ct/Cr-Sb), and T10-(Sg/Ct/Cr) (*where slash separate one crop per year and dash mean two crops per year). The trial started in 2005 (no tillage with irrigation), and in 2011 soil samples were taken until 0,8 m of depth at intervals of 20 cm (n=20 for each depth and treatments) to evaluate macronutrient concentrations and stock of CO for a mass equivalent to 2500 Mg.ha-1. The differences between treatments T3 and T5, T1, T2, T8 and T4 for CO and Nt were significant ($P<0.05$) for all studied profile, showing a significant influence of these rotations in the 4 depths. The greatest differences in soil CO an Nt among treatments occurred between T5 and T3. In the profile, the average values of CO in T5 were 10.8, 7.7, 4.9, and 3 g.kg-1 to 0-20, 20-40, 40-60, and 60-80 cm, respectively; while for T3 were 9.01, 5.6, 2.6, and 1.7 g.kg-1 in the same order within the profile. The same trend was observed for Nt, which average values in T5 from surface to 0.80 m deep were 1.05, 0.78, 0.52, and 0.37 g.kg-1, while for T3 were 0.9, 0.6, 0.4, and 0.3 g.kg-1. For the first 0-20 cm, the stock of CO for a mass equivalent to 2500 Mg.ha-1 was significantly higher ($P<0.05$) in T1 (31,64 Mg.ha-1), T5 (31,45 Mg.ha-1) and T8 (33,1 Mg.ha-1) than T3 (28,9 Mg.ha-1) and T2 (29,03 Mg.ha-1). The stock de CO until 0,8 m was higher in T5 (69,07 tn.ha-1), T1 (58,7 tn,ha-1) and T8 (55,2 tn.ha-1) than T3 (45,7 tn.ha-1). Not same trend was observed for Nt, which average values of stock until 0,8m was higher in T8 (7, 5 tn.ha-1), T5 (7,1 tn.ha-1) and T1 (7 tn.ha-1) than T3 (5,6 tn.ha-1). This crop system wheat-soybean (T3) showed the lowest values of Nt and CO throughout the soil profile, and this is the generalized management used currently in the northwest of Argentina. Therefore, this rotation is not recommendable to develop in these environments. In contrast, the combination of crops like cotton, corn, and sorghum are capable of capturing, storing, and preserving the CO and Nt in deeper soil layers. The treatments T1 (whit stubble), T5, T6 and T8 should be considered in the irrigation area of the Rio Dulce, and a new-purpose crop management should be analyzed to prevent the development of degradation processes.

Keywords： *semiarid - zero tillage - irrigation - rotation - CO and Nt profile*

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[DS2] Soil Development and Soil Properties and Functions

Physical Characterization of Top- and Subsoils and Their Implications in Stress Propogation

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Soil compaction is a serious problem in modern agriculture. State-of-the-art soil compaction models derive from foundation engineering and consider soils as continuous and homogeneous media. However, agricultural soils are structured at different scales. Paterns of stress propagation were measured using stress transducers and visualized on images obtained from x-ray CT scans for undisturbed topsoil (i.e. regularily tilled soil layer) and subsoil samples as well as for packing of aggregates. A specially constructed oedometer was constructed to be used in a medical x-ray CT scanner. Analogy of physical properties was analyzed between soil samples and model materials to better understand the mechanical processes leading to the stress propagation paterns observed. Results showed that mechanical behaviour of topsoils was close to that of packing of aggregates. Mechanical behaviour of subsoil samples could be described reasonably well using the elasticity theory. A important perspective of the present work is the oppertunity to propose a more realistic way of describing the mechanical behaviour of agricultural soils in soil compaction models.

Keywords：*soil mechanical behaviour, stress propagation, soil compaction*

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[DS2] Soil Development and Soil Properties and Functions

Geochemical Model of the Distribution of Metals in the Surface Layer of the Supergene Zone (Soils)

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After years of experimental field and geochemical studies supergene zone was studied , the distribution of chemical elements in the vertical section of the supergene zone , including soil .

Study area (Donbass) soil profile represented ordinary black granulometric composition refers to clay soil carbonate on the surface of fixed carbon dust .

Study of clay component X-ray diffraction showed that the association of clay minerals in these soils include kaolinite, montmorillonite and hydromica , which is typical for black soil of the region. Almost all samples have been investigated in an appreciable number of tumors observed gypsum.

All samples were subjected to spectral analysis of 47 elements , further Hg and F, as well as determined the movable and stationary (fixed) forms of Pb, Zn, Cd, Cu, Hg, Ni, Cr, Mn, Sn - multistage extraction stood out : the water-soluble , acid soluble , by organic , exchange- sorption and stable forms of presence of metals. Parallel studied mineralogical , petrographic , hydrochemical microbiological composition vertical section of soil .

Arising out of work performed for the first time to the territory of the arid zone of Ukraine (Donbass) , a model of distribution of metals in the supergene zone vertical section , the upper part of which are the soil . In the vertical section of soil and elyulyuvialnyh traselyuvialnyh landscapes, irrespective of the degree of anthropogenic impact , and allocated 2 akumulyativnye horizon metals : first - 0 -10cm from the surface , the second - 20 - 35cm from the surface. In the first accumulative horizon on background areas almost all the studied metals in water-soluble form is 1-1.5 % of the total concentrations , on the areas of technogenic geochemical anomalies mobile forms comprise : Pb 21-24%, Mn up to 50 %, Zn, Cu, Cr - 1-4%, Cd> 85 % composed of mobile forms , the second accumulation horizon is fixed at a depth of 20-35 cm from the surface .

Depth - 20 - 30cm - redox - horizon (BSO4). Registered education sulfides some siderophile elements Hg, Pb, Zn, Cu, As. And the graphics content in soils MES inversely content , indicating that the process of sulfate . Due to the sulfate-reducing bacteria soil profile indicates that they may translate + → Me MES . (technogenic geochemical anomaly Alchevsk Iron : 10cm depth , Hgslf - 6 · 10-7%; depth of 30cm (redox - horizon) , Hgslf - 30 · 10-7%; depth 20cm , Hgslf - 0 , 03 · 10-7% . Increase Hgslf occurs in parallel with a sharp decrease to almost 0 sulphate content in soil solutions .

As a result of studying the distribution of metals in the supergene zone arid conditions of Donbass (squares technogenic geochemical anomalies and background regions) , first established patterns of distribution of metals in the vertical section of different landscapes. The studies found that the majority of metals entering the soil profile by both natural and man-made by accumulated to a depth of 35cm and deeper distribution of metals to their content corresponds to the background of the region. Exceptions include metals such as Mn, Cr, Cd - they do not accumulate on geochemical barriers and migrate in the first aquifer that from an environmental point of view is very dangerous, as Cd and Cr ions are toxic .

Patterns of distribution of metals in the vertical profile of the supergene zone (in particular soil) shows

- At what depths , (depending on climatic conditions and soil structure) they are located in the ionic state (available to plants and biota) and mineral (unavailable to biota);
- Actual increased migratory properties of some metals (Mn, Cr, Cd) - typical for this region ;
- The behavior of metals in a given block of the supergene zone allows you to control processes in the areas of industrial technogenesis technogenic waste , environmental risk creating artificial barriers to migration of metals;
- Concentration of rare, expensive metals and scattered artificial geochemical barriers for waste storage areas of mining , etallurgical and chemical industries .

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[DS2] Soil Development and Soil Properties and Functions

Environmental Functions of the Farmer's Land Classes Into the Zone of Influence in Two Natural Protected Areas of Michoacan, Mexico

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In the last two decades the research in the soil sciences has made emphasis on the environmental soil functions, nevertheless, exist only a few cases where the soil's functions evaluations results are in quantitative form and based in the data of the soil profile description. The land classes identified by the farmers are the best medium for communicate the environmental soil functions of their lands. For these two reasons, the objective for this research was to made soil functions evaluations to eight farmers land classes in a volcanic zone using the software Assofu (Assessment soil functions), this software, recently designed allows the environmental soil evaluations from the profile soil information. The samples of soil were taken in four different landforms with different soil use in the biosphere reserve Zicuiran-Infiernillo, Mexico. For each land classes we described the soil profiles, we collected samples by horizons for the physics and chemical analysis. The information was capture in the software Assofu for the evaluation of the following soil functions: filter and buffer of heavy metals; soil as component of the water cycle; soil as production site of food and other biomass; soil as component of the nutrient cycle; soil as basis for life and habitant of flora and fauna; soil as transformation medium (compounds); soil as medium of infiltration and seepage; and, soil as a source of organic carbon. Were made soil functions maps using a land classes map, made with a geomorphopedologic approach as cartographic base for assigning the soil functions. The land classes evaluated were: Barrosa/Polvilla, Barrosa, Polvilla, Polvilla/Charanda, Polvilla/Barrosa, Charanda, Cementante and Tocura. The results indicated that the land classes: Barrosa/Polvilla and Barrosa possess the best aptitudes for the retention of heavy metals, are considered as a productive soils with favorable nutrients supplies, with ideal quality and quantity of water recharge and with high content of carbon; in general this lands are fertile because of the high clay content, they also shows a good cationic exchange capacity (CEC), an appropriate quantity of organic matter, calcium, magnesium and favorable pH; unlike the Polvilla and Polvilla/Charanda land classes where the evaluations shows low aptitude levels for the previously mentioned functions, despite the fact that the Polvilla land class contain the necessary nutrients for it be cultivate and as restriction the abundance of rocks and stones; in the case of the Polvilla/Charanda land class, the evaluations are more unfortunate because of the low cationic exchange capacity and organic matter content. The average aptitude levels were focused in the Polvilla/Barrosa, Cementante, Charanda and Tocura land classes. For all cases, the land classes qualify as anthropogenic and with low capacity of transforming organic pollutants by the microorganism; nevertheless, they are considered suitable for the human life and with cultural and natural importance. Adequate soil managements will be required in order to conserve the area for a more sustainable land use. On the other hand, considering that the land class of high agricultural potential is the Barrosa and such class of land is becoming urban area, it is necessary to analyze land uses planning taking into account their best skills and environmental functions.

Keywords：*Soil functions, farmer's land classes, software Assofu.*

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[DS2] Soil Development and Soil Properties and Functions

Estimation of the Brooks-Corey Soil Characteristic Curve with the Tension Disc Infiltrometer Data

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The measurement of soil water characteristic curve (SWCC) is among the most difficult and time-consuming tasks in soil physics. The current standard methods using the pressure chamber or tensionmeter, however, are often time-consuming and difficult to carry out. In this study, we proposed a simple method to estimate the SWCC with sufficient accuracy tension disc infiltrometer data obtained with the disc infiltrator. The proposed approach was tested in both of three different textured disturbed and undisturbed soil columns under three different pressure head (0,-5cm,-10cm). The measurement was replicated for four times for each soil. The validity of this method was confirmed by showing good linear regression relationship with data sets obtained by standard pressure chamber method. However, the pore size distribution method (PSD) could only predict the SWCC in disturbed soil columns. The results of this work strongly suggest that the proposed method can be applied for the in situ measurement of water retention in the fields.

Keywords：*soil water characteristic curve, disc infiltration, pore size distribution*

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[DS2] Soil Development and Soil Properties and Functions

The Total Content and Distribution of Iodine in the Profile of Some Soils and Plants of Western Siberia

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We are study halogens in soils and plants of Western Siberia. We are discussed in this report a situation with iodine in the natural objects: soils, plants. A definite combination of soil and iodine properties creates conditions for the larger or smaller content of iodine in the soil. The organic matter of the soil and salinity levels last play major role in the accumulation of iodine. Size distribution, particularly silt of soil particle minimal influence and presence of carbonates, as a natural barrier. The process migration of iodine controlled and reaction of the soil environment. In an acidic environment due to some chemical reactions loss halogen amplified, and in alkaline activated its accumulation. Due to the solubility of most salts of iodine, the intensity of its growing in the context of migration and periodically wash and washing water regime types, а непромывной и выпотной типы снижают ее.

Our research in Western Siberia showed that soils of the northern and southern parts differ markedly of the iodine content. Soil tundra and forest tundra, northern and middle taiga depleted halogen due to their lack of explicit preconditions for its accumulation. Low humus content (0,07- 2,02%), predominance of fulvic acids, sometimes pronounced lack of humus horizon (podzols) and acidic reaction of soil prevent the accumulation element. Cations Fe 3+ and Mn4+ in acidic medium due to the difference in the magnitude of the redox potential is easily oxidized to the free iodine element, which then volatilizes. Iodine concentration are from traces to 1mg/kg quite natural.

Other situation is observed in the south of Western Siberia. In the group of zonal soils south of Western Siberia iodine is most rich black soil (min - 1,21, max - 6,4 mg/kg) , due to the high content of organic matter, the predominance of humic acids. According to the literature, the humic acid may be concentrated to 88% iodine, and only 12% - a fulvoacids. Sod-podzolic soils are less rich in iodine. Min - 0,23, max - 2,36 mg/kg. There is little humus, acidic environment and the washing water regime. Among intrazonal soils the highest content of iodine found in salt marshes (min-5,6; max- 33,2 mg/kg). They are common in intermane depressions where accumulated various salts, including iodine. Less iodine found in solonetzes (min- 1,8, max -18,7 mg/kg) with a maximum in the illuvial horizon.

This horizon is much sludge as well as oxides and hydroxides of iron and aluminum, which are voluminous precipitates sorption active element.

The content of the humic matter of soils was analyzed using two methods: the determination of humus composition in mineral soils by the Kononova-Bel chikova procedure and the determination of iodine traces in biological objects by the Proskuryakova-Nikitina procedure with some modifications necessary for iodine determination. It was found, that the content of iodine is in humic acids and in fulvic acids with residue varied at a level of = 50% of its total amount. The iodine concentration in fulvic acids was estimated to be half that in humic acids.

Contents of water-soluble iodine depends on the gross amount. Typically, the concentration of water-soluble forms of halogen decreases with a decrease in total. Although the relationship is not strictly enforced.

The content of iodine was studied in natural and sown meadow plants grown on the territory of the Novosibirsk region. The highest element concentration was found in natural meadow plants (0,21-0,26) and the lowest content- in wheat (0,12-0,17); oat occupies an intermediate position (0,19 - 0,22 mg/kg dry substance). Significant differences in the iodine were not found between the plants in different regions of the territory.

The knowledge of the total content each element in the soil, including iodine, is necessary for the overall performance. But is important data of mobile forms that can enter plants. This forms include of salt-soluble form, to extract which we proposed to use a solution KCl with C=0,1 n/l. Proposed earlier version with C= 5% KCl we rejected for several reasons, which I will report orally. Salt-soluble iodine content in different types of soil ranged from 0,02 to 1,42 mg/kg of soil, which is higher that the water-soluble.

Keywords：*soil, plant, iodine*

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[DS2] Soil Development and Soil Properties and Functions

The Potential of Exotic and Native Species Plantation to Improve the Productivity of Degraded Forestland in Malaysia

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Deforestation and land use change to other land use types have contributed to degraded secondary forests or forestland and increases the emission of greenhouse gases which ultimately led to global climate change. Forest plantation on degraded forest is regarded as an important approach for carbon sequestration. However, limited information exists on productivity and potential of fast growth exotic and indigenous tree plantations for sequestering CO2 from the atmosphere through photosynthesis. Therefore, this study aimed to assess the productivity and biomass accumulation along with the potential for sequestering CO2 of planted exotic and indigenous species on degraded forestland. The present study conducted at five year-old forest plantation of Khaya ivorensis and Hopea odorata in Segamat Johore, Malaysia. To evaluate the forest productivity and biomass accumulation of both species, we established plots with a size of 40x30 m in three replications in each stand, followed by measuring all trees in the plots in terms of height and Diameter at Breast Height (DBH). To develope allometric equation, five representative trees at each stand were chosen for destructive sampling. The growth performance in terms of mean height, DBH, annual increment of height and diameter and basal area of exotic species (K. ivorensis) was significantly higher than that of the indigenous species (H. odorata). We used the diameter alone as independent variable to estimate stem volume and biomass production of both species. The stem volume of K. ivorensis stand was 43.13 m3ha−1 and was significantly higher than H. odorata stands (33.66 m3 ha−1). The results also showed that the K. ivorensis and H. odorata stands have the potential to absorb CO2 from the atmosphere which was stored in aboveground biomass with value 15.90 Mg C ha−1 and 13.62 Mg C ha-1, respectively. In addition, the carbon content in root biomass of H. odorata stand was higher than that in K. ivorensis stand with value 7.67 Mg C ha−1 and 4.58 Mg C ha−1, respectively. The exotic (K. ivorensis) and indigenous (H. odorata) species which was planted on degraded forestland exhibited different growth rate, biomass production and ability to absorb CO2 from the atmosphere in each part of the tree. In general, forest productivity and ability to absorb CO2 from the atmosphere of exotics species (K. ivorensis) was higher than that indigenous species (H. odorata) indicating productivity of enrichment planting on degraded forest affected by species site suitability. Thus, to sustain high productivity with suitable species selection for carbon sequestration, these factors should be considered for future forest establishment.

Keywords：*Allometric equation, biomass, carbon sink, deforestation, forest plantation*

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[DS2] Soil Development and Soil Properties and Functions

Geostatistical Approach to Optimize Impact of Long Term Cultivation and Fertility Management on Soil Surface Physical Properties

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The study compared the behavior of soils surface physical properties under different land use systems; intensive cultivation and forest-fallow. The aims were: (1) to evaluate the effects of 22 years of mechanized tillage and fertilizer application on the soil surface physical properties and (2) to study the spatial variability of the soil physical properties using a geostatistical tool, called variogram. soil siampling was carried out on the two adjacent field (cultivated and fellow) along established transects at regular intervals. some random sample were also collected. result obtained showed that 22 years of cultivation had resulted in coarser texture, reduced aggregate stability and increased bulk density (significantly from 1.2 to 1.7 g/cm3). Under fallow, all the soil physical properties evaluated did not show any spatial structure while under cultivation anisotropic spatial dependence at a distance of 10m was recorded.

Keywords：*Geostatistics,Variogram.*

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[DS2] Soil Development and Soil Properties and Functions

Development of an Assay for Estimating Root Phosphatase Activity from Excised Plant Roots

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Decline of soil fertility in the tropics and subtropics is a major hurdle towards sustainable food production and ensuring food security. Furthermore economically accessible Phosphorus (P) fertilizer sources are expected to become exhausted over the next 50 to 100 years. Thus it is increasingly necessary to understand and improve the utilization of P sources to maintain food and fiber production into the future. Another source is resident soil organic P, which becomes plant-available via root and microorganism processes. Soil organic P; a resident P source is available upon mineralization mediated by phosphatases. Phosphatases hydrolyze organic P into inorganic P that can be taken up by plants. We investigated a method to determine mineralizable organic P by phosphatases exudated by excised live roots. We used excised green house and field grown roots with para-nitrophenylphosphate, glucose-1-phosphate and phytic acid as sources of organic P. Different aspects of the experimental variables were analyzed including linearity of the reaction, presence of inorganic P, organic P exudated from roots, possible abiotic degradation of organic P and background inorganic/organic P. Mineralization of organic P by root-phosphatase complex was found to be linear till 6 hours and other possible sources of contamination into the system were found to be within 10% of mineralized organic P. We used this technique to answer questions pertaining to organic P bioavailability including mineralizability of different P sources, effect of plant species, effect of plant varieties and plant stress. Overall this method was very sensitive to root conditions, organic P source and plant stress which was reflected equally by field roots. Unlike other methods used to determine phosphatase activity this method is not limited by lengthy set up times to develop model plants nor there is any restriction to use any particular organic P as source since this technique was validated using field roots and different organic P sources. Our results suggest that this method developed can be instrumental in determining species specific mineralizability of organic P and can be used universally in routine lab analyses.

Keywords：*Bioavailability, organic phosphorus, mineralization, excised roots, phosphatase activity, Q10, , bahiagrass, peanut, cotton, phytic acid, glucose-1-phosphate, para-nitrophenylphosphate*

P1-170

[DS2] Soil Development and Soil Properties and Functions

Effects of Light Fraction Organic Matter on Key Soil Functions and Microbial Communities in Dryland Agricultural Systems of Western Australia

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Light fraction organic matter (LFOM) is considered as an important ready source of carbon (C) for soil microbes and nutrients for plant growth, and has been used as an indicator of changes in labile organic matter as affected by management practices and environmental factors. In order to quantify how LFOM affects key soil functions and microbial communities in crop systems of Western Australia, a gradient of previously obtained LFOM (0, 20%, 50%, 100%, 200% and 500%) were added into two field soils with variable background organic C levels ("tilled" and "tilled plus organic matter") and incubated under 25°C and 45% water holding capacity (WHC) for 12 weeks. The two field soils had been similarly managed with the exception of 80 tonnes organic matter added as chaff over the past 10 years to the "tilled plus organic matter" plots. Microbial activity was measured as CO2 evolution from the soil throughout the incubation period. Soil pH(CaCl2), total C (TC), total N (TN), WHC, ammonium and nitrate concentration, microbial biomass C (MBC), and activities of enzymes including acid phosphtase, β-glucosidase and cellulase, and cation exchange capacity (CEC) were determined after 6 weeks (T1) and 12 weeks (T2). Community level physiological profiles (CLPP) was examined to assess the changes in microbial community structure.

The results showed that the added LFOM was used up quickly; however, the soils which had historic amendments of organic matter had significantly higher microbial activity (CO2-C evolution). The recent addition of LFOM also significantly increased microbial activity, but the difference between treatments diminished over time. Both background soil organic carbon (SOC) level and recent addition of LFOM had significant effects in increasing TC and TN, ammonium and nitrate concentration, acid phosphatase and β-glucosidase activities, WHC, and CEC. Higher background SOC level and LFOM addition were associated with a decrease in soil pH(CaCl2) which might suggest increased acidification as a result of higher nitrogen (N) mineralisation rates. Higher background SOC level also supported higher MBC but it decreased with increasing LFOM. Cellulase activity demonstrated a negative relationship with increasing background SOC level and LFOM at T1, but a positive relationship with background organic matter level at T2, which might suggest that with the consumption of LFOM after 12 weeks, soil microbes might mainly rely on the more recalcitrant organic matter for C source. Higher background SOC level supported higher evenness of microbial community as reflected by CLPP, which was not affected by LFOM addition.

In conclusion, LFOM had a significant influence in microbial activity and key soil functions (e.g. N mineralization, WHC, CEC, etc.) in the short term regardless of the background SOC level, but might not directly affect the structure of microbial communities.

Keywords：*Light fraction organic matter, soil function, microbial activity, microbial community structure*

P1-171

[DS2] Soil Development and Soil Properties and Functions

Residual Effect of Poultry Manure on Selected Soil Properties, Growth and Yield of Okra in an Ultisol

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A field experiment was conducted at the Faculty of Agriculture experimental field, University of Benin, Benin City, Edo State, Nigeria to determine the residual effect of poultry manure on some soil properties, growth and yield of okra in an ultisol. Three rates of poultry manure namely 0, 10 and 20 tons/ha replicated four times was fitted in a randomized complete block design (RCBD). Results indicated that residual poultry manure produced significant differences ($p<0.05$) in Soil pH, organic carbon, total nitrogen, available phosphorus, potassium, calcium, magnesium, exchangeable acidity, iron, manganese, zinc and soil moisture retention compared to the control. Plant height, number of leaves, leaf area, days to 50% flowering and okra pod yield were significantly enhanced ($p<0.05$) by residual poultry manure treatment. The 20 t/ha residual poultry manure yielded twice the pod yield compared to control.

Keywords：*Poultry manure, Okra, Soil properties, Residual, Yield*

P1-172

[DS2] Soil Development and Soil Properties and Functions

Characteristics of Soil Physico-Chemical of Watermelon Field Under Plasric Film House in Chungbuk Province

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Watermelon is one of the most important fruit during summer season in Korea. Watermelon cultivation is different because its cultivation time and cropping pattern are different according to the cultivation regions.

Recently, for improving the watermelon quality and yield, it's chiefly cultivated in paddy soil under the vinyl house. The Eumseong and Jincheon are the major cultivation regions where a lot of watermelon greenhouses are located in Chungbuk. When installed greenhouses, it is difficult to move them, therefore, we have a little chance to do to another region. Because the translocation of existing structures to another region requires a big investment in land, equipment and labor. Therefore soil management is the most important factor for the long-term stable production of high-quality agricultural products. First of all, for scientific soil management, it is very important to know how to compose soil and how to know soil environment characteristics. It is also useful in determining the soil environment characteristics and the aspect of soil environment characteristics plan for soil management. This study were carried out to understand soil environment and soil management effectively under the watermelon greenhouses at Eumseong and Jincheon paddy soil in Chungbuk with data of soil environment information system(http://asis.rda.go.kr) from 2003 to 2011.

The topsoil of Eumseong area and Jincheon area soil texture were distributed in the order of loam, sandy loam, silt loam, and fine sandy loam. The land topography has the highest mountain foot slope and is followed by diluvial plateau, alluvial fan and riverside at Jincheon area and the highest alluvial fan, and isfollowed by inland plain, diluvial plateau and riverside at Eumseong area. The sedimentary style of Eumseong and Jincheon area have the highest eluvium(56.5%, 60.5%) followed by alluvial disintegration layer(29.8%, 18.7%)) and alluvium(9.2%, 14.8%), respectively. The soil morphological classification have inceptisols 87%, 87.8%, and entisols 7.6%, 7.8% and alfisols 4.7%, 4.4% at Eumseong and Jincheon area, respectively. The parent materials of soil were in order of acidic rock>quaternary sediments>sedimentary rock at Eumseong area and quaternary sediments>acidic rock>sedimentary rock in Jincheon area. The optimum cultivation land of watermelon were 40.6% at Eumseong area and 28.7% in Jincheon area. Watermelon cultivation field was investigated at 33 soil series that typical soil series at Jincheon area is Deogpyeong series, Seogcheon series, Gangseo series, Ogcheon series, and Pyeongtaeg series. Eumseong area was investigated at 43 soil series that Jisan series, Ogcheon series, Sangju series, Cheongweon series, and Deogpyeong series.

The average pH, organic matter, available phosphate, exchangeable potassium, calcium, and magnesium at Jincheon area were 6.2, 34g kg-1, 520mg kg-1,0.94cmolc kg-1, 6.5cmolc kg-1, and 3.0cmolc kg-1, respectively and the average pH, organic matter, available phosphate, exchangeable potassium, calcium, and magnesium at Eumseong area were 6.2, 21g kg-1, 472mg kg-1, 0.81cmolc kg-1, 8.7cmolc kg-1, and 3.4cmolc kg-1, respectively

The frequency distribution within optimum range of soil chemical properties were 27.0%, 27.5%,8.0%, 5.9%, 20.1% and 15.9% for pH, organic matter, available phosphate, exchangeable potassium, calcium, and magnesium, respectively at Jincheon area and 26.9%, 29.2%, 8.7%, 4.5%, 11.8%, and 13.9%, respectively at Eumseong area.

Especially, excessive portion of exchangeable calcium, and magnesium were high 77.1% and 76.6%, respectively at Eumseong area

From these results, we considered that understanding of soil chemical properties could be able to improve the fertilization methods for sustainable agriculture in plastic film house.

Keywords：*soil properties, watermelon*

P1-173

[DS2] Soil Development and Soil Properties and Functions

Background Concentration of Heavy Metals in Soils Developed from Different Parent Rocks in Korea

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Monitoring heavy metal concentrations in agricultural soil which is likely influenced by the contamination source nearby is conducted every year in Korea. This is basically to eliminate any possible degradation of agricultural soil due to elevated heavy metals. In order to evaluate whether the heavy metal concentration is increasing, exact background values for each heavy metal concentration in soil needs to be established. The current study was conducted to determine the background level of heavy metal concentrations in natural soil developed from different parent rocks in Korea. For this, 322 soil samples (Igneous rock 55 points and 176 samples, Metamorphic rock 27 points and 72 samples, Sedimentary rock 27 points and 74 samples) from natural forest soils which are assumed not to be affected by any contamination source. Total concentrations of heavy metals in soil samples were determined using ICP-OES after microwave assisted digestion using aqua regia. Cadmium concentration from all the samples were below the Korean soil guideline (4 mg/kg) with higher values observed in the soil developed from sedimentary rock compared to the soil from igneous and metamorphic. Chromium concentrations were remarkable high in the soil from metamorphic rock and sedimentary with the highest values (350 mg/kg) determined in the soil from sedimentary. Copper concentration was higher in the soil from igneous rock than the soil from metamorphic and sedimentary. In contrast, Nickel concentration was high in the soil from igneous rock rather than metamorphic and sedimentary. In particular, a soil from sedimentary rock showed high concentration exceeding the Korean soil guideline (100 mg/kg). There was no significant difference in Pb concentration depending of the parent rocks but the average concentration appeared to be higher than the average Pb concentration in paddy soil. Zinc concentration was higher in the soil from metamorphic rock and sedimentary than igneous. Likewise, the distribution of heavy metal concentrations varied depending on the parent rocks and hence consideration of the parent rock properties should be required for better management of the metal contaminated soil.

Keywords：*Heavy metals, Background level, Parent rock, Korea*

P1-174

[DS2] Soil Development and Soil Properties and Functions

Textural Interfaces affected the Distribution of Roots, Water, and Nutrients in Reconstructed Soils

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Re-constructed soils in the reclaimed landscape in the Athabasca oil sands region (AOSR) usually consist of an upper amendment layer (cover soil) and a substrate layer below. The cover soil used is typically peat-mineral mix (PMM) and the substrate can be materials such as tailings sand (TS) and fine-textured overburden (OB) materials. Abrupt changes in soil properties between the cover soil and the lower substrate layer create the so-called textural interface that can restrict water and nutrient movement and subsequently affect root growth. To assess the effect of the textural interface on the distribution of roots, water, and nutrients, we collected soil samples from the 10-5, 5-2, and 2-0 cm layers above and 0-2, 2-5, and 5-10 cm layers below the interface (zero at the interface) from nine sites each of PMM/TS and PMM/OB that were planted to lodgepole pine (Pinus contorta) and white spruce (Picea glauca) trees, respectively. Fine root (< 2 mm) biomass (FRB) decreased logarithmically ($p<0.01$) through the interface. The greatest decrease was found between 5-2 and 2-0 cm above the interface in TS due to lack of capillary rise of water and at the interface in OB due to compaction of fine-textured OB material. Based on stepwise regression analysis, volumetric water content and NH4-N or DON explained the variation of FRB in TS while electrical conductivity (EC) was the main parameter explaining FRB in OB. Our results indicate that management practices need to consider the influence of textural discontinuity or textural interface on the distribution of fine roots, water and nutrients and for water and N availability in TS and salt stress in OB as potential limiting factors for improving tree growth in the reclaimed/reconstructed landscape in the AOSR.

Keywords: *Fine root, land reclamation, overburden, tailings sand, textural interface*

P1-175

[DS2] Soil Development and Soil Properties and Functions

Development for Standard of Soil Physical Properties for Upland Soil in Korea

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For healthy growth of crops, it is important that criteria for soil management could cover various soil physical properties and crop growth, including soil texture, soil moisture contents, soil strength, drainage, aeration, root extension, productivity and so on. However, it is complicated to assess effects of soil physical properties on crop growth as the effects are combined and a number of properties are interrelated to each other. Soil compaction is general in modern farm in Korea by agricultural machine. This study was performed to find out indices and to make standards in the upland soil to represent soil physical quality considering crop growth and productivity.

Experimental soil was 3 texture, sandy loam, loam and silty clay loam. Compaction treatment was conducted by driving roller on the subsoil in the field. It was supposed that main factors for soil physical properties were water permeability, aeration, strength, effective moisture condition and crop rooting & productivity. The tests were followed. (1) The relationship of soil compaction and porosity was determined by investigating bulk density and aeration porosity which was defined by 'total porosity – moisture content at 10kPa'. (2) The relationship of soil compaction and water permeability was found out by investigating bulk density and hydraulic conductivity. (3) Crop growth was investigated after compaction treatment in the field.

From the test, the results could be combined into ground water table commonly and bulk density with soil texture, which were involved in water permeability, aeration, strength, effective moisture condition and crop rooting & productivity. It is conluded that ground water table and bulk density could be as indices for soil physical quality with soil texture, including main function of soil. According to the indices, optimal criteria are ground water table, lower than 100 cm and bulk density, less than 1.55 Mg m-3, 1.50 Mg m-3, 1.40 Mg m-3 in sandy loam, loam and silty clay loam of subsoil, respectively.

Keywords：*soil physical properties, bulk density, compaction*

P1-176

[DS2] Soil Development and Soil Properties and Functions

Quantifying Uncertainty in the Measurement of Heavy Metals in the Soil

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Heavy metals in soil create several environmental problems. So the accurate and precise measurement of heavy metals in soil is needed to develop practical guideline for managing heavy metal contaminated areas. We calculated the uncertainty of measurement of three heavy metal concentrations from contaminated soil. The calculation of uncertainty is based on the Guide to the Expression of Uncertainty in Measurements (GUM), proposed by the International Organization for Standardization (ISO). We have considered various factors of uncertainty from sampling to final result such as the calibration curve, digestion, dilution and etc. The concentration of Cd, Cu, Zn were 3.09, 70.83, 547.23 mg/kg, respectively. The expanded measurement uncertainty of Cd, Cu, Zn were 0.10, 3.05, 14.39 mg/kg, respectively.

Keywords：*Heavy metals, Uncertainty*

P1-177

[DS2] Soil Development and Soil Properties and Functions

Influence of Rice Varietal Characteristics on Methane Emission in a Temperate Paddy Soil

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Cultivar selection management is important for increasing rice (Oryza sativa L.) productivity and mitigating methane (CH4) emissions in paddy soil. However, the underlying causes of the differences in CH4 emission among cultivars have not been thoroughly evaluated. We hypothesized that CH4 emission differs significantly among cultivars due to the inherent differences in apparent plant growth characteristics and physiological traits. In particular, rice cultivars with a short crop duration (i.e., an early-maturing cultivar) could be more effective to reduce CH4 emission that those with a long crop duration (i.e., late-maturing) due to shorter flooding period. To that end, a field experiment was conducted to investigate the eight Korean cultivars which include Chuchung, Dongjin, Ilmi, Junam, Nampyeong and Samkwang (late-maturing cultivars) and Odae and Woonkwang (early-maturing) were studies for three years (2010-2011) in terms of their CH4 emission characteristics as well as other plant and soil properties. The results showed that mean CH4 emission rates and total CH4 fluxes differed significantly among the cultivars ($P<0.05$) but not between the late- and early-maturing cultivates. The shortening of the flooding period in the early-maturing cultivars did not decrease total CH4 fluxes. Instead, microbial abundances affecting CH4 dynamics in paddy soil through the methanogens (i.e., mcrA gene copy numbers) and methanotrophs (i.e., pmoA gene copy numbers) significantly differ among the cultivars ($P<0.05$) but not between the late- and early-maturing cultivars. Methane fluxes were correlated in highly positive manner with methanogens and negative manner with methanotrophs, but not with any of the apparent plant growth parameters (e.g. grain yield, straw yield, etc.). The varietal differences of CH4 emission traits might have been due to the individual plant root's biomass and other physiological characteristics like organic substrate excretion and its root oxidation potential. Root-derived C can be an important nutrient source for CH4 production by methanogens while oxygen (O2) supply in the rhizosphere is important for enhancing CH4 consumption by methanotrophs, controlling the overall CH4 dynamics during the cropping season. In 2012, simple organic C substrates in soil as well the plant's above- and below-ground characteristics were investigated in homogenized soils that were transplanted with six cultivars (Chuchung, Dongjin, Ilmi, Junam, Nampyeong and Samkwang) in the rice paddy field, and their root oxidation potentials were investigated by characterizing the root oxidized area through digital image analysis in the rhizotron experiment. Methane emission characteristics as well apparent plant growth and grain yield properties differed significantly among the cultivars ($P<0.05$). In particular, labile organic C contents in soil (e.g. dissolved organic C, carbohydrate, and total organic acids) differed significantly among cultivars ($P<0.05$) and had a strong positive correlation with CH4 emission rates and methanogens abundances. On the other hand, root oxidized area significantly and negatively correlated with CH4 emission rates and dissolved CH4-C, and significantly positively correlated with dissolved CO2-C, pmoA gene copy number, root biomass and root volume, suggesting that the O2-releasing capacity of the cultivars has an important role in regulating CH4 production and enhancing CH4 oxidation in the flooded paddy soil. In conclusion, low CH4-emitting, low root organic C excretions and high root oxidation potential are important traits to consider in order to minimize CH4 emissions during rice cultivation from temperate ricefields like Korea.

Keywords：*methane emission; temperate paddy soil; rice cultivar*

P1-178

[DS2] Soil Development and Soil Properties and Functions

Effect of Wheat-Soybean Cropping Systems and No-Tillage on Soil Structure and Chemical Properties

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The cultivation management of soil is mostly dependent on tractor or other cultivars, however, heavy tillage brought serious pollution and CO2 emission problem. So, for reducing those problems we introduced no-tillage cropping systems. Actually, No-tillage (NT) was introduced in Korea in 1980s but the cropping acreage was not increased until 2010s, in spited of, NT have several potential benefits including reduced production costs saved tractor power, equipment and labor and improving soil physical characteristics. The objective of this study was to find out the effects of soil NT and crop rotation (wheat-soybean) on soil structure and chemical properties in upland. The experimental design was a split-plot with three replicates. The soybean and wheat seed was direct-sown in early-summer and late autumn, respectively, in no-tilled field. Soybean and wheat were harvested in later October and Early-summer, respectively, for 5, 4, and 2 year. Liquid fertilizer was applied with 3-levels (0, 3, 6-N kg/10a). The content of soil organic matter and phosphors were decreased by increasing NT years, however other chemicals were not significantly different with NT years. The bulk density at 0-20 cm soil depth was not significantly different between NT years and soil depth (i.e. 1.34 and 1.36 g cm-3). The value of penetration resistance was significantly increased with increasing soil depth between 15 and 30 cm. The NT 4-year produced lower penetration resistance than NT-1year. There was no significant difference between the NT years below 30 cm depth. The content of soil biomass-C was highest in 1-year no-tillage which was almost two times higher than 4-year no-tilled soil. So no-tillage is very valuable practice for the economically viable and agriculturally sustainable management.

Keywords：*No-tillage, Direct-sown, Denetration resistance, Bulk density*

P1-179

[DS2] Soil Development and Soil Properties and Functions

Effects on Soil Carbon by Green Manure Crops at Rice Paddy Fields under Tillage Methods

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Field experiments were conducted to evaluate winter-adaptable single or mixed cropping systems on tillage methods intended to improve plant biomass yields and soil carbon. Tillage methods were divided into tillage (T) and No-tillage (NT). Five cropping systems of green manure crops, namely 1) ray (R), 2) triticale (TC), 3) hairy vetch (HV), 4) TC+HV, and 5) control (fallow), were investigated during the winter and spring of 2012-13. The contents of carbon and nitrogen fixed in the aboveground biomass and soil carbon content by depth were measured for each green manure cropping system. The aboveground biomass was the highest in T-TC+HV followed by NT-TC+HV and NT-R with 6.75, 6.61, and 5.44 Mg/ha, which exceeded the biomass of control by 202, 198, and 163%, respectively. The amount of carbon accumulation was higher in the soil surface than deeper soil, which followed a similar pattern to the aboveground biomass yields. Therefore, green manure cropping in winter and spring seasons has the potential to effectively increase soil carbon in the short-term through belowground carbon inputs.

Keywords：*tillage methods, plant biomas, soil carbon*

P1-180

[DS2] Soil Development and Soil Properties and Functions

Response to Excessive Water Stress of Upland Crops By Subsurface Drainage in Poorly Drained Sloping Paddy Fields

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Most of upland crops such as sorghum (Sorghum bicolor L.), foxtail millet (Setaria italica L.), proso millet (Panicum miliaceum L.), soybean (Glycine max L.) and adzuki bean (Vigna angularis L.) are damaged by either excessive soil water or capillary rise of the water table during rainy season in paddy fields. And their growth and productivity are limited by soil water stress with various degrees of intensity. The purpose of this study was i) to test the effect of the installed pipe drainage in poorly drained paddy soil for multiple land use and ii) to evaluate changes in the growth and the yield of upland crops such as sorghum, foxtail millet, proso millet, soybean and adzuki bean.This experiment was carried out in poorly or somewhat poorly drained paddy fields of alluvial sloping area located at Toero-ri, Bubuk-myeon, Miryang-si, Gyeongsangnam-do. The drainage system was designed to remove excess water from the soil quickly enough to minimize crop stress and installed within 1-m distance beneath upper field bank using two kinds of drainage methods, open ditch and pipe subsurface drainage. The measurement of soil moisture levels after drainage, which were used to determine the soil bearing capacity, was made at 1, 5, 10, 15 and 20 m positions from the edge of the upstream bank of the field where each of drainage type was constructed. During the same period of soil moisture measurement, the levels of the water table were monitored from 150 cm-long sensing systems. The results showed that the infiltration rate of 5.46 cm/hr recorded in the subsurface drained fields was substantially higher than the 2.20 cm/hr obtained in the field with open ditch. The decrease in moisture within the soil profile and the attainment of the maximum water-holding capacity after the occurrence of rainfall were faster in the tile drainage than in the open ditch drainage. The sum of excess water days (SWD30), which was used to represent the moisture stress index, was 42 days (the lowest) in the pipe subsurface drainage method compared with 110days in the open ditch drainage method.

The spatial variance of soil water content by pipe subsurface was reduced while yield of upland crops showed the same trends. Value of 'Semivariance' of soil water content using the geostatistical analysis was higher in the open ditch drainage method than in the subsurface method, calculated as 29 m and 24 m, respectively. The effectiveness pipe drainage method was more cleared up than the open ditch drainage method. It was shown that the pipe subsurface drainage system had helped in increasing crop yields as well as improving soil productivity and consequently total economic value of such a production. Yield of upland crops in the pipe subsurface method was continuously increased by the rate of 15.1% on sorghum, 15.4% foxtail millet, 53.6% proso millet, 49.6% soybean and 47.9% adzuki bean as compared in the subsurface method. Coefficient of variation (C.V) of yield of upland crops was higher in the open ditch drainage method than in the subsurface method. C.V of yield in the open ditch drainage method was 6.59, 25.22, 26.95, 42.07, and 47.55, whereas C.V in pipe subsurface method was 4.25, 6.31, 11.35, 17.11, and 14.71.In conclusion, the capacity for tolerance by excessive soil water based on yield of each upland crops in the poorly drained sloping paddy fields was the order of sorghum, soybean, foxtail millet, proso millet and adzuki bean.

Keywords：*Subsurface drainage, Moisture stress index, Soybean, Water table level, paddy field, upland crop*

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[DS2] Soil Development and Soil Properties and Functions

Properties of Soil in Landslide Hazard Area in Pyeongchang-Gun in Korea

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1. Background and Significance :

Increase of heavy rains due to the climate change causes natural disasters. Especially, damages by landslides have been increasing in Pyeongchang-gun. The risk of damages like destruction of facilities, transportation system and loss of lives could be increased by landslides. Therefore, landslides risk management in Pyeongchang-gun is very urgent.

Existing landslides studies are focusing on the causes and the possibilities of landslides (Kee 2012; Yoo et al. 2012). They found that the highest occurrence possibility area and the reason of landslides occurrence. These results can be help to local government. For example, local government can get information of prior area by using the map of landslide occurrence possibility. Therefore, these landslide studies are very important to manage the risk of landslide.

Landslide relevant studies are utilizing lots of environmental variables (soil, vegetation, topography, rainfall etc.). However, most of studies were using data provided by government or national institutes. Especially, soil is the key factor of landslide occurrence. But soil data like soil map provided by institutes is too big scale (30m*30m or 100m*100m) to apply landslide studies. Therefore, studies that explored soil properties of landslide hazard area by using big scale map had included lots of uncertainties and errors.

This research aims to explore more objective and specific soil properties of landslide hazard area. We got information of soil properties (physical, chemical) by field survey and experiment. The soil properties can be used to estimate probability of landslide occurrence and find prior area to establish landslide adaptation plan.

2. Methods :

We chose two types of sites for filed survey. One type is hazard area to landslide (unstable area), and the other type is stable area to landslide. Specific field survey sites were found by using overlay analysis. Control variables (slope, vegetation, aspect, bedrock) were included for the overlay analysis. Therefore we selected sites consider specific conditions (similar slope, same vegetation type, similar aspect, same bedrock).

Sampling points were selected consider disturbance after landslide in the hazard area. In the stable area, sampling points were chosen consider topography.

Basic data (slope, coordinate, aspect etc.) was investigated in the field. We made 2~3kg sampling for each site. The depth of soil

that sampled had range of 0.5 ~ 1.0m. Requesting experiment to specialized institution for analyzing soil properties(soil hardness, porosity, soil texture, bulk density, degree of soil aggregation). After we got some results about soil properties, analyzed it for investigating properties of landslide hazard area. Statistical methods were used to find significant differences between hazard and stable sites. We analyzed correlation of soil properties between landslide hazard area and stable area. Differences of soil properties were found from the results of correlation analysis.

3. Results :

In landslide hazard area, soil hardness was higher (bad for vegetation), porosity was lower, soil texture was coarser and degree of soil aggregation was lower than stable area. Almost every soil properties showed different value. The result of correlation analysis also showed different tendency in two types of sites. The result of this study can be applied to find landslide hazard area. Especially it will be help to GIS based spatial model that require lots of soil properties information.

Keywords：*soil characteristic, soil sampling, debris flow, natural disaster, correlation analysis*

P1-182

[DS2] Soil Development and Soil Properties and Functions

Effects of Different Tree Types on Microbial Community Structure in the Mt. Jiri of Korea

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Tree species play important roles for plant productivity and mediator of microbial process with supply of nutrients in forest soil. In the study, we investigated microbial composition and community structure by using FAME methods in A horizon of forest soils under two broad-leaves (Carpinus laxiflora and Stewartia koreana) and two conifers (Abies koreana and Quercus mongolica). Microbial composition and community were significantly different between conifer versus broad-leaves. The first axis, which accounted for 46.7% of the variation in the FAME data, resulted in the separation of the different tree types with i17:0, 18:2 ω6,9c. The second component explained 17.4% of the variation and separated the two areas from each other with 16:1 ω7c, cyc17:0, and 18:2 ω6,9c among wholes FAME profiles. The abundance of specific microbial biomarker lipids correlated with soil pH, total C and N. Consequently, these results indicates that tree species have significant impacts on the shift of microbial community through their effects on soil pH, total C and N in forest soil.

Keywords：*Forest, tree species, microbial community structure, FAME*

P1-183

[DS2] Soil Development and Soil Properties and Functions

Influence of Cultivated Regions in Organic and Conventional Farming Paddy Field

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The purpose of this study was to find out optimum cultivated regions for rice organic farming. The organic and conventional rice as control were grown in three different places : secluded hill paddy field for Hapcheon, normal rural paddy field for Sancheong and suburban paddy field for Jinju from 2005 to 2006. In secluded hill paddy field, the organic material and pesticide to control pest and disease were input two times for organic and conventional rice cultivation. However, in normal rural and suburban paddy field, they were input three times for organic and conventional rice cultivation. The occurrence of sheath blight in organic farming was higher than in conventional farming. Whereas planthopper population per 20 plant was significantly high 10.1~19.5 for conventional farming compared with 4.4~10.0 for organic farming. For that reason, the density of the planthoppers was higher in organic farming than those in conventional farming. Dominated weeds occurred in organic and conventional paddy field were namely Monochoria vaginalis, Ludwigia prostrata, and Cyperus difformis. The population per 20 plant and dried weight per m-1 of weed were higher in 121 and 50.5 g for organic paddy field. The productivity of rice in different cultivated regions for organic farming was 2.96 Mg ha-1 in hill paddy field, 4.03 Mg ha-1 in normal rural and suburban paddy field. Toyo-taste value and ratio of perfect grain of milled rice were not different by cultivated regions in both farming system.

Keywords：*Conventional farming, Cultivated region, Organic farming*

P1-184

[DS2] Soil Development and Soil Properties and Functions

Verification of Phenomenon Explanatory Power of New Concept Model on Time-Series Decrease of Crop Production During Conversion from Paddy to Upland Condition in Paddy Field

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The concept model that was established is that time-series decrease of crop production during conversion from paddy to upland condition in paddy field results from decreases of natural nitrogen supply according to exhaustion of easily degradable soil organic matter by a rapid degradation of soil organic matter in lasting aerobic condition. But, this model had lack of phenomenon explanatory power that decrease of crop production was excessively more than decrease of soil organic matter, etc. Therefore, reestablishment of concept model was required for cultivation research in paddy field converted to upland. The object of this study was suggestion of new concept model on time-series decrease of crop production in paddy field converted to upland. In summary of new concept model, a small portion of iron involved in phosphorus absorption was as reduction state in paddy soil repeated flooding and drainage. If converted to upland, the iron was converted to oxidation state and phosphorus absorption of soil increased. An abundant phosphorus supply by a rapid degradation of soil organic matter can counter balance a increase of phosphorus absorption in early conversion to upland. As time passes, this balance is upset and increased phosphorus absorption is more than natural phosphorus supply and phosphate is deficient in ecosystem. Mineralization of organic nitrogen and crop production decreases due to its spin-off. Additionally, a weak phosphorus deficiency symptoms, a weakened resistance to disasters in related to phosphorus(cold wave, low temperature, etc), a distorted response of crop growth on nitrogen fertilization and soil fertility(law of minimum nutrient), a strange fluctuation of available phosphate, etc are involved.

The original object of field study used for verification of phenomenon explanatory power was to investigate changes of growth and production on each crop and soil physicochemical properties according to cropping system and weather barley straw was applicated to soil or not in cropping system of barley(Hordeum vulgare L.) + soybean(Glycine max L.), adzuki bean(Vigna angularis L.), proso millet(Panicum miliaceum L.), sorghum(Sorghum bicolor L.), foxtail millet(Setaria italica L.). The used experimental field had been cultivated rice until 2008 and a boundary of two soil series locates in area range from 10 m northeast to 50 m southwest with experimental field as the center. The research results at 2013 were that growth and production of barley decreased in order of barley + soybean > azuki bean > proso millet > sorghum > foxtail millet and divided into barley + legumes and barley + gramineaes. By the way, compared barley + legumes without barley straw to barley + gramineaes with, the production of barley in barley + legumes without barley straw was more than barley + gramineaes with barley straw as 162 kg 10a-1 nevertheless soil fertility was lower. Then, nitrogen content of barley straw was noticeably higher in barley + gramineaes than in barley + legumes and phosphorus content was reverse. This phenomenon can not be explained by the established concept model on time-series decrease of crop production in paddy field converted to upland as well as general plant nutrition theory except allelopathy.

This phenomenon could be explained by new concept model as follow: If premised that the boundary of two soil series which occurs in some place of a certain area including experimental field actually passes between barley + legumes plot and barley + gramineaes plot or center of barley + proso millet plot, time when balance of natural supply and soil absorption on phosphate broken in both soils must be different. The balance should be more quickly broken in soil of barley + gramineaes plot and a distorted response of barley growth on soil fertility due to limit of phosphorus uptake should remarkably come about. Therefore, on the whole, the growth and production of barley decreased in order of barley + soybean > azuki bean > proso millet > sorghum > foxtail millet and divided into barley + legumes and barley + gramineaes. Then, nitrogen content of barley straw was noticeably higher in barley + gramineaes than in barley + legumes and phosphorus content was reverse.

Keywords : *Phenomenon explanatory power, Concept model, Conversion to upland, Upland crop , Decrease of crop production, Iron oxidation, Unbalance of phosphorus supply-demand*

P1-185

[DS2] Soil Development and Soil Properties and Functions

Comparison of Land Use Types on Soil Organic Carbon under Different Altitude of Mt. Odae Areas, Korea

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Soil organic carbon (SOC) content, a potential indicator for soil fertility in agro-ecosystems, is influenced by many factors. This study was conducted to compare the SOC content in two distinct land use types of the arable and a forest in Mt. Odae, Korea. Soil samples were collected from thirty sites at each of an arable and a forest land from depths of 0-30 cm and 30-60 cm in adjacent places. The SOC content was compared with topsoil temperature, variation altitude and of terrain. In both the arable and forest land, topsoil had a relatively higher SOC content than subsoil. The SOC content at all sites increased with the altitude. The SOC content was higher in the north-facing slope than in the south-facing slope due to the relatively low temperature of about 5℃. In case of the south-facing slope, the SOC content in topsoil was approximately two times greater in the forest land than in the arable land. Generally, the SOC content at all sites was lower in the arable land than in the forest land. This meant that agricultural practices such as cultivation and tillage led to a decrease of SOC stock. From the results, we can conclude that the SOC greatly affects by a range of factors, such as topography, land use, soil management, and climate. The results will also provide useful information for an appropriate level of SOC stock in different land use types.

Keywords：*soil organic carbon, topography factors, land use type*

P1-186

[DS2] Soil Development and Soil Properties and Functions

Nutrient Balances and Soil Properties Affected by Application of Crop Residue

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An accurate analysis of nutrient balance in different cropping systems is necessary for improving soil fertilities, causing higher crop yields and quality. This study was carried out to investigate the nutrient balance, changes in soil properties, and their effects on crop yield in long-term field cultivation under mono- and rotation-cropping systems (MCS and RCS, respectively). The analytical results of the soil properties showed that the application of mineral fertilizers alone in the MCS leads the reduction of soil CEC, exchangeable Ca, and microbial biomass C and N. Compared with the MCS of soybean, the RCS of soybean and barley significantly improved the soil properties, which increased crop yield. It might be due to the barley residue added to the RCS soil. Mean nutrient balances for 4 years were ?5.6 kg N, +3.5 kg P2O5, and?0.1 kg K2O 10a-1 for the MCS and +2.0 kg N, +10.7 kg P2O5, and?4.8 kg K2O 10a-1 for the RCS, respectively. These nutrient imbalances mean that conventional fertilizer recommendations were inadequate for maintaining soil nutrient balance. From these results, we can conclude that the crop rotation may change comprehensive physical, chemical, and biological soil properties. These changes could affect the nutrient balance and then the crop yield.

Keywords：*nutrient balance, soil properties, crop residue*

P1-187

[DS2] Soil Development and Soil Properties and Functions

Evaluation on the Equilibrium Distribution Patterns of Trace Metals by Comparison with Ph and Ec in Uncultivated Soil in Korea

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To identify the background level of trace metals and understand the relationship among trace metals, pH and electrical conductivity (EC) in uncultivated soil, 322 surface and subsoil samples become weathered from igneous rock(176), metamorphic rock(72), sedimentary rock(74) were taken at the 109 site, from 8 provinces except Jeju province of hilly area in Korea. All of sampling sites have been not disturbed for long time and no farming practices before. Total concentration of trace metals were measured by ICP-OES after microwave digestion.

Soil pH were ranged from 3.9 to 7.3. EC were from 20 to 320 ㎲ ㎝-1, showed very wide and even distribution range at the soil of igneous rock compared to metamorphic and sedimentary soils. Also the distribution pattern of EC in accordance with pH was very similar with those of Cd and Cu and concentrations of Cd and Cu were higher at the soil of igneous rock. On the contrary, the distribution pattern of among EC, Pb and Zn were completely different compared to the result of relationship with pH, and mostly concentrated at the low level and scattered at the high level of contents without great difference between parent rocks.

Among trace elements, concentration of Cd were mostly below of 1 ㎎ ㎏-1 and over half of them were not detected level. In view of parent rock, background level of Cd was in the order of igneous rock> sedimentary rock> metamorphic rock. Relationship of concentrations between Cu and Cd was mutually increasing pattern, even though the concentrations of Cd in many soil were not detected level. However, on the relationships among trace metals, uniquely in the case between the concentrations of Ni and Cr showed direct proportional relationship (r2=0.78), exceptionally. By increasing of Cr concentration, Ni concentration also proportionally increased at the same time. The concentrations of Pb and Zn were below 100 ㎎ ㎏-1 at 97% of soil sample and showed slightly direct proportional relationship.

Keywords：*trace metal, pH, electrical conductivity, background level*

P1-188

[DS2] Soil Development and Soil Properties and Functions

Chemical Properties Changes and Fertilization Status of Upland Soil in Jeju Island

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Soil chemical properties and fertilization status were examined to provide the data for conservation of agricultural environment with the improvement of fertility and fertilization system of upland soil by every 4 years from 2001 to 2013 in Jeju Island. Soil pH, the content of available P2O5 and exchangeable cations were no significant changes among the survey years. By comparing with soil pH and organic matter between 2005 and 2013, soil pH was increased as 0.3, but organic matter was dereased as 6 g kg-1. Available P2O5 was increased to 364 mg kg-1 in 2009, whereas it was reduced to 238 mg kg-1 in 2013. Exchangeable K has fallen from 1.05 cmolc kg-1 in 2001 to 0.99 cmolc kg-1 in 2013. While exchangeable Ca was decreased to 7.7 cmolc kg-1 until 2009, it was slightly increased to 8.7 cmolc kg-1 in 2013. Exchangeable Mg showed the continuing decrease from 2.4 cmolc kg-1 to 1.9 cmolc kg-1 since 2001. The short rate of soil pH was reduced from 50.0% in 2001 to 46.4% in 2013, but its over rate has been slightly increased from 30.0% in 2001 to 34.3% in 2013. The short rate of available P2O5 was decreased from 63.6% in 2001 to 53.1% in 2009, but it has increased to 66.4% in 2013. Its over rate was increased from 18.5% in 2001 to 28% in 2009, but it has been reduced to 13.6% in 2013. The short rates of exchangeable K and Mg were increased respectively from 9.3% and 29.3% in 2001 to 20.2% and 45.7% in 2013, but its over rates were decreased respectively from 82.9% and 47.1% in 2001 to 72.9% and 42.9% in 2013. The short rate of exchangeable K was decreased from 43.6% in 2001 to 37.9% in 2013, but its over rate was increased from 47.8% in 2001 to 55.0% in 2013. In the result of soil chemical properties and fertilization status, soil pH, the content of available P2O5 and exchangeable cations of investigation points were similar to the overall average of upland soil, but soil pH and the content of exchangeable cations in garlic cultivation were significantly higher than the optimum level. Farm household conventional fertilization amount was more excessive than N 2.5 to 4.3 times, P2O5 1.9 to 2.1 times, K2O 3.1 to 3.9 times by comparing to the soil testing recommended amount. Especially, in the garlic cultivation, it was excessively fertilized more than CaO 1.7 times, MgO 1.2 times against the soil testing recommended amount.

Keywords：*Jeju island, Upland soil, Chemical properties changes, Fertilization status*

P1-189

[DS2] Soil Development and Soil Properties and Functions

Changes of Chemical Properties of Orchard Soils in Gyeonggi Province

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Soil chemical properties of agricultural soils in Gyeonggi province were investigated at four-years interval in order of paddy, plastic film house, upland and orchard soil since 2000. Orchard soil samples were taken from the surface 15cm at 100 sites in 2002, 2006 and 2010, respectively. Chemical properties of orchard soils were 6.3 for pH, 21.0g kg-1 for organinc matter, 653mg kg-1 for available phosphate, 0.72cmolc kg-1 for exchangeable potassium, 6.1cmolc kg-1 for exchangeable calcium, 1.9cmolc kg-1 for exchangeable magnesium in 2010. Long-term change was shown that pH, available phosphate, exchangeable calcium and magnesium contents have increased gradually whereas exchangeable potassim level in 2002 was 0.81cmolc kg-1 but had decreased to 0.72cmolc kg-1 in 2010, respectively. Average concentration of available phosphate in 2010 was higher than the upper limit of its optimal range for orchard cultivation. However, Soil organic matter contents were below the lower limit of their optimal ranges, which were 82% and 92% of them, respectively.

Keywords：*Orchard soil, Soil chemical property, Optimal range, Available phosphate*

P1-190

[DS2] Soil Development and Soil Properties and Functions

Effect of Long-Term Fertilization of Organic Matter on Soil Physical Properties in Paddy Soil

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Organic matter has been widely used as a essential means in terms of enhancement of soil fertility and soil physical properties to stabilize crop production in agricultural field. To find out these effects of organic sauces, many researchers have been studies for long term experiments. We studied that long-term process in 41 year old paddy soil with a fine silty loamy textured alluvial deposit were continuously carried out on chemical fertilizer(NPK), rice based compost, combination these two (NPK+Compost) and no fertilization (control), respectively. Ap layer, top of surface soil could be found increase by treatment of compost and NPK+compost. Also, cone penetration resistance value and a bulk density in same treatments could know that there are distinct differences in terms of improvement on soil physical properties compared to other treatments. The rice root weight with 10cm depth in NPK+compost was 1,406 kg ha-1 which improved 25% compared to NPK, while there was no significantly differences in root length in all treatments. MCI(Maximum Cone Index) of the control and NPK is shown each depth 25.7, 26.0 cm, while that of compost and NPK+compost are 31.7, 30.3 cm, respectively. Among parameter of soil compaction, depth of MCI and thickness of compaction were highly correlated with distribution of rice root weight. These result is shown that proper combination process of organic matter and chemical fertilizer in paddy soil should be required to enhance rice rhizosphere and soil physical properties which will help in sustaining production.

Keywords：*Long term, Compost, Chemical fertilizer, soil physical property, rice root*

P1-191

[DS2] Soil Development and Soil Properties and Functions

Distribution of Stable Pb Isotopes in Natural Forest Soils, Korea

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Lead isotopes are widely used for tracking sources of the Pb contained in sediments, atmosphere, industrial products, food and animals. The ratio of the stable Pb isotopes was assumed to be varied depending on the source of Pb in soil. This means that the stable Pb isotopes ration in contaminated soils affected by mining sites or smelter is likely different from that of non-contaminated soils which has not been affected any other sources. In this matter, the background level of stable Pb isotopes ratio needs to be determined exactly for comparison with that from contaminated soil. For this reason, the current study was conducted to determine the background level of stable Pb isotopes in soil, Korea. A total 50 soil samples were collected from natural forest at Ap-horizon(0-20cm) in national wide. The collected samples were analyzed for Pb concentration and Pb isotopes(204Pb, 206Pb, 207Pb, 208Pb). Total concentration of Pb was measured by ICP-OES after microwave digestion and Pb isotope was measured by MC-ICPMS after graphite block acid digestion.

Lead concentrations varied from 3.4 to 110.8mg·kg-1, with a median value of 16mg·kg-1. Isotopic ratios of 206Pb/207Pb ranged from 1.563 to 1.126 with a median value of 1.198. The determined Pb isotopes showed variability but the pattern of Pb isotopes could not found significance relation-ship. For comparison with the natural forest soil, two mine soils (wondong and dogok), as Pb contaminated soil, were collected and Pb isotope ratio were determined. The 206Pb/207Pb-isotope ratios in the mine soils showed a similar ratio to natural forest soil. The isotopic signatures of 208Pb/207Pb and 206Pb/207Pb of mine soils showed similar values by soil. These results indicated that lead stable isotope technique would be use as useful evaluation to technique for the potential for the trace of contaminants.

Keywords：*Lead isotope, Korea, stable isotope composition, background, soil, MC-ICPMS*

P1-192

[DS2] Soil Development and Soil Properties and Functions

Effects of Redox Potential and Ph Condition on Nitrogen Stability

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Soil redox potential (Eh) with pH is the most important characteristic for nutrient availability during the crop growth. The concentration of nitrate, nitrite and ammonium ion were governed by the equation of NO3- + 2H+ + 2e- ? NO2- + H2O (log k0 = 28.64) and NO3- + 10H+ + 8e- ? NH4+ + 3H2O (log K0 = 119.07). This study was conducted to calculate the mole fraction of nitrogen species at 200 mg L-1 as NO3- ion on pH 7.0, 6.0, and 5.0 and to compare the calculations to the results of on-site analysis. Below Eh 480 mV at pH 7.0, these chemical dynamic showed the decrease of nitrate ion and the increase of nitrite ion in solution. This result indicated that emission of nitrous gas (NO2) could damage crop growth in low Eh condition. Because pH+pe was constant, the nitrite ion increased below 600 mV of Eh at pH 5.0 and it meaned NO2 gas could be emitted in oxidant soil status. Calculating nitrogen species equilibria suggested that occurrence of growth inhibition might be induced by nitrogen uptake or damage of NO2 gas in the status of low Eh.

Keywords：*redox potential, pH, nitrogen stability, nitrogen species*

P1-193

[DS2] Soil Development and Soil Properties and Functions

Development of an Assessment System for Soil Quality Based on Soil Functions in Korea

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Soil is the basis of all life on earth together with air and water and plays important roles in keeping Earth's ecosystem healthy. Due to a slow formation rate of 100-400 years/cm of soil, it must be considered as a limited and non-renewable resource from the viewpoint of human. In Korea, the soil protection related to natural resources conservation has become an issue of increasing concern at the national level in recent years. To manage soil conservation, the quality of soil or rather the functions of soil should be sustainably protected or restored. In this study, we aimed to develop an assessment system for Korean soils regarding soil quality, selecting important soil functions and their indicators, scoring the indicators for each soil function and indexing each soil function, and eventually combining the indexed soil functions. The choice of an assessment tool will depend on the purpose for which it is needed and the type of database. For this study, the following databases were used: 1) chemical (pH, OM, EC, CEC, P2O5, NH4-N, and NO3- N) and physical properties (clay, texture, permeability, gravel, and bulk density) from about 1700 sites in Korea (own project), 2) geographical, geological, chemical, and physical properties of 313 soil series provided by the National Academy of Agricultural Science (RDA; 1: 5000), 3) the Digital Geologic Map provided by the Korea Institute of Geoscience and Mineral Resources (KIGAM; 1: 250,000), and 4) the Environmental Conservation Value Assessment Map provided by the Ministry of Environment (ME; 1: 25,000). Selected soil functions were as follows: 1) plant biomass production, 2) groundwater recharge, 3) habitat for native plants, 4) carbon storage, 5) filtering and buffering of heavy metals, and 6) soil erosion. On the basis of statistical (principal component analysis) or reference data, indicators were selected and subsequently scored. For example, pH, OM, caly content, and gravel content were used to assess the soil function of filtering and buffering. After scoring and indexing, soil functions were combined based on the arithmetic or weighted mean depending on the purpose of use. A GIS was employed to display the spatial distribution of soil quality results.

Keywords：*Assessment tool, indicator, principal component analysis, soil function, soil quality*

P1-194

[DS2] Soil Development and Soil Properties and Functions

Research on Dynamic Changes of Rhizosphere Soil Properties of Alder Birch Plantation

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This article emphatically reviews the difference of soil chemical properties, biological and biochemical activities between the rhizosphere and non-rhizosphere soil of Alder Birch(Betula alnoides Buch.-Ham.) plantation. It also reviews their dynamic patterns during Alder Birch plantation development. The results show that the contents of organic and inorganic nutrients in the rhizosphere soil of young, half-mature and near-mature Alder Birch are more than those in non-rhizosphere soil, except for total K in young Alder Birch plantation. Various patterns of soil nutrients and physical properties in different stages of Alder Birch plantation development are as follows: available N shows the trend of declination in both rhizosphere soil and non-rhizosphere soil; the content of available P also declines, only increases a little from half-mature stage to near-mature stage, but total P decreases from the beginning to the end. The content of available K increases from young stage to half-mature stage, but decline from half-mature stage to near-maure stage both available K and total K. The contents of Cu, Zn, Mn, decrease greatly from young stage to half-mature stage, and rehabilitate a little from half-mature stage to near-mature stage in non-rhizosphere soil. As for the variation of the soil enzyme activity, both hydrolytic enzyme and oxidizing enzyme are less active in rhizosphere soil than in non-rhizosphere soil at young stage. However, when Alder Birch becomes into mature, the activities of soil enzymes are higher in rhizosphere soil than those in non-rhizosphere soil. The results of soil micro-flora show that the quantities of bacteria, actinomyces, fungi in rhizosphere soil is more than that in non-rhizosphere soil in the young Alder Birch plantation. The quantities of bacteria and fungi decrease in rhizosphere and non-rhizosphere soil, but the quantities of actinomyces increase along with the Alder Birch becoming into half-mature. From half-mature Alder Birch plantation to near mature stage, the quantities of bacteria, actinomyces and fungi increase. The variation of the three types of microorganism in genus, species and amount in rhizosphere soil and non-rhizosphere soil during stages of Alder Birch plantation development indicates the dynamic process of soil degradation.

Keywords：*Alder Birch plantation, Rhizosphere soil, Non-rhizosphere soil, Soil properties*

P1-195

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Temperature Regime Observed and Analyzed for A Japanese Andosol.

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Soil temperature for a Japanese Andosol was observed for a decade 20 years ago.

The observed temperature data for 4 years was analyzed with Fourier method.

We found the thermal diffusivity for the soil to be about 180 cm^2/day.

According to this analysis, the soil temperature was simulated for a depth up to 12 meters.

This simulation suggests that the annual temperature change will delay half a year by about 4 to 5 meter depth.

We may utilize this analytical result for warming and/or cooling of any substance for half a year delay for instance.

Keywords：*Soil temperature, Thermal diffusivity , 180 cm^2/day*

P1-196

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Development of a Simple Model for Estimation of Soil Moisture Content Using Routine Weather Data and Comparison with Multiple Regression Model

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In soils and agrometeorological studies, soil moisture content is one of the most important parameters in surface fluxes modeling, drought and frost studies. Since, in-situ measurement of soil moisture is costly and time consuming, its estimation by using routine weather data and soil temperature in surface and depth is suitable offer. In this research, routine weather data including soil temperature, air temperature, wind speed, sunshine, pan evaporation, relative humidity and precipitation of nine selected agrometeorological station of Iran were collected and used for soil moisture estimation by two approaches, Stepwise multiple regression analysis and a simple balance model. Correlation coefficient between observed and calculated soil moisture (by developed model), were compared with obtained results from regression analysis. Suitable statistical indices of RMSE, MAPE, ME, MAE and MBE, were used for evaluation of the results. In each station, the best regression equations for different depth of 10, 20, 30, 40, and 50 centimeters were introduced. The results of regression analysis showed that correlation coefficient vary between 5.7% in Kahriz Orumie station, to 71% in Najafabad station. The results of this study showed that estimation of soil moisture in top level layers of soil (25 to 35 centimeter) is more accurate and dependable. The results of both approaches are coinciding but the developed model did a better job in deeper layers of profile

Keywords：*Regression analysis, soil temperature, modeling, moisture profile, weather data*

P1-197

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Molecular Modelling of Humic Substances

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The molecular basis for many properties of humic substances (HS) and related processes is a topic of intensive research already for decades. Advanced analytical techniques such as NMR, FT-IR, pyrolysis-MS, and many others provide detailed insight into specific features of HS (e.g. chemical composition, molecular weight, or structural functionalities). However, owing to extreme structural complexity and chemical variability detailed configurations and structure of HS still remain unknown and need to be further elucidated. This, together with gathering information about important interactions of HS molecules with various species in soils and formation of organomineral aggregates, leaves ample room for further investigations. Besides advanced analytical methods, molecular modelling offers the opportunity to investigate and characterize various detailed features of HS at molecular level. Modelling techniques cover a broad scale of methods, from computationally demanding techniques known as ab initio methods (quantum mechanical methods, QM) that are based on the approximate solution of the Schrodinger equation to effective and cheap molecular mechanics (MM) methods also known as “force-field”(FF) methods. The QM methods provide a broad scale of properties such as electronic structure, energy-minimized molecular structures, spectroscopic parameters (e.g. NMR, EPR, IR/Raman), or thermodynamic quantities. The important step is to define simplified but representative model capable of mimicking certain important moieties and HS characteristics. To this end we developed several structural models of various complexity. The model consisting of trimers of polyacrylic acid was used in investigation of wetting process of nanopore segments in humic substances as a function of the distance. At shorter distances between the two trimer chains an outer solvation was most stable. However, with increasing distance between two trimeric segments the water molecules penetrated into the formed free space, connecting the two chains by means of a hydrogen-bonded network, which had a significant stabilization effect. The model strongly supports the hypothesized bridging function of water molecules in humic substances. Another model setting comprised four undecanoid fatty acids served as models for spatially fixed aliphatic chains in HSs terminated by a polar (carboxyl) group. The rigidity of the oligomer chains is significantly enhanced as soon as the water cluster is large enough to comprise all four carboxyl groups. The role of multivalent cations in the formation of stable supramolecular aggregates of HS (cation bridges) was investigated by modelling interactions of Al3+, Ca2+, and Na+ cations with carboxyl/carboxylate groups that terminated aliphatic chains. The degree of microhydration and a distance between functional groups were parameters affecting the stability of cation bridges. The strongest effect on the local environment and the stability of cation bridges was observed for Al3+ cation. The calculations reflect the amphoteric character of the hydrated Al3+ complex showing in most cases its acidic character via proton transfer from the water molecules of the hydration shell to the carboxylate group, but in some cases also deprotonation of the carboxyl group. Dry aluminum cation acts as a strong Lewis acid and initiates electron transfer from the carboxylate groups to the cation also at larger intermolecular distances. Further, micelle-like models consisting of 6 aliphatic chains terminated by carboxyl groups served as model system to investigate the interaction with MCPA in a microhydrated environment and naphthalene trapping in the hydrophobic part of the nanopore system. Both interactions could be proven to be energetically favourable.
In addition condensed phase models of humic substances were developed and diffusion of ions was investigated. Graphene nanoribbons were selected as models for black carbon surfaces in soils. Structures like n-acene, n-phenacene, n-periacene and circumacene were modelled and the unpaired electron densities for different chain-lengths and were determined. A clear dependency of the number of unpaired electrons with chain length and thus a dramatic increase in the multiradical character was shown.

Keywords：*molecular modeling, humic substances, ab-inito, force field methods*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Modeling Ph Effect on Antimony(v) Adsorption-Desorption and Transport

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As the biggest antimony producer, China has suffered serious antimony pollution in several regions where soils were highly enriched in Sb with concentration up to thousand times of natural background. However, there are significant knowledge gaps on the understanding of the fate and behavior of antimony in soil environment. Earlier studies have indicated soil properties including metal content, organic matter, flow regime, and pH as potential controlling factors of antimony retention and transport in soils. The effect of pH on antimony(V) adsorption-desorption kinetics and non-equilibrium transport has not been previously determined. In this study, kinetic batch and saturated column transport experiments were performed to study the effect of pH (4, 6, 8) on a sand coated with amorphous or poorly crystalline iron oxides. In addition, the applicability of multi-reaction models using various equilibrium and kinetic sorption expressions were tested for describing adsorption-desorption kinetics of antimony. A transport model based on advection-despersion equation (ADE) and surface reaction mechanisms were developed to simulate the breakthrough of Sb(V) through columns.

Keywords：*antimony, adsorption-desorption, advection-dispersion*

P1-199

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Exploring on Integration of Soil Nutrient Grading Index for Large-Regional Soil Nutrient Mapping in China

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The soil nutrient grading indexes might be different for the different counties of China in the second national soil survey. The soil nutrients mapping in large region such as national or provincial regions has to be done after the integration of those grading indexes. The hardcopy of the soil nutrient maps for most of the counties were collected and vectorized. These maps are mostly scaled at 1:50 000 to 1:500 000 and could be used as the input data for the integration of the grading index. Considering the original data is quite massive and complex, a model named Soil Nutrition Index Integration Model (SNIIM) is established based on ARCGIS10.0 and is written in C#. SNIIM will not change or revise the properties of the spatial soil nutrient maps and will save the original grading index for every soil polygons and it is designed in two color systems for more easy reading. SNIIM consists of five modules, and can be easily used to intelligent soil grading index integration for the massive soil nutrient mapping. A case study is done using the 1:500 000 soil organic matter maps of 17 provinces from the second soil survey. SNIIM is a general model and is also applicable to the environment, ecology and other areas to resolve the similar problems.

Keywords：*Soil nutrient maps , Nutrient grading index, Integration , SNIIM Model*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Computational Intelligence-Based Model for Prediction of Soil Cation Exchange Capacity: A Data Mining Approach

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The advances in computing and information storage have provided vast amounts of data. The challenge has been to extract knowledge from this raw data; this has lead to new methods and techniques such as data mining that can bridge the knowledge gap and discover interesting information from the hidden data, which can either be used for future prediction and/or intelligent summarization of the data details. Cation exchange capacity (CEC) indicates soil nutrient conservation and buffering capacity, so it is a key indexing parameter for soil fertility and buffering capacity evaluation. Measuring the CEC for all horizons of every map unit component in a survey area is very time consuming and costly. The objective of this study was to develop CEC prediction model that encompass most soils of North and Central Iran using Artificial Neural Network (ANN) for data mining approach and apply it to a soil science database to establish if meaningful relationships can be found. A large data set has been used to conduct this research and was stratified into more homogeneous groups based on the CEC, Organic Carbon (OC) and clay contents. The data set was divided into two subsets for calibration (80%) and testing (20%) of the models and their normality were tested by Kolmogorov-Smirnov method. OC and clay contents were used as input parameters in the predictions. The Levenberg-Marquardt BP algorithm was used and optimal neuron number was determined as 2 for CEC prediction model. In order to evaluate the models, mean square error (MSE) and R were used. The best values of MSE and R derived by ANN models for CEC were 0.0083 and 0.6901, respectively. Results indicated that 69% of the variation in CEC could be explained by OC and clay data.

Keywords：*Artificial neural network, CEC, Data Mining, Iran*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Assessment of Ct-Measured Pore Characteristics and Soil Physical Properties Using Principal Component Analysis

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Knowledge of soil variability plays an important role for implementation of land management strategies for enhanced environmental and economical benefits. Variability in soil properties is associated with spatial, temporal or management related factors and these can impact soil erosion, groundwater pollution, water movement and chemical transport. The objectives of this study were to determine the variability of computed tomography (CT)-measured pore characteristics including soil physical properties and combine them into a few principal components (PCs) using principal component analysis (PCA).

Undisturbed core soil samples were collected form three study locations using 7.6 cm diameter and 7.6 cm long cores from the 0-10 cm depth in northern Missouri: the silvopasture with buffers (SPBF) at New Franklin, paired watersheds (PW) of a corn (Zea mays L.) soybean [Glycine max (L.) Merr.] rotation with buffers at Novelty, and prairie management (MP) at Centralia, Kingdom City and Williamsburg. The SPBF study location consisted of agroforestry buffers, grass buffers, rationally grazed pasture and continuously grazed pasture. The PW consisted of no-till corn-soybean rotational watersheds with pin oak (Quercus palustris Muenchch) and cool season grass legume buffers. The MP study location included a native prairie (Tucker Prairie) and a restored prairie (Prairie Fork).

Soil physical properties including bulk density (BD), saturated hydraulic conductivity (Ks) and sand, silt and clay percentages were analyzed for all three study locations separately. CT-measured pore characteristics including macroporosity, mesoporosity, pore numbers, circularity, and fractal-D were measured using a Siemens Samaton Plus 4 volume Zoom x-ray CT scanner. The scanned images were analyzed using the public domain software Image-J version 1.27. Measured data sets were lumped together by study locations for correlation analysis, descriptive statistics, variability analysis, PCA, and discriminant analysis.

Pearson's correlation analysis showed that most of the CT-measured pore characteristics and soil physical properties including Ks and BD were significantly ($P < 0.05$) correlated with each other either positively or negatively within all three study locations. This indicated that sufficient amount of correlation was present among the measured variables to perform PCA analysis. Coefficients of variation (CV) indicated that number of pores, macroporosity, mesoporosity and Ks were most variable ($CV > 0.35$) whereas circularity, BD and silt content were the least variable ($CV < 0.15$) at all three locations. Larger values of CV were observed at the SPBF study location which could be attributed to cattle grazing.

The PCA grouped five CT-measured pore characteristics and five soil physical properties into three PCs (eigenvalue >1): soil porosity, water transport and soil texture. At all three study locations, the first PC explained 51% of the variance with positive loadings on macroporosity, mesoporosity, and pore numbers. Similarly, the second PC explained 12-26% of the variance with negative loading on fractial-D, and Ks and positive loading on circularity and BD. The third PC explained 7-12 % of variance with positive loadings on silt and negative loadings on silt and sand content.

Based on the canonical coefficient, three equations were obtained for each study location using redundancy analysis of the three PCs. The values of the discriminant coefficients were the highest for soil porosity PC (2.34-3.45), followed by water transport PC (1.19-1.57) and soil texture PC (0.37- 0.39). Therefore, soil porosity PC was identified as the most discriminating PC at the three study locations. Further discriminant analysis of porosity PC indicated that the pore number soil attribute was the most discriminating followed by macroporosity and mesoporosity at all three study locations.

Regression analyses showed that number of pores at each study location were significantly correlated ($r > 0.81$) with macroporosiy, mesoporosity, and Ks. The coefficient of determination between log(Ks) and log(CT-measured pore numbers) ranged between 0.50 and 0.76.

In general, the overall investigation showed that the soil porosity factor containing number of pores followed by macroporosity and mesoporosity were vital and influenced the other soil physical properties such as Ks and BD. The results of the analysis also showed that management practices that increase the number of pores, macroporosity and mesoporosity could help reduce soil degradation on agricultural lands. This can be achieved by introducing buffers at strategic locations in continuous/rotational grazing and row crop lands.

Keywords：*claypan, grazing, pores, row crop*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Effect of Textural Layering on Water Movement and Alfalfa Growth

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The effect of textural layering on water movement and alfalfa growth was assessed through a series of laboratory column tests and numerical modeling. Alternating horizontal layers of coarse sand and sandy loam were placed in 90 cm long soil columns with three different layer thicknesses (11.25 cm, 22.5 cm and 45 cm), while two homogeneous columns were constructed with coarse sand and sandy loam as control, respectively. Three continuous experiments of drainage, evaporation, and alfalfa growth were conducted in these columns. Firstly, all soil columns were completely saturated and then allowed to drain to a water table boundary at the base of the columns. The changes of water storage with time were measured by weighing the columns and monitoring water content profiles using TDR during the 120-hr drainage. Secondly, evaporation and water distribution were lasted for 60 days after the 120-hr drainage. Soil water content profiles and changes in water storage were monitored along with changes in potential and actual evaporation with time. Finally, alfalfa was planted in each column, and the biomass and root growth in each column were monitored. The hydraulic properties of the coarse sand and sandy loam were measured in the laboratory and also optimized using numerical simulations of the homogeneous column tests. These properties were then used to simulate the drainage, soil evaporation, and alfalfa transpiration of each profile. The laboratory tests and simulated results indicated that the available water holding capacity (AWHC) increased with a decreasing layering thickness until the maximum AWHC was obtained at the layering thickness of 5 cm. Layered columns with coarse sand at the surface significantly limited soil evaporation, and the total evaporation was 110 mm for homogeneous sandy loam column and 8 mm for layered columns without significant difference for different layering thicknesses. The biomass of alfalfa decreased with an increasing layering thickness and presented the same trend as the AWHC. Different textural soils significantly impacted root distribution in the profile of layered columns. The finer roots mainly distributed in sandy loam, while the larger roots were mainly grown in coarse sand. These results highlight the roles of textural layering with coarse sand at the surface in increasing AWHC, limiting soil evaporation, and providing more available water for plant growth.

Keywords：*Layered soil; Available water holding capacity; Soil evaporation; Plant growth.*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Managing Lateral Infiltration in Permanent Raised Beds Using Different Renovation Methods on Two Soils

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Permanent raised bed (PRB) is a bed-furrow farming system that is kept in place for several seasons with minor pre-sowing renovation operations. The PRBs has been shown a suitable option for sustainable crop production. Wide PRBs are often preferred to narrow because smaller irrigation volumes are normally applied and land available to grow crop is increased. However, for such irrigation to be effective the soil in the beds needs to be highly sorptive. Poor lateral infiltration negatively affects water productivity (WP) of wide PRBs thus farmers use a variety of renovation methods to restore its sorptive behaviour. No field research has been found that is specifically focussed on this issue. Many studies have illustrated the need for research into renovation practices that embody all the principles of conservation agriculture and build and maintain a soil structure in beds that ensures they are permanently sorptive enough to ensure quicker lateral wetting.

Therefore, this article evaluates three PRB renovation methods and irrigation strategies to improve lateral infiltration under two soils, Vertisol in Australia and Sandy Clay loam in Pakistan. The three PRB renovation methods were:

1: No tillage: The beds were not disturbed and furrows were cleaned with bed former. Only the soil in the sown rows was disturbed by the seeder during planting;

2: Shallow cultivation: The whole top of the bed cultivated to a depth of about 10-15 cm without relocating furrow positions using a six metre wide cultivator prior to furrow cleaning with bed former;

3: Blade ploughing: The furrows were reshaped and the soil in the bed opened by horizontal blades that were passed through the base of the bed at ~30 cm depth opening the soil without disturbing the roots of the previous crop and without causing any soil inversion using a 200 cm wide blade plough.

A one metre long section of the centre furrow in each treatment, with their three replicates, was isolated at both ends and the experiment commenced with recording antecedent soil moisture in both soils in all four 100 cm deep tubes, installed in furrow centre, in bed centre and two equidistantly between the two using a micro Gopher soil moisture profiler. The furrow spacing was 200 cm in Vertisol and 130 cm in Sandy Clay Loam. The 9 cm water depth was kept constant during the experiment and a log of time (15 minutes interval), soil moisture across the bed (at 10 cm depth interval) and volume of water added to each furrow section was recorded in both soils. The data was used to calibrate the Hydrus 2D model for further analysis. The results showed that:

- The soil moisture distribution across the beds was not uniform and varied under all three PRB renovation methods. Thus, the assumption of uniform soil moisture distribution across the beds is not appropriate.
- The three PRB renovation treatments significantly altered the lateral infiltration capacity on both soils. Thus, bed renovation can be used as a management tool to minimise yield loss of densely grown crops in the middle of wide beds.
- Blade ploughing was more efficient than Shallow Cultivation and No Tillage in reducing the bulk density and increasing the sorptivity, lateral infiltration capacity and soil water storage on both soils.
- The wetting time of bed middle was 20, 14 and 8 hrs on the Vertisol and > 40, > 40 and ~32 hrs on the sandy clay loam when 4 cm furrow water head (1 L s-1) was applied to No Tillage, Shallow Cultivation and Blade Ploughing treatments, respectively. Hence, the required wetting time may be achievable for 200 cm wide bed under Australian conditions but is likely to be difficult to achieve for 1130 cm wide bed on the sandy clay loam under Pakistani conditions.
- The minimum wetting time (15 hrs) required to wet the bed middle on the sandy clay loam with Blade Ploughing and full furrow water head is greater than the irrigation application period (~7 hrs) commonly available in Pakistan. This suggests that the bed width may need to be reduced from 130 cm. Another option could be to fill the furrow by just overtopping the bed at the crop early stage.

Keywords：*Permanent raised beds, Vertisol, sandy clay loam, Hudrus 2D, Lateral infiltration*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

The Effect of Sampling Density on the Accuracy of Estimation for Some of Soil Properties in Shahrekord Plain, Iran

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The quality of soil mapping affects the efficiency of soil use and management. A good understanding of the variability of soil properties between and within map units is a prerequisite for optimum soil use and management. In many places in the world, legacy soil information is difficult to obtain or non-existent. On the other hand, traditional soil mapping methodologies are costly and time-consuming. Therefore, a methodology has to be developed for estimating soil properties where time and budget is limited. Many scientists have developed and used mathematical methods to estimate soil properties. However, spatial variability of soil properties may affect the outputs of soil landscape models. Thus, geostatistical methods have been used to study the spatial variability of soils. Geostatistics is also of great value in the design of optimum sampling and for kriging. The present study was investigated to study the effect of sampling density on the accuracy of estimation for some of soil properties in Shahrekord plain, Iran. 240 soil samples (horizon A) with 125 m intervals were collected and GPS recorded. After sample preparation, they were passed through the 2 mm sieve. Then, the physical and chemical properties including bulk density, particle size distribution, pH and electrical conductivity, and percentage of gravel, calcium carbonate equivalent and organic matter were determined according to the standard methods. The second (120 samples) and third (60 samples) sampling densities were selected randomly from the first samplings (240 samples) by considering their uniform distribution throughout the region. Finally, statistical and geostatistical studies on the dataset were performed. The means comparison test showed that, there are no significant differences for the same soil properties in different sampling densities. Therefore, if the aim of mapping in the area is to estimate an average of soil properties, acceptable results can be achieved by the lower budget and time. By reducing the number of samples, no regular increase or decrease was observed for coefficient of variation (CV), mean estimation error (ME) and root mean square error (RMSE). Low values of the root mean square error (RMSE) showed that the accuracy of the estimation for kriging is acceptable for all of the sampling intervals. The visual comparison of kriged maps showed that all of the soil properties have a similar pattern in three sampling densities. High accordance for different sampling intervals was also achieved based on overall accuracy and Kappa index. Therefore, both statistical and geostatistical results indicate semi-detailed specific soil maps may be replaced for the detailed ones which allow saving time and budget. Such investigations for other soil properties and larger areas can give a better insight for soil variability.

Keywords：*Sampling density, Estimation, Overall accuracy, Kappa index*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Quantification of Soil Quality Using Vis-Nir Spectra

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Visible (VIS) and near-infrared (NIR) spectroscopy has been shown to be effective for prediction of several soil properties over the past three decades. Spectroscopy has the potential to provide time and cost effective quantification of the effects of management practices on soil quality (SQ). Soil quality indices (SQI) offer a method to integrate multiple soil properties for evaluation of SQ. If spectroscopy can be used to quantify the most important soil properties compiled in the SQI, then the SQI can be determined directly from the spectral data. In this study, soil VIS-NIR spectra were employed for assessing the influences of arable and pasture management practices on Irish soil quality. The objectives were; to determine appropriate indicators (soil properties) for assessing SQ; to calculate SQIs; to evaluate the effects of management systems on soil quality; and to assess the efficiency of spectral data for prediction of SQI and separate indicators. The study was conducted on 40 sites under different agricultural management systems (20 arable and 20 grassland). At each site five subplots were selected and twenty one bio-chemical and physical properties were measured as potential indicators of SQ using standard methods (n=200). Regarding the dominant management practices in Ireland, arable sites were characterized into conventional and minimum tillage with crop rotation or mono-cropping systems, and K-means clustering was applied to identify three levels of management intensity (low, medium and high) under grassland. The visual evaluation of soil structure (VESS), which has been shown to reflect agricultural management impacts, was used to select appropriate indicators and validate indices. Principal component analysis was performed to determine a minimum data set and SQIs were calculated using two scoring functions (linear and non-linear) and integrating procedures (additive and weighted additive). Eight indices were developed under grassland and four under arable systems. Soil organic carbon (SOC), total nitrogen (TN), aggregate size distribution, bulk density, bulk density of ≤ 2 mm fraction, extractable potassium (K) and carbon nitrogen ratio (CN) were identified as SQ indicators for grassland, and soil penetration resistance, CN, TN, extractable magnesium (Mg), bulk density, aggregate size distribution and soil respiration were identified under arable management. Management intensification had adverse impact on SQ under grassland, and resulted in lower average values of indices under higher intensity, associated with reductions in SOC, TN and increases in bulk density and CN. SQ under arable indicated the positive effects of crop rotation and adverse impact of mono-cropping under minimum tillage, while there was no significant difference between crop rotation and mono-cropping under conventional tillage. Minimum tillage with crop rotation was found to be a good management option for improvement of SQ. Partial least square regression with cross validation was used to develop prediction models of indices and indicators using spectral data sets. Under arable management, soil VIS-NIR spectra showed an excellent efficiency (RPD > 2.5, R^2 ≥ 0.91) for TN and CN, good prediction ability of aggregate size distribution and Mg (RPD from 2 to 2.5, R^2 ≥ 0.82), and moderate capability for prediction of penetration resistance, bulk density, and soil respiration (RPD from 1.5 to 1.99, R^2 ≥ 0.60). Under pasture, an excellent model was achieved for TN and SOC (RPD > 2.5, R^2≥ 0.91), good models for CN, bulk density, and bulk density of ≤ 2 mm fraction (RPD from 2 to 2.5, R^2 ≥ 0.75), moderate models for aggregate size distribution (RPD= 1.95, R^2= 0.72,), and poor model for prediction of K (RPD= 1.4, R^2= 0.66). All SQIs under arable and pasture were predicted accurately with RPD > 2.2 and R^2 ≥ 0.78. The best prediction model acquired was R^2= 0.90, RMSE= 0.02, RPD= 2.9 under pasture and R^2= 0.87, RMSE= 0.04, RPD= 2.6 under arable. This study showed that spectroscopy could provide a reliable technique for quantitative assessment of SQ.

Keywords：*spectroscopy, soil quality, tillage, grassland, index*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Contemporary Temporal Alterations of Probabilistic Models of Soil Properties at the Different Scales in the South of Western Siberia

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Changes of soils are inevitable process under change of climate and intensive agricultural and other usages that in many cases leads to deterioration of soils properties. Nevertheless desired rational soil-protective usage allows reducing this impact to minimum and sometimes it is possible to improve soils. Reliable quantitative information about changes of soils is necessary for development of soil processes models for projects of soil protection, engineering etcetera. But considerable natural inherent changeability of properties complicates revealing true parameters of soil processes. We can consider soil as more or less uniform at the taken level of organization. But in the lower level there is considerable oscillation. It is very important because the changeability is the ground for big variety of living conditions of soil organisms, which lead to high biodiversity and biomass that form the part of soil organic matter.

We have proposed considering three conceptual categories of the spatial changeability of soil properties using the concept of nesting: heterogeneity for significant changes in soil-forming factors, variability for their insignificant changes, and fluctuation for leveled soil-forming factors. All three changeability categories are observed at different organization levels of the soil and soil cover. In our opinion, the quantitative evaluation of relationships between different changeability categories of soil properties is also necessary for assessing the stability of the soil cover as a hierarchical system.

Case study has been done at Kashtanozems (chestnut soils) that are most widespread soils at the south of Western Siberia. Investigated soils were formed from ancient Quaternary coarse-textured alluvium. Geological processes resulted in formation of series of soils with different texture: loose sand, sand, loamy sand, sandy loam, sandy clay loam, but prevailing soil's texture is loamy sand. We revealed that heterogeneity of soils and their properties, including sustainability to wind erosion, is determined by texture. Wind erosion is usual phenomena in dry zone of Western Siberia. Strong aeolian activities, forestless, wavy smooth relief, big content of sand particles in these soils are reasons, which explain possibility of deflation here.

Input data were obtained by large-scale soil surveys (1:25000) of big part (16000km2) of Kulunda steppe and by not long (6 meters) uniform trenches of Kashtanozems pedons under different usage (virgin soil, unirrigated arable soil, and irrigated arable soil). Data on contents of humus, particles of texture fractions, and other soil properties, were grouped depending on taxonomy type of soil, its texture and degree of intensity of appearance of deflation (absent, slight, middle, and strong). Numbers of observations in each group were large (n=50-600) that provide opportunity to carry out statistical and probabilistic analysis. The analysis of statistical characteristics of properties of soils and their probability distributions has been carried out within of soil lithological series, which are the most homogeneous units of the soil cover.

Statistical comparison of soils status at different moments of time or under different usage may be done by comparison of statistical characteristics such as averages, variances, coefficients of variation, etc. of soil properties. The other way is to compare probability distributions as a whole, but there are some difficulties connected with checking of statistical hypothesises. So we applied new methods to identify mathematical function of probability distribution and its parameters in such a way that it is the best approximation of empirical frequencies of values of attributes. Besides we have introduced probabilistic indicators: statistical entropy and information divergence as characteristics of soil status and alteration.

As a result fluctuations of properties in soil individuum (pedons) of Kashtanozems under different usage (virgin soil, unirrigated arable soil, and irrigated arable soil) were quantitatively evaluated. It was shown that these fluctuations make up to 20-40% of the property changeability in an elementary soil area. Probability distribution functions (pdf) with high p-values were considered as probabilistic models of soil properties. Analysis of pdf regularities gives clear and stable information about difference of soil properties in the soil volumes in space in soil horizons under agricultural impacts and climate change. Information divergences quantify these regularities. Analysis of entropy value highlighted the main tendency of agricultural impact – the tendency of outstanding decreasing quantity of various micro conditions of soil on organic matter content through all soil profile, which is important change of edaphic factor.

Keywords: *soil, properties, variability, fluctuation, pdf, information divergence, and statistical entropy*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Comparison of Remote Sensing Energy Balance Models: Sebal V.S. Metric

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SEBAL and METRIC are remote sensing algorithms that compute spatio-temporal patterns of evapotranspiration using a surface energy balance. SEBAL and METRIC are have been widely accepted in the western US because of the use of internalized calibration procedures. These procedures index sensible heat flux from the land surface to satellite measured surface temperatures at specific surface boundary conditions. The indexing of the heat flux to satellite-based surface temperature and calibration using available ground weather data greatly reduces impacts of biases in calculated energy balance components and reduces the need for atmospheric correction. The evapotranspiration maps created by METRIC and SEBAL have been tested against lysimeter and eddy covariance measurements and show good consistency and agreement for irrigated fields, rangelands and arid riparian areas in the southwestern US. The principal difference between SEBAL and METRIC is that SEBAL can be applied without using any ground measurements while METRIC needs at least one high quality weather station on the ground to calculate the reference ET. Thus, the former algorithm would be the method of choice in regions of the world that have no ground weather data or where high quality weather data are not available. The latter algorithm is applied where high quality ground meteorological measurements are available on an hourly basis. The main objective of this study was to compare the performance of each model. Energy balance component products from SEBAL and METRIC models have been compared to each other as well as to ground measurements. These comparisons have provided an opportunity for improvements to the algorithms.

Keywords：*Remote Sensing, Energy Balance, Evapotranspiration, SEBAL*

P1-208

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

The Modified Pore-Solid Fractal Model for the Soil Water Retention Function

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The existed soil water retention curve models, like Brooks-Corey model (BC), Campbell model (C) and the pore-solid fractal model (PSF), are often deficient in the determination of parameters, which can only be fit with a serious of measured data. This limits the advancement and application of these models, especially in case of less measured data. In this study, a modified pore-solid fractal model (M-PSF), based on the theory of the pore-solid fractal model (PSF), was presented, which characterized by a pair of random measured values Θ_0 and h_0. The suggested M-PSF not only expands the parameters range than the BC and the PSF, but also can be parameterized with easily retrievable parameters. Using the data sets of 12 soil textures from the Unsaturated Soil Hydraulic Database (UNSODA), the M-PSF was tested, and predicted well with the measured data. The preliminary analysis suggests that if there are multiple levels of Θ_0 and h_0, the middle levels of values may perform better for the M-PSF. It is also easily found that the better the soil matched with a power function, the better the M-PSF model works. Moreover, although some outliers appear in the different levels, they may be amended by adjustment parameter. The root mean square errors (RMSE) between measured and predicted water content ranged from 0.014 to 0.119, with the RMSE of most soil textures are less than 0.06. Furthermore, the model efficiency (Nash-Sutcliffe coefficient, NSE) of the M-PSF are mostly >0.5. To compare with BC and VG model, M-PSF showed very similar NSE values. While from preliminary analysis, the M-PSF performs better than the VG under the condition of a small number of points. Moreover, the two parameters except the fractal dimension in the M-PSF are random, which includes the air entry suction and the saturated water content, so the BC, the PSF and the C models can be seen as the special situations of the M-PSF. However, the M-PSF showed its excellent parameters accessibility and elastic with wide parameters range, and can be further evaluated in the future study.

Keywords：*Soil water retention curve; Fractal dimension; Modified pore-solid fractal model*

P1-209

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Modeling Land-Use-Induced Soil Pore-Space Changes: State of the Art and Perspectives

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Adaptive land use practices as a preventative element for soil and water conservation with respect to changing climatic conditions are gaining importance. Planning of adaptation strategies is often based on the application of numerical models. By this, the impacts of proposed or potential changes in land use on plant growth and water balance components can be estimated and evaluated under recent and changing climatic conditions. In existing models, soil hydraulic properties are assumed to be temporally constant. However, previous studies have shown that soil structure (and with it the soil water retention and hydraulic conductivity functions) change significantly as a result of land use and management operations. If the dynamics of soil structure are neglected, the uncertainty of the model results increases. This could lead to incorrect planning, and greater or misdirected resource consumption in land use. Therefore, the objectives of a recently started joint Austrian/German research project are a) to measure land-use-induced changes in soil structure and in the soil hydraulic properties; and b) the implementation of the results into hydrological models that quantify the changes on the basis of equations describing temporal changes of soil water retention and hydraulic conductivity. Based on the evolution in the soil pore-size distribution, the effect of different land use practices and changes across different temporal scales, such as soil tillage, crop rotations, or land conversions will be studied. To derive general principles for the influence of land use on hydrologically relevant soil properties, comparable land use practices with similar soils along a climatic transect from Brandenburg,via Saxony and Lower Austria to Styria will be analyzed. For the characterization of the soil hydraulic properties, field methods (hood infiltrometer and dye tracer experiments) will be combined with laboratory methods (transient evaporation experiments, soil-water contact angle measurements). This approach allows a comprehensive characterization of the hydraulically relevant properties of the pore system and the differentiation between macropore and matrix flow domains, which may be fundamental for the development of functions describing land use-induced changes of the soil pore space. Based on a better understanding of the involved processes, we will develop methods and models that are able to quantify the impact of a given adaptive land use on the soil hydraulic properties and in turn on components of the water cycle (soil water capacity, groundwater recharge, water quality). This will provide a basis for the development and assessment of sustainable land use systems.

In the present paper, we will review the current state in modeling soil pore-space changes and discuss relevant physical and biological controlling mechanisms for soil pore-space dynamics. We give an overview of control mechanisms that were previously studied by our working group. This includes (i) impacts of soil management and land use on the occurence of soil water repellency, macropore abundance, and solute leaching, (ii) climatic impacts such as wetting-drying cycles on temporal pore-space dynamics, but also (iii) pore-space alterations as a result of plant root growth. On this basis, we intend to demonstrate how the new research project can help to close important knowledge gaps and initiate a discussion how it ties in with the multiple scientific outcomes of the SPP 1315.

Keywords：*Soil pore-space changes, Soil hydraulic properties, Land use, Soil management, Temporal variability*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Describing Spatial Process and Prediction of Soil Aggregate Stability at Different Scales in a Teak (tectonia Grandis) Plantation in a Nigerian Savanna

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The understanding of the spatial process of soil aggregate stability in a forest landscape is critical for a reliable and accurate forecast which is essential for successful management aimed at restoring and sustaining the forest ecosystem. In this study, sampling sequences of soil parameters underlying aggregate stability in a teak plantation should be diagnosed and their spatial association described and evaluated in autoregressive models. In the sequence of analysis, autocorrelation functions of all soil parameters investigated were derived and the subsequent cross correlation behavior between mean weight diameter (index of soil aggregate stability) and each spatial parameter quantified. Furthermore, the autoregressive state-space estimation was compared with classical multiple regression with respect to their capability for predicting aggregate stability. Moreover, the effect of transect sampling distance on the accuracy of prediction of aggregate stability was evaluated with the state-space models. With respect to aggregate stability process description, state-space models accounting for local neighborhood information performed better than classical regression models which are purely based on slope and intercept while ignoring spatial support information. The coefficient of determination (r2) for the state-space estimation decreased monotonically with increasing sampling distance along transect, indicating that prediction of aggregate stability became less accurate and reliable as sampling distance increased. This study highlights the necessity of appropriate sampling interval and the importance of developing other means of examining the nature of analysis beyond the r2 in state-space estimation.

Keywords：*State-space analysis, spatial correlation, transition coefficient, soil structure*

P1-211

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Modeling the Formation and Evolution of Some Characteristics of Anthrosols: Studies of Amazonian Dark Earths (terra Preta De Indio), Shell Mounds (sambaquis) and Earthworks (geoglifos) in Brazil

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Old anthropic soil horizons in the tropics are only relatively recently being thoroughly investigated. To understand their formation and evolution is a rare opportunity not only to clarify cultural practices of prior civilizations but also to comprehend mechanisms to preserve carbon and to hold nutrients in the constantly leached soils of the tropics. The characteristics and challenges to model the process of formation and evolution of three distinct anthropic horizons found widespread in Brazil are presented. The Amazonian Dark Earths (Terra Preta de Índio - TPI), the anthropic shell mounds (sambaquis) and large ditches from human earthworks (called geoglifos). TPI refers to expanses of anomalously dark, fertile soil horizons, created by pre-Columbiam populations largely duringd the period from 500 to 2500 year B.P, they are found mainly in the Amazon Basin. TPI anthropic horizons exhibit high densities of ceramic sherds and greatly increased levels of total and available phosphorus and other minerals as Ca, Mg, Zn, Mn, Ba and Sr, when compared with surrounding soils. TPI owes its name to the dark color originated from a large stocks of carbon and it is believed that large part is preserved because a pyrogenic origin from incomplete combustion of organic materials. However new hypothesis to this preservation have been studied. In spite of a relatively intensive history of investigations concerning Amazonian Dark Earths the studies carried out so far were interdisciplinary, but the research groups did not investigate the same site. Presently an Embrapa project is trying to model the creation and evolution of a specific TPI site located in the Research Station of Caldeirão in the Central Brazilian Amazon (Projeto TerraPreta). The sambaquis are found mainly along the Brazilian coast and are predominantly constituted of piled up mollusk shells and sediments in very complex stratigraphic configurations. Frequently they contain burial remains covered by dark soil and rare lithic artifacts. The sambaquis are believed to have been intentionally built by a population that inhabited the region for over 6000 years. Frequently they show dark horizons not only in the top horizon, but also dispersed in a complex stratigraphic sequence. Some studies are trying to understand the contributions from natural depositional processes and cultural deposition to their characteristics and rresults also indicated that those dark horizons have a large amount of phosphorus and carbon. The mechanism of stabilization of the carbon in the sambaquis is not clear, but probably is involved in the heating of organic material (pyrolysis) and large amounts of available calcium carbonate from the shells. The geoglifos are constructed earthworks of large and precise geometric forms (mainly circular or rectangular). They are characterized by excavated ditches and earthen banks, formed by deposition of the excavated soil frequently they are connected by roads believed to have built by a large and sophisticated per-Columbian civilizations in the Upper Amazon Basin. Until now the investigations carried out have not found dark soil horizons related with the geoglifos or near them. What is intriguing in this case is the absence of dark horizons or clearly chemical signatures typical of anthropic modifications. To build ditches with a diameter larger than 300 meters with 10 meters wide and over four meters deep, surely a huge human work force was required and these people needed to be fed. Many facts and myths that have been created about those anthrophic soil modifications since they were first reported in the 19th century. To understand so complexes processes to face spatial statistics and a systemic modeling approached will be necessary. Therefore, it is still a large open field for multidisciplinary research and many lessons are waiting to be learned about soil modification and mechanisms to preserve the carbon and hold the nutrients in the tropical soils. understanding the management used to create those anthropic soil s have possibility to provide new soil management practices for soil reclamation, sustainable production, and to enhance soil carbon storage and nutrient holding capacity.

Keywords：*Biochar, Terra Preta de Indio, Anthrosols, Shell mounds, antropic horizons*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Modified Composition Of Clay In Monument Repairing

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Theme: Research in Materials and Technology for Conservation and Contemporary Architecture

clay is the most common element of construction in arid climates of Iran, In order to protect monuments use of new methods are unavoidable. Change in composition of clay components can be a solution to reduce the damages of climate changes. For this purpose different criteria such as number of cracks on the surface or the rate of contraction and expansion can be measured as the sign of environmental influences on buildings.

This article tries to show the necessity of monument repairing by using new sort of clay that cause increase material capabilities to resist erosion. As a fact, any change in the component of clay must support by new kind of mortar and other materials which are in relation with clay. This article also tries to provide new solution to modify the components of clay in order to make more resistance in different aspects. At first it concentrate on the morphology of clay and then by discuss on effective factors on erosion suggest new composition of clay which is compatible with the environmental changes. The critical point is attention to use natural substance and agricultural residue which emphasize on sustainable architecture. So use of this new method can be useful in both protecting historical heritage and environment.

Keywords：*clay, monument, material, climate*

P1-213

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

A Comparison of the Temporal Relationship Between Liquid P Application and P Concentration in Surface Runoff for Two Contrasting Tasmanian Pasture Soils: A Rainfall Simulation Study.

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Wastewaters that do not contain harmful contaminants can provide viable alternatives to supplement traditional fertilisers for optimising pasture growth and their use may contribute to conservation of Phosphorus (P) resources. As with all fertiliser use, wastewater irrigation must be managed to prevent runoff and leaching of nutrients that may be detrimental to surface and ground water quality. This issue becomes critical when wastewater is being irrigated to meet wastewater disposal needs and it is applied in excess of pasture requirements or in wet conditions when infiltration to the soil and plant uptake cannot occur.

Food processing industries in Tasmania commonly discharge wastewater to irrigation systems on nearby pasture lands. A survey of wastewater irrigation and wastewater quality from Tasmanian food industries shows that food industry wastewaters contain agronomically useful amounts of P. A summary of the survey results is presented. In Tasmania wastewater irrigation systems need to include a large storage capacity for times of year when irrigation is not needed as rainfall exceeds evaporation. However, where adequate storage is not available wastewater may still be irrigated. In these conditions the risk of runoff generation and nutrient transport to ground or surface waters is increased.

Run off events that occur close to fertiliser applications are known to create higher nutrient concentrations in runoff. This temporal relationship is investigated here for liquid P applications on two contrasting Tasmanian pasture soils - a high P sorbing Ferrosol (clay loam) and low P sorbing Hydrosol (sandy loam). The study investigated the P sorption properties of these soils. The Ferrosol has very high iron oxide content which drives a strong P sorption capacity. The Hydrosol has relatively inert quartz dominated chemistry and lacks mechanisms to strongly sorb phosphorus. To investigate the change in P sorption with time a series of experiments were conducted on miniswards of perennial ryegrass to measure P concentration in runoff generated under simulated rainfall at 0, 1, 2, 5 and 10 days after a P solution application.

The sorption properties of soils, the timing of runoff events and soil P concentration are all important variables in determining the risk of P being transported in runoff from pastures following a wastewater application. High P sorbing soils have an inherently lower risk of environmentally detrimental P concentrations occurring in runoff compared to low P sorbing soils. The risk of environmentally detrimental P concentrations occurring in runoff increases after application of P and at higher P application rates, even for high P sorbing soils. Where wastewaters must be disposed of in excess of pasture demands, application to a soil with high sorption properties and high infiltration rates will minimise the risk of transport of nutrients to ground or surface waters.

Keywords：*Phosphorus, run-off, wastewater, rainfall simulation*

P1-214

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Effects of Grain Size, Probe Diameter and Filling Material on Thermal Conductivity and Contact Thermal Conductivity Measurements

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The single-probe heat-pulse method (SPHP) was widely used in measuring thermal conductivity (λ) of snow, rock and soil. However, the existence of thermal contact resistance causes errors for the SPHP method when it was used for porous materials. In this study, a new kind of probe was designed, and the effect of grain size, probe diameter and filling material on measured contact thermal conductivity (H) and λ by the SPHP method was investigated . Better contact was found for the new probes when compared with the traditional epoxy filled probes, but no correlation was obtained between λ and the diameter of the probes. For epoxy filled probes, H and λ decreased with the increasing diameter for both quartz and sand approximately, i.e. the epoxy probes were more sensitive to the contact resistance. When the SPHP method was used for dolomite powders of different grain sizes, a negative correlation was found between H and the grain size except for the finest sample, however, the result of λ was much more complicated. The irregular micropores morphology and the existing of thermal contact resistance may be possible reasons.

Keywords：*thermal contact resistance; soil thermal property; heat pulse method*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Dynamics of Base Cations in Raised Bed Soils on Tidal Swamps

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Dynamics of base cations including K+, Mg2+, Ca2+, and Na+ plays an important role for contributing soil nutrient pools and buffering soil acidification. Balances between base cations in soil solution and on exchangeable sites are of importance for its bio-availability for plants. As part of the study of soil acidification of raised beds, the present study was conducted to describe dynamics of base cations on four different ages of raised beds on tidal swamps. Ion composition of sub components of the raised bed system was measured in soil solution pores, rain water, river water and drainage. The study showed that dynamics of base cations in the raised bed soils varies according to the age of raised beds. Base cation dynamics on the raised beds was affected by tidal fluctuations in the river or sea water and rain water deposition. Tidal fluctuations and rain water deposition can leach or otherwise supply base cations in the raised bed soils

Keywords：*base cations, raised bed, tidal swamps*

P1-216

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

A Model for Estimating Soil Thermal Conductivity from Texture, Water Content, and Bulk Density at Moderate Temperature

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Soil thermal conductivity (λ) models are needed frequently in studying coupled heat and water transfer in soils. Several models are available but some are complicated and some produce relatively large errors. In this study, we introduced a simple model for predicting λ as a function of soil water content (θ) in the entire water content range. Three parameters are included in the model: thermal conductivity of dry soil (λ_d), a shape factor (α), and a range factor (β). The parameters α and β are related linearly to soil bulk density (ρ_b) and the mass fractions of sand and clay. We determined λ_d, α, and β by fitting the model to heat-pulse λ measurements on seven soils of various textures, and validated the model using additional λ measurements and data from literatures. The results showed that the model was able to express the general trend of λ variation with increasing θ from oven-dry to saturation at a fixed ρ_b. When ρ_b was varied, the errors of λ estimates were within 25% of the measurements on 155 soil samples ranging from silica sand to silty clay loam under both dry and moist conditions. Further validation with three literature datasets indicated the predicted λ data agreed well with measured values with an RMSE of 0.19 W m^{-1} K^{-1} and a bias of -0.04 W m^{-1} K^{-1}. The new model can be used potentially for studying the spatial and temporal dynamics of soil λ under field conditions.

Keywords：*modelling, soil thermal conductivity, heat pulse, bulk density*

P1-217

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Determination of Optimal Irrigation Rate and Time for Various Soils Using Hydraus-1d Model

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Nowadays, 40% of the world's food is produced by irrigated agriculture. It consumes 70% of fresh water worldwide, and 60% of irrigation water is wasted due to various causes. With the increase in global population, the area of irrigated land is expected to increase by another 15% by 2050, and the threat to the environment of over use of water resources is increasingly become acute. There is a pressing need to save water use in agriculture. One of the controlling factors causing over use of irrigation water is unwisely-designed irrigation plans. Inappropriate irrigation rate and time could result in water waste via surface runoff and drainage out of the root zone.

In this study, the determination of optimal irrigation rate and time for crops grown in different soils was attempted by numerical experiments for sprinkler irrigation. A systematic investigation by numerical simulations was carried out using Hydraus-1D model. Three typical and contrasting soils were used in the simulations: sandy loam, clay loam and clay. The soil hydraulic property values were the same as those recommended by the model. The upper boundary condition is specified as the influx water flow, while the lower boundary condition is set as free drainage. The initial soil water content in the profile was assumed to be the sum of one-half of soil water content at filed capacity and at the permanent wilting point, i.e. a threshold for irrigation. This assumption was based on the work by Allen et al. (1998). For most crops, when soil water content in the root zone is below the threshold, root water uptake cannot meet the crop water demand for maximum growth, and thus irrigation is required (Allen et al., 1998).

The simulations started with soils irrigated with various irrigation rate and time to observe soil water content in the profile immediately after irrigation, and then the changes in soil water content in the profile 24 h after irrigation. For sandy loam soil, the irrigation rate was set to be 10, 20 and 30 mm/h, respectively. The corresponding figures were 3, 4 and 5 mm/h for clay loam soil, and 1, 2 and 3 mm/h for clay soil. The irrigation time ranged from 1 to 5 h for all the soils. Also, the surface runoff was simulated during irrigation.

The simulated results reveal that for sandy loam soil no surface runoff occurred, and the soil could infiltrate water irrigated with a big irrigation rate for a long time. The wetting depth 24 h after irrigation increased with time, for a given irrigation rate, in an approximately linear manner. For the irrigation rate of 20 mm/h, the wetting depth was about 22 cm for the irrigation time of 1 h, and increased to 63 cm for the irrigation time of 5 h. However, for clay loam and clay soils, the maximum irrigation rate was drastically reduced. The maximum irrigation rate without significant surface runoff over a period of 5 h was only 4 mm/h and 2 mm/h for clay loam and clay soils, respectively. The maximum possible wetting depth was about 20 cm for both soils, much smaller than that for sandy loam soil, indicating that for plants grown in clay loam and clay soils it is unlikely that irrigation can wet the entire root zone. Results also show that the change in wetting depth was marked between the end of irrigation and 24 h after irrigation. The principal implication of this finding is that the re-distribution of soil water content in the profile after irrigation should be taken into consideration in devising an irrigation plan for a pre-specified soil wetting depth.

Acknowledgements: The authors are grateful to the financial support from National Science Foundation of China (NO. 51379187) for carrying out the work.

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Keywords：*Hydraus-1D, Irrigation modeling, Water infiltration, Various soils*

P1-218

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Dependence of Soil Anisotropy on Capillary Pressure

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Hydraulic properties of natural soils vary considerably in space. The impact of heterogeneity in the soil hydraulic properties on flow and transport in the vadose zone has been the focus of considerable research in recent decades. Defining scale-appropriate effective soil hydraulic properties to describe heterogeneous soils is a difficult challenge for a variably saturated system. In this study, we investigate the anisotropy of layered soils in a finite-depth heterogeneous domain with same top and bottom capillary pressure head boundary conditions. Our main objectives are to address the impact of layer structures on the anisotropic characteristics of layered soils and to examine the performance of commonly adopted conceptualization of harmonic and arithmetic mean approach in characterizing unsaturated soil anisotropy. In particular, we perform detailed analysis of unsaturated flow processes both parallel to and perpendicular to the layering using two different structural arrangements of soil layers to achieve the objectives: 1) a repeated pattern of binary units with each unit being formed by two contrasting soil layers, and 2) a large number of soil layers which randomly arranged with given statistics of hydraulic parameters. Two expressions of anisotropy factor are derived, one based on the commonly adopted the conceptualization of harmonic mean and arithmetic mean of hydraulic conductivities and other based on the actual fluxes parallel to the layering and perpendicular to layering. The anisotropy is determined by the fluxes in directions perpendicular and parallel to the layering subject to the same hydraulic gradient condition. For the regularly structured layers of repeated units, the crossover capillary pressure head of the distinct soil layers is important to determine the capillary pressure distribution in the layered system and the associated anisotropy. The layered formation is generally less anisotropic when the more permeable layers are located on the top of formation. The anisotropy factor is usually a non-monotonic function against the capillary pressure head, which displays a minimum anisotropy at an intermediate capillary pressure head value. Minimum anisotropy is more pronounced when the formation consists of only a few contrasting soil layers. The minimum anisotropy is mainly due to the fact that at some intermediate capillary pressure head, individual layers have similar hydraulic behavior around the crossover point as a result of non-linearity of hydraulic conductivity in relation to the capillary pressure head.

Keywords：*layered soil formation; anisotropy; p-norm average; water flux.*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Contributingarea-Slope Relationship and it's Implication of Soil Grading on Hilslopes

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Through the work done using the mARM 1D paedogenesis model which simulated armouring and weathering processes on a hill slope, Cohen found a strong relationship with respect to size distribution of the soil in terms of d50, the contributing area and the slope. However Cohen performed his simulations using only single grading data derived from Ranger mine spoils site data and limited number of Area-Slope combinations. A computational model principally similar to mARM was developed and calibrated using the results produced by mARM model. In order to establish the robustness of the Area-slope and d50 relationship, a parametric study was carried out using different soil gradings available in literature and synthetic gradings. In addition to the different soil gradings, higher number of area slope combinations was explored in the simulations. These simulations confirmed the Area-Slope and d50 relationship uncovered by previous mARM simulations. A relationship of $\alpha 1$ and $\alpha 2$ coefficients ratio used in calculating shield stress threshold and the distribution of d50 with respect to area-slope was found through the parametric study. Also current model revealed that at higher Area-Slope regimes, total mobilization of the entire soil grading occurs and d50 of the soil peaks at a certain value and starts to decrease with increasing Area-Slope combinations where the soil gradings are rich in fine particle sizes. These findings will be useful to further develop available paedogenesis models and to arrive at a comprehensive theoretical framework to better understand paedogenesis processes

Keywords: *paedogenesis, armouring, weathering, computational model*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Temporal and Vertical Variation of a Loam Entisol's Pore Size Distribution and Hydraulic Properties: Farmland VS Forestland

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We studied temporal and vertical variation in pore size distribution and hydraulic properties of a loam entisol which has a poorly developed structure and is widely distributed in the hilly area of the Yangtze River's Upper Reaches. A variety of selected parameters related to effective macroporosity (pore radius > 125 μm), the fitted van Genuchten (1980) water retention curve at the inflection point, and the fitted bi-exponential soil water retention curve which can separate the structuralporosity from the texturalporosity were determined for a farmland and a forestland on two adjacent, representative slopes in the study Jieliu catchment. Based on tension infiltration experiment, soil macropores (r> 125 μm) were found to be the main contributing pores to the total water flow under both landuses, inspite of their very low percentage porosities (0.4-2.7%).The study soil contained large volume of residual(non-drainable) water (θr-BE) in the range of 0.203-0.347 m3 m-3,which was unavailable to plants. Particularly, The lowest θr-BE observed in the 0-5 cm topsoil of the farmland in March 2012 reflects the soil textural pores' decreased ability of water retention which was probably caused by increased soil water repellency following the long dry period starting from November 2011 through the measurement time. The content of plant-available soil water, calculated as the drainable soil textural porosity using the bi-exponential model, was found to be very low (0.031-0.098 m3 m-3), resulting in high vulnerability of the crops grown in the farmland to seasonal drought particularly in the summer. Rather than the total soil water content, the soil's field capacity to hold plant-available water in textural pores, which varies with time in a year, should be taken into account when considering irrigation operation and required amount.

Keywords：*Entisol; Macropore; Tension infiltration; Soil water retention curve; Inflection point*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Mapping Soil Degradation Based on Medalus Model Using By Gis in the East Qazvin Province, Iran

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oil degradation in the recent century as the third challenge of world, is located after climate change and the scarcity of fresh water.. Soil degradation as a direct threat to the global environment and human welfare, is negatively most effective factor on food security which threatens the lives of future generations. The present study was conducted to map the
soil degradation based on MEDALUS model, by using GIS in east Qazvin province (44560 hectares). Five criteria, including ground water, vegetation, soil quality, climate, and management were considered as key criteria of soil degradation, according to local conditions. The results showed that the study area is significantly degraded.. Soil degradation map in the study area showed that 16.42%, 18.73%, 15.41%, 21.24% and 25.10% of the total area are classifide as fragile (1), fragile (2), fragile (3), critical (1) and critical (2), respectively. According to this study, numerical value of the weighted average soil degradation severity (soil degradation status) for the entire region, based on selected five criteria, is equal to 1.506 (soil degradation severity class is critical (2)).

Keywords：*GIS, MEDALUS model, soil degradation, Qazvin, Iran*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Modelling Pedogenesis over Millennial Time Scales

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Soil plays a fundamental role in natural ecosystems. The soil body provides many ecosystem services that are beneficial for humankind such as storing water from rainfall and providing nutrients from organic or mineral sources that are essential for plant growth. Ecosystem changes such as change in land use and land management practices can affect the functioning of soil systems, and in turn can have a major impact on the global water and energy balance. Therefore it is important to understand how fast a soil can form, especially in response to the consideration of soil as a renewable resource.

Recently there has been a movement of interest towards quantifying the rate of soil formation in situ to better understand the dynamics of soil systems. Work on quantifying the processes that form a soil profile however is still minimal, but the availability of new sophisticated laboratory techniques has opened up the possibility of addressing the demand of quantifying processes of soil landscape evolution in the critical zone. Therefore, a field study was conducted in old growth forest areas along three principal toposequences in Werrikimbe National Park situated along the Great Escarpment in northeastern NSW, Australia, to actually measure and quantify the rate of soil formation. To investigate soil formation processes terrestrial cosmogenic nuclides (TCN) were used to derive production rates of soil in mm kyr-1 and optically stimulated luminescence (OSL) was applied to examine vertical mixing rates of soil. The outcome of this work has advanced the fundamental knowledge in soil science and provides basic data which can be used to model the stability of the soil-landscape.

In this study, we therefore implemented the derived rates of pedogenic processes in a quantitative-mechanistic soil formation and landscape evolution model, MILESD (Model for Integrated Landscape Evolution and Soil Development), and tested its ability to predict the current soil landscape of the sub-catchment (100 km2) analyzed at Werrikimbe National Park. MILESD includes the most significant pedogenic processes starting from bedrock weathering to particle size transformation, clay translocation, bioturbation and horizonation and combines these with geomorphic processes of redistribution of soil in the landscape through erosion and deposition.

Keywords：*Pedogenesis, pedogenic processes, mechanistic modelling*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Temperature Dependency of Solute Transport Characteristic in Soils at Saturated Condition

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The Earth subsurface is facing increasing thermal impacts by global warming, urban heat islands, and widespread use of ground source heat pump (GSHP) systems. This subsurface warming potentially causes changes in subsurface mass transport. Therefore, understanding temperature dependency of the solute transport characteristic is essential to accurately assess environmental risk due to the increased subsurface temperature. In this study, one-dimensional column experiments for solute transport were conducted to investigate effects of temperature on solute transport parameters such as solute dispersion coefficient, solute diffusion coefficient, hydraulic conductivity, and retardation factor. Undisturbed soils were taken by means of boring at Saitama University campus (Sakura-ku, Saitama city) in Japan. The site is located in the Arakawa Lowland, consisting of the latest Pleistocene to Holocene (called alluvial) strata down to the depth of 50 m. The core samples at different depths representing different geological deposits (i.e., backmarsh deposit (brackish silty clay), deltafront deposit (marine clay loam), sandy-fluvial deposit) were used in the solute transport experiments. In the experiments, the core sample with diameter of 5 cm and height of 4 cm was first isotropically consolidated under an effective overburden pressure corresponding to the sample depth, then KCl solution was injected to the sample from the bottom. The concentration of Cl- in the effluent was analyzed by an ion chromatograph to obtain breakthrough curves. The solute transport parameters were calculated from the breakthrough curves. The experiments were conducted under two different temperature conditions (15 and 40 oC). The results showed that the obtained solute dispersivity were similar at different temperature conditions. However, the retardation factor decreased with increasing temperature, probably caused by temperature dependency of equilibrium reaction between clay surface and solute molecule, and changes in the mobility of solute molecule in pore water. The effects of soil texture on the temperature dependency of the solute transport characteristics will be further investigated based on the comparisons of the results obtained from samples at different depths.

Keywords：*solute transport, temperature*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Modeling of Water Movement and Solute Transport in Multilayered Tunisian Soil (bouhajla - Central Tunisia) - Assessment Of Salinization Risks

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The semi-arid region of Bou Hajla (Kairouan – Central Tunisia) is exposed to the risk of soils and aquifers salinization. A characterization of water movement through the use of TDR probes installed at up to 5.5 m in depth, and of salts transfer by soil sampling was conducted to highlight this risk. At the same time, climatic parameters were monitored. The water movement and salts transfer were simulated by Hydrus-1d model, and inverse modeling was used to optimize the required hydrodynamic parameters. It was found that the simulated profiles of volumetric humidity and the electrical conductivity of soil are close to those measured. The calculated RMSE values are low, indicating the reliability of Hydrus-1d for the simulation of the hydro-saline dynamics in field conditions. Validation results allowed the study of many scenarios for understanding and manage salinization risks in semi-arid regions.

Keywords：*Soil, Salinization, Hydrus-1d, Aquifer, Semi-arid region, Tunisia*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Wettability of Organically Coated Tridymite Surface as Proxy for Organo-Mineral Soil Surfaces - Molecular Dynamics Study

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The understanding of wettability of soils and their reactive surfaces is crucial to understand manifold soil properties. In this work a model system was developed to allow a deeper understanding of the processes on solid interfaces on a molecular level.

Self-assembled monolayers (SAMs) are ordered molecular assemblies formed spontaneously by adsorption of an active surfactant on a solid surface. By variation of the length of alkane chains and functional groups the thickness of the organic layer and its properties can be controlled with a great precision. SAMs are used as surface coating for applications including control of wetting and adhesion, chemical resistance, bio compatibility, friction, bio sensing and in many others areas [1].

Wettability of surfaces is primarily related to their energetic characteristic. The wettability of a solid surface is mainly determined by its chemical composition, structure and topography [2]. The solid-liquid contact angle method is often used to characterize the surface wettability and to determine the surface free energy of ideal plane surface.

In the presented work we have investigated the wettability of the (001) surface of tridymite, organically modified with three siloxanes with different chain length and polarity of the tail group, namely dimethylsiloxane (DMS), octadecylsiloxane (ODS), and aminopropylsiloxane (APS). Two different concentrations of the surface coverage have been modeled: 50 and 100% (10,77 and 21,53 molecules/Å2), respectively. In case of DMS we have studied different modifications of the surface to reproduce possible polymerization between silicon-hydroxyl atoms of neighboring siloxane groups of the surface.

The interactions of the water droplet with the mentioned surfaces were studied using classical molecular dynamics simulations at room temperature (NVT ensemble). Calculations were performed using LAMMPS program package where surfaces were described by CLAYFF, OPLSAA force-fields and SPC/E for water molecules. From temporal evolution and averaged shape of the water nanodroplet on the surface it was possible to characterize the hydrophobic/hydrophilic character of the studied surfaces.

Obtained contact angle (CA) values are in good agreement with experimentally measured CA and correctly describe the hydrophobic/hydrophilic character of the surface. Simulations of models representing a possible polymerization of siloxanes at the SiO2 surface showed that polymerization has an impact on the hydrophobic/hydrophilic character of the surface.

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Keywords：*Self-assembled monolayers, Molecular Dynamics, Contact angle*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Models for Prediction of Water Flux in Unsaturated Zone in Relation to Capillary and Non-Capillary Soil Pores

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Description of the transport processes in the unsaturated zone has been aided at the experimental local level by the present availability of accurate measuring techniques and devices, it is still difficult to make reliable predictions on their evolution, particularly at the space and time scales of interest for environmental planning.

Downward water flow in the vadose zone occurs principally through the non-capillary pores, while the redistribution and lateral and upward flow occurs in the capillary pores. Most of water flow models that applied to soil describe the flow velocity (flux) as a laminar flow and ignore the turbulent flow. This is due to that these equations contain the viscosity (?) as the main parameter. So these models considered the viscous forces in narrow capillary tubes (pores) rather than the inertia forces. Also, laminar flow prevails in silt and clay, while the non-laminar prevails in coarse sand and gravels. In case of the coarse fractions are existed, and at high velocity of water flow (flux) the inertia forces are no longer negligible compared to viscous forces. The purpose of this study was to propose equations to estimate water flow, $Q(\theta)$, and hydraulic conductivity, $K(\theta)$, in the capillary and non-capillary soil pores with respect to laminar flow and non- laminar flow. The equations related $K(\theta)$ to soil pore radius (r) were based on soil hydraulic data, including water retention h(?), field basic infiltration rate, water sorptivity (S) and distribution density function f(r) of the soil pore size. Calcareous sandy loam and alluvial clay soils located at the Nile Delta were used to test the validity of the assumed equations. Data showed that the values of $K(\theta)$ calculated by the proposed equations were in the common ranges for such soils. The equations are therefore expected to be applicable for both coarse and fine textured soils. Also, an equation was derived to estimate the sorptivity (S) at steady state infiltration. It was observed that S is decreased in going from the un-saturation condition to steady state infiltration by 15.1% and 45.9% in sandy loam and clay soils, respectively.

Keywords：*unsaturated hydraulic conductivity, sorptivity, laminar and non-laminar flow, soil pores*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Assessing the Use of Digitized Agricultural Data to Strengthen the Modernization of Agriculture in Uganda

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Objective: This paper attempts to discuss the agricultural process in Uganda with emphasis on the utilization of agricultural data. Contributions of the latest technologies are both theoretically and really highlighted with emphasis on digitization. Overall, not much has been done in the area of digitizing agricultural data in Uganda.

Methodology: The study employed quantitative methods coupled with random stratified techniques using the Casley and Kumar (1988) equation for stratified sampling. The diffusion innovation theory was incorporated in the analysis (Roger, 1995). Two institutions were chosen (Makerere University and Kawanda Research Institute). A sample of 45 respondents was involved in the feasibility.

Results: National Agricultural Research Services are essential for identifying technological problems and for developing and adapting appropriate technologies. Findings reveal that without a strong and effective research system, advances in agricultural processes are unlikely to be realized. National Agricultural Research Services play a central role in the process of agricultural modernization. Integrating the latest information computer technologies into agricultural research process will increase the rate of modernization.

Conclusion: Research in Information Science is at an infancy stage in Uganda and the application of information computer technologies is a new phenomenon amidst a largely illiterate community.

Keywords：*Digitization, agricultural modernization, information computer technologies, agricultural*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Adsorption Modeling from a Pure Ion-Exchange Point of View

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Modeling the adsorption of anions and cations by minerals present in soils has undergone many historical evolutions since the 1800s. A critical review of the reasons and methods of adsorption modeling techniques are presented. This includes discussions on why the minerals are said to have pH-dependent or pH-independent charge, how the data are collected, and the mathematical procedures developed to describe the data collected. This also includes discussions of reasons for and against modern surface adsorption models, and the basic principles that support a reintroduction of pure ion-exchange modeling theories.

The crux of much of our understanding of the charging properties of soil minerals stems from our interpretation of electrokinetic data. The movement of particles under an applied electric field was discovered in 1809 and has been studied extensively ever since. Electrophoresis, electroosmosis, streaming potential and sedimentation potential have all presented a very convincing picture of particle charge properties. There are, however, alternate, perfectly logical, interpretations that can be given for the electrokinetic data. These alternate theories have a very strict adherence to the basic principle of electroneutrality, and make extensive use of ion exchange and ion shearing processes.

Another important milestone in adsorption modeling development was the introduction of intrinsic equilibrium constants in the 1970s to describe the pH-dependent adsorption of protons on soil minerals. These intrinsic equilibrium constants allowed us to finally correctly predict proton adsorption collected from acid-base titration experiments. The goodness-of-fit presented by these new models gave rise to a generation of convincing discussions that the minerals are charged. The older ion-exchange models would not fit the proton adsorption data well, and thus seemed to be proven wrong. Note, however, that traditional acid-base titration methods do not generate data that are error-free. If the data collected are not correct, then the goodness-of-fit of the models used to fit these data are meaningless. Perhaps the older ion-exchange models did fit the proton adsorption data because the data were wrong, rather than the models.

All adsorption models offer important insights about the chemical processes involved. These models hopefully work well to explain the data, but they can also be used to suggest what the chemical processes are and what surface species may be like. Sometimes adsorption models incorporate information acquired from spectroscopic studies. Sometimes adsorption models offer ideas of specific surface species for spectroscopist to try to find, for one often only finds what one is looking for. Ion exchange models are relatively easy to construct, are scientifically sound, and adhere to the well established principles of electroneutrality.

Keywords：*adsorption modeling, ion exchange, electrokinetics, titration, electroneutrality*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

An Assessment of Airborne Derived Radiometric Soil Data at the Catchment Scale

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The development of environmental models has increased in abundance the last several decades. In particular, there has been considerable recent focus on pedogenesis modeling and digital soil mapping. Catchment scale variability of soil properties can drive hydrology and other environmental models, yet we do not have remote sensing technologies to derive maps of soil properties at these scales. Modeling of soil spatial variability is thus necessary to provide spatially consistent soil inputs with other spatially distributed properties (e.g. digital terrain data). Testing model accuracy and predictability is ongoing and is largely based on available and newly collected data as well as new models. This research looks at field testing 3D soil models on a catchment scale to assess the models' accuracy and usability as a tool in environmental research.

The recently released airborne gamma-ray spectrometry provides a new data set, with potential insights into soil systems. Coupled with digital terrain analysis radiometric models have been used to develop erosion and pedogenesis models with calibration at physical sites. There is increasing interest to develop advanced 3D models with digital soil mapping, however testing of these models is needed to ensure that incorporation and calibration is accurate. Thus there is a need for field testing the existing environmental models.

Here we examine the national airborne radiometrics dataset (referred to as NARM) correlation with field soil samples. The study site was the Krui catchment, a sub-catchment of the Hunter on the east-cost of Australia. Samples were taken by penetration of 94mm by 200mm circular cores into the land surface until flush with soil surface and removed through excavation of the surrounding soil Samples were dried in a laboratory at ~40^{0}C in an oven for up to 7 days until all moisture in the sample was removed and then sieved at 2mm. Samples with a mass between 300 grams and 1000 grams of the sieved soils were placed in a Marinelli beaker on a hyperpure germanium detector to detect potassium 40 (40K) and samples were counted for a minimum of 8 hours (i.e. 28800 counts) and a maximum of 24 hours (i.e. 86400 counts). Results were converted to counts per minute per kilogram (cpm/kg) of 40K and used to test the NARM.

This research found that the NARM and field 40K were correlated and that this correlation extends across changing soil types and geology. A complex relationship with topographical features was also determined that needs further investigation. The use of NARM and other spatially distributed datasets may produce more understanding of geological, geographical and pedogenesis drivers. This research validates the use of NARM to investigate these drivers and with further investigation has the potential to aid in environmental modeling. Further investigation is currently being undertaken into soil spatial distribution and depth analysis which may also lead to insights into 40K dynamics in the soil matrix. This research is the tip of the iceberg in understanding how airborne radiometrics can be used in understanding terrestrial environments.

Keywords：*radiometrics, soil modelling, airborne derived data, potassium*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

The Effect of Soil Information on Air Quality Modeling

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In regional simulation of weather, climate conditions and air quality assessments, realistic representation of soil parameterization is critical because moisture and heat exchange at the soil surface strongly influence the boundary layer conditions between land and atmosphere. Land surface models provide predictions of soil moisture content, and partition latent and sensible heat from the soil surface. When coupled with meteorological models, land surface models initialize the boundary conditions at the soil surface, making accurate soil information crucial to climate and weather modeling. The NOAH land surface model, named for the four agencies that developed it, is a community model used by thousands of scientists around the globe for the initialization of the Weather Research and Forecasting (WRF) model. The NOAH model, along with many other land surface models, use soil texture information for parameterization, but this information in Texas has not been updated for 20 years. Therefore, modification of the soil parameters may have significant effects on land surface models, and consequently, the predictions generated by regional weather and climate models. The current soil parameters applied in the NOAH land surface model have been revised for Texas and will be presented. The investigations will be conducted by using NOAH with Multi-Parameterization (NOAH-MP) options and WRF. Results will include impacts of the revised soil parameters, as well as the implications of the spatial distribution of these parameters.

Keywords：*Land surface models, air quality modeling, NOAH, LSM, WRF*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Software for the Assessment of Climate (moclic), Soil Functions (assofu), and Agricultural Water Quality (agriaqua) for Land Evaluation

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Evaluation of present and potential land uses and functions requires of knowledge about relief, soils, climate, water bodies, forms of management, and infrastructure. During the past few years many assessment models of land use have been created, and more recently about the environmental functions of soils, however, the advances made in creating these models was not accompanied by the design of software for performing the required tasks. Our objective was to design and develop software for the assessment of climate, soils, and irrigation water quality in order for land evaluation tasks becoming more systematic and less biased by the experience or inexperience of the planners. We used previously established models for evaluation of climate using Climate Data Base monthly (CDBm), soils with model "Technique Of Urban Soil Evaluation in City Regions Implementation in Planning Procedures" (TUSEC-IP), and agricultural water quality (Unite State Department of Agriculture, Soil Survey Staff) for designing software: a) a monitoring climate change software (Moclic); b) an assessment of soil functions software (Assofu); and c) an irrigation water quality evaluation software (Agriaqua). Moclic is a database and as data processor allows for calculation of agroclimatic indexes (humidity, aridity, concentration of precipitation, rainfall erosivity, soil leaching), climograms; and for identifying trends of climatic change in indices or weather elements by means of monthly or annual time series. The Moclic software can be used to review the data in the time series; Moclic can display graphically, in seconds, thousands of data. Assofu works as a database of soil profiles (soil horizons and their chemical and physical properties) and sites (geographical location, land forms, weather, vegetation, land use, etc.). Assofu allows storage of images of the site and/or soil profile. Assofu allows for evaluation of the environmental functions of soils (buffering of pollution, carbon stock, role in the hydrological cycle, substrate for life, habitat of flora and fauna, etc.) considering the complete profile of the soil. Assofu is aimed at storing and evaluating the properties of soil profiles, it is useful to: a) facilitate the capture and storage of data, b) maintain the integrity and consistency of information, c) implement evaluations of soil use; d) support in making decisions regarding the viability of the soil for various activities, and e) estimating soil chemical properties with field observations. Agriaqua is also a database and a data processor of chemical properties of water, software has three functions: a) Analysis of data quality; data conversion and descriptive statistics. (Agriaqua allows for converting between measuring units (mmol/L, meq/L, mg/L), calculating the allowable error rate, the sodium adsorption ratio, the proportion of sodium possible, the residual sodium carbonate and descriptive statistics of the ions; b) Calculate indices of water quality and water families. Agriaqua calculate several indexes of salinity of water (potential salinity; effective salinity and the plotted with electrical conductivity vs sodium adsorption ratio), identifying water families and calculate the risk of water use from the concentration of chlorides, sulfates, sodium and boron; c) Assess changes over time series in water quality indexes and ions using the linear correlation tests, Mann Kendal test and Sen test.

Keywords：*land evaluation, agroclimatic indices, climate change, carbon stock, water quality, soil quality*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Unfrozen Water Content of Andisol Under Different Freezing and Thawing Conditions

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In soil, a certain amount of water remains unfrozen at subzero temperatures because of a decrease in the free energy of soil water due to surface forces of soil particles and the pore geometry among soil particles. The relationship between the unfrozen water content and temperature is called the soil freezing characteristic curve (SFC). SFC is one of a specific property of soil and modeling the SFC is important in estimations of heat and water transport in freezing soils, snowmelt infiltration, and microbial activity in frozen soils. SFC is often discussed under temperature equilibrium condition, while soil temperature dynamically changes during practical freezing and thawing processes. In this study, we measured SFC of an Andisol under various freezing and thawing conditions. The soil sample was collected from the A horizon at an experimental field in Iwate prefecture, Japan. The experimental field has been managed as a fallow field for several years. The A horizon is consists of volcanic ash soil with a low bulk density, high porosity and high hydraulic conductivity. The soil was passed through a 2-mm screen and packed into an acrylic column with an inner diameter of 7.8 cm and a height of 5.5 cm. The column was set between two temperature control units that regulated identical top and bottom temperatures. Different initial water content was applied by supplying distilled and deionized water from bottom of the column. Three copper-constantan thermocouples (2, 3, 4-cm depth), a tensiometer (2-cm depth), and a TDR probe (3-cm depth) were inserted horizontally into the column, and the side wall of the column was insulated with a glass wool layer. The TDR probe was preliminarily calibrated to properly measure unfrozen water content. The soil was then frozen and thawed by changing temperature in stages or dynamically. For the case of staged freezing and thawing, temperature was held at each stage at least for 12 hours and measured the unfrozen water content and the equilibrated temperature. For the case of dynamic freezing and thawing, unfrozen water content was continuously measured under different temperature change rate. The unfrozen water content decreased to 0.09 m^3/m^3 if the soil was dynamically cooled to -17 °C while it became 0.02 m^3/m^3 if the soil was cooled in stages. When former soil was kept at -17 °C for a week, the unfrozen water content slightly decreased (c.a. 0.07 m^3/m^3) but never reached to 0.02 m^3/m^3. This difference in SFC during soil freezing process may come from presence or absence of freezing of intra-aggregate water, difference in grain size of pore ice, and solute exclusion from pore ice. The unfrozen water content in thawing soil was strongly affected by the unfrozen water content prior to the thawing. Comparing staged and dynamic thawing processes, similar SFC were observed under -5 °C if soils had same initial unfrozen water content, for example 0.09 m^3/m^3 at -17 °C. At above -3 °C, however, the dynamically thawed soil had less unfrozen water than the soil that thawed in stages, and the lessening was pronounced as thawing rate increased. It is considered that the pore ice could not melt as same rate as the macroscopic temperature change, resulting in hysteresis-like SFC for dynamic freezing and thawing soils. The hysteresis-like SFC was also compared to the hysteresis of soil water characteristics of relatively dry soil and the hydraulic properties of frozen soil was discussed.

Keywords：*frozen soil, unfrozen water, soil freezing characteristic, soil water characteristic*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Phosphorus Availability in Walloon Soils - A Modelling Approach

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During many years, ordinary practices of phosphorus fertilization have led to an accumulation of P in agricultural soils of Wallonia [1]. It has resulted from continuous and excessive fertilization and manure applications [2]. Thus, a better understanding of P behavior in Wallonia soils is needed to adapt practices of P fertilization to the requirement of reducing agricultural impact on the environment (e.g. eutrophication of surface waters) [3, 4] without impairing crop yields. Historically, studies were interested to the P behavior in soil, more particularly to the P availability in soil, used chemical extraction approach. However, this approach can be disputed. Indeed, P available in soil determined by chemical extraction is influenced by P form, P mineral type [5, 6] and chemical extractant type used [7].

In that context we studied P available (PO4-P) in different agricultural soils of Wallonia (N = 110) [1] by modeling approach with the USGS software PHREEQC [8] in order to: (1) compare soil (PO4-P)Measured by the Lakanen-Erviö chemical extraction method [9] with soil (PO4-P)Modeling by PHREEQC ; (2) define soil chemical parameters which influence the P behavior in Walloon soils.

In a first step, the chemical parameters necessary in input data to have an optimal modeling of P available in Wallonia soils were defined. During this input data calibration, our results show that it is necessary to use soil pHwater rather than soil pHKCl and [Al]ox (oxalate-extractable Al) rather than [Al]total. For other parameters, this study shows that using total content is suitable enough. In a second step, sensitivity tests were performed to define soil chemical parameters which influence the P behavior in Walloon soils and quantitatively evaluate the impact of input data variations on soil (PO4-P)Modeling at soil pHwater contained between 6 and 9. Results of these sensitivity tests show that only pHwater and [Mg]total variations significantly influence the modelling results. On the contrary, [Fe]total and [Ca]total variations have a low influence, even almost nonexistent for [Al]ox. Indeed, soil (PO4-P)Modeling increases by a factor 3 when the soil pHwater is raised from 7.3 to 8.0. Furthermore, on average, soil (PO4-P)Modeling values decrease of 20 ppm and 40 ppm, respectively, when [Mg]total increases of 20 and 40%, at soil pHwater = 8.2. However, results show that soil (PO4-P)Modeling is not sensitive neither to soil pHwater nor to [Mg]total variations, when soil pH $\leq$ 7.0.

This study has shown the high potential of PHREEQC modelling to predict available P and to estimate chemical parameters that govern P availability in Wallonia soils. As these input data parameters and PHREEQC model are calibrated, we will further try to predict the impact of various agricultural systems on the fate of P in soils.

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Keywords：*Phosphorus availability, Modeling, Walloon soils, PHREEQC*

P1-234

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Removing the Effects of Environmental Factors from Proximally Sensed Vis-Nir Spectra

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Proximal soil sensing with visible and near infrared (Vis-NIR) spectroscopic measurement of soil organic matter (SOM) is receiving more and more attentions recent years. However, the features of SOM are masked by the environmental factors such as soil moisture and surface roughness, making its predictions more difficult to detect. We invested two chemometircs methods, the direct standardization (DS) and piecewise direct standardization (PDS), to remove the environmental effects from proximally sensed spectra in SOM research. Both of the two methods were following the same procedures: the first step was to select a few well-representative samples, named transfer samples, and measure them in both laboratory and field condition. The second step was to compute the transfer parameters by the differences between the laboratory and proximally sensed spectra of the transfer samples. The last step was the transfer of the proximally sensed spectra from the rest of the whole dataset so that the proximally sensed spectra looked as if they were measured in the laboratory condition. In another word, the environmental effects were removed. The difference between the two methods was that for each wavelength, in PDS algorithm, the spectral response of the transfer samples recorded in the laboratory was related to the corresponding spectra in a small window of neighboring wavelengths obtained from spectra in the field, while in DS algorithm, it was related to the whole wavelength of the field spectra. The performances of the two methods were assessed by the prediction of SOM. In this study, 104 samples were chosen from 9 paddy fields in Zhejiang province, China. In situ spectroscopic measurements were firstly completed on the surface soil (0-20 cm) by a Fieldspec ProFR vis–NIR spectrometer. Laboratory measurements were then carried on the same but air-dried ground samples. The 104 samples were then divided into calibration (70 samples) and validation (34 samples) set. A subset of the training samples was selected by Kennard-Stone algorithm for the DS and PDS algorithms. We used partial least squares regression (PLSR) for the prediction of SOM. Good predictions were achieved when the laboratory spectra were used to model and predict SOM. However, spectroscopic models derived using 70 laboratory spectra could not predict with the 34 proximally sensed spectra well. After spectral transformation with DS and PDS algorithm, predictions of the 34 transformed field spectra improved greatly. The PDS algorithm performed better when fewer transfer samples were used than DS. With the increasing of transfer samples, the predictions of SOM with DS-transferred field spectra were comparable to that of the PDS-transferred field spectra. We thus concluded in this study that the spectral transfer algorithms, DS and PDS, can be used to remove the effects of environment factors from the proximally sensed spectra for better predictions of SOM content.

Keywords : *Proximal soil sensing, soil organic matter, environmental factors, Direct standardization, Piecewise direct standardization*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Application of Pedological Indicators on Desertification Assessment Based on G.I.S And R.S (case Study: Eshtehard Region,iran)

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In investigation of pedological criterion on land degradation in Quaternary rock units, a part of the shoor watershed area was selected(Eshtehard Region). After distinguishing target area, maps of slope classes, land use and geology were created, and then map of units was founded by overlaying and crossing these maps.In this research three indices of soil erodibility, salinity and permeability were considered that finally each of them was shown in the shape of classified map. Then by overlaying and cross of these maps, a new map was created that is an expression of research area zonation from the viewpoint of indices that formerly, were explained. For creating land use map after monitoring and investigation of previous studies like face of watershed area plan (2003) and using satellite image of landsat 7 (ETM+, 2004) and provided image from Google Earth site (2005,2006), map of land use was created through optic analysis and in some cases digital (id est. investigative method).After classification of obtained map from function of 0.8 from fuzzy gamma model, by overlaying the desertification potential zonation map with land use map, kinds of soil zones were characterized on the base of their desertification effect. This research determined two classes of desertification qualitative potential (high 43.08% and moderate 56.92%).

Keywords：*Quaternary rock units,erodibility, salinity ,permeability,fuzzy gamma model,desertification*

P1-236

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Spatial Analysis for the Prediction of Soil Organic Carbon (soc) Using Digital Soil Mapping (dsm) Techniques in Mediterranean Region

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Soil organic carbon is one of key soil property related to soil fertility, aggregate stability and the exchange of CO2 with the atmosphere. Existing soil maps and inventories can rarely be used to monitor the state and evolution in soil organic carbon content due to their poor detailed information, low spatial resolution, lack of consistency and high updating costs. In Turkey, detailed soil maps (at 1:5000 scale) were carried out by TRGM only on the land consolidation projects regions. The aim of the study is towards providing uniform national-scale estimations of soil organic carbon, meeting an increasing demand for information on that can be used in the monitoring of soil degradation, calculation of carbon stock in deforestation lands linked with LULUCF sector. The project covers an area of 45709 ha that include crop lands as an area of 28528 ha. We predicted soil organic carbon contents using a large-scale soil survey of about 45 soil profiles, 317 sample points and 1279 total samples. Values of 10–15 kg/m2 were predicted for the shrub lands and 4–8 kg/m2 in the cultivated area in the plains.

Keywords：*Soil Organic Carbon, SOC, Digital Maping*

P1-237

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Application of Soter-Database Approach for Sustainable Management of River Oases Along the Tarim River, China

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The Tarim River Basin covers an area of approximately 1,000,000 km2 of flat desert regions and some oases of popular forests and arable lands. The basin is characterized by an extremely continental desert climate with little rainfall combined with a high degree of potential evaporation. A soil and terrain information System using the SOTER approach (Soil and Terrain Digital database) for this region is being developed within the SuMaRiO project (Sustainable management of River Oases along the Tarim River / China) in order to make this data available in adequate form for some applications at various scales.

Several layers of maps (Soil maps, geological maps, DEM) were overlaid to delineate the terrain units, terrain components and soil components. For the soil characterization in the region 50 soil profiles were dug, completely described and classified according to FAO guidelines. The chemical and physical analyses (pH, EC, CaCO3, nutrients, CEC, C-org, Nt and grain size) were done in the laboratory. Additional databases with climate data and crop information were linked to the system. The whole system provides the EPIC model (Environmental Policy Integrated Climate) with detailed information about the spatial variability of soil, terrain, management and climate. The model was run for cotton crop.

Soil types affected by salinity e.g. Solonchaks and by waterlogging e.g. Gleysols were the dominant soils in the area. For validation of modeling result with EPIC a comparison between simulated and measured cotton yield on field scale was done. The model simulation showed highest estimated cotton yield on Gleysols and Phaeozems, and the lowest on Arenosols and Solonchaks. Soil salinity was the main limiting factor for the estimated cotton yield.

This database can be a framework for storage and quarry of soil, terrain and climate data at various scales and with the applying of EPIC model, the impact of climate change and management strategies can be assessed. EPIC model gives reliable quantitative estimation for large agricultural regions and can be a good tool for regional planning and serves the decision support system in the region.

Keywords：*EPIC, SOTER, Sustainable Management,Tarim*

P1-238

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Response of Soil Losses on Slope Gradient and Rainfall Intensity by Rainfall Simulator

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Using rainfall simulator (Model DIK-6000, Japan), soil loss was tested for two major soils of Saprolite and Chahang-series representative of Daegwanryung Highland northern east of Korea. The texture of both soils is loamy coarse sand and loam, respectively. The experiment was conducted on the basin area of 0.64m2 (0.8m by 0.8m) of 0.15m soil deep under a constant rainfall intensity of 20, 60, 90mm/hr with slope gradients of 0.5, 7, 15, 30%. The soil is bare or chinese cabbage-cultured at the heading stage in the time of experiment. Chahang-series soil showed more sensitive response that the loss increases readily for the small increment of rainfall intensity and slope gradient like 20mm/hr intensity and 0.5, 7% gradient, while Saprolite soil showed little loss increase at the above given range of intensity and gradient. Soil losses increase abruptly when both soils meet up-rated condition of 60, 90mm/hr intensity and 15, 30% gradient. Two soils showed very different response in loss from bare soils on condition that chinese cabbage is growing at the heading stage. Two soils in cabbage-cultured condition show a little and slow loss increase until soils meet the condition of 60mm/hr intensity and 15% gradient. Two soils show all the abrupt increase in loss at 90mm/hr intensity and 30% gradient, but such the loss increments are very low compared to those of bare soils. To address the process of soil loss, the variables of stream power and rainfall interception, etc. were obtained. Stream powers increase proportionally to rainfall intensity and slope gradient. And then, there is no in the difference of power values between in bare soil and in cabbage-cultured soil under the same rainfall intensity. This is due to the low-concentrated soil particle load despite of the increased run-off water in the cabbage-cultured soil. But soil losses are very large in difference between two treated surface conditions in both soils. Intercepted rainfall intensity by chinese cabbage at the heading stage was 15.5, 49.8, 77.5mm/hr in Chahang-series soil, and 16.3, 49.9, 78.7mm/hr in Saprolite soil one hour after the commencement of rainfall-down for 20, 60, 90mm/hr rainfall intensity of bare soil, respectively.

Keywords：*Soil losses, Slope gradient, Rainfall intensity*

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[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Data Mining Approach in Soil Carbonate Determination Problem Using Lars and Lasso Algorithms

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Carbonate is a key component of soils on calcareous parent material, influencing both chemical and physical soil properties and hence fertility and productivity. A number of different methods of carbonate determination in soils were proposed over the last decades. One of the last works on carbonate determination is presented based on combination of Fourier transform mid-infrared (FT-IR) spectroscopy and X-ray Diffraction (XRD); which gives a high dimensional data with many more variables than observations, that makes classical methods useless for feature selection. Feature selection plays an important role in high dimensional data analysis where a large number of variables are given as potential predictors of a response of interest. To select most effective variables for soil carbonate determination, LARS and Lasso algorithm was applied as feature selection methods. The LARS (Least Angle Regression) algorithm works gracefully for the case where there are many more variables than observations: p>>n. It's a new variable selection algorithm, which is useful and less greedy version of traditional forward selection methods or forward stepwise regression. The LARS algorithm is guaranteed to find the best ranking among all possible inputs. On the other hand, Lasso is a popular technique for simultaneous estimation and variable selection, combined with LARS in variable selection studies.

To Compare the efficiency of LARS and Lasso algorithm for this study, results from classical methods such as forward selection , and also GA as an innovative and popular feature selection method are presented.

The best model performance was achieved when LARS algorithm as the feature selection method combined with SVM (support Vector Machines); The RMSEP (Root Mean Square Error Percentage) of this approach (2.36) and also other statistical index (such as MAE and MSE) show the accuracy of proposed approach in soil carbonate content prediction.

Keywords：*soil carbonate determination, data mining, LARS, LAsso, GA.*

P1-240

[DS3] Modelling of Soil Properties and Processes-Challenges and Opportunities

Development of Estimation Method for Crop Yield Using Modis and Process-Based Model in US Corn Belt Region

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Several models for estimated vegetation productivity have been developed by combining remote sensing data with carbon cycle processes. Many models for estimated vegetation productivity have been developed by combining remote sensing with carbon cycle process. In particular, crop productivity is intimately associated with the food security. In present study, we attempted to estimate crop GPP and NPP using algorithm based on the LUE model and a simplified respiration model. The state of Iowa and Illinois was chosen as the study site for estimating the crop yield for a period covering the 12 years (2001-2012), as it is the main Corn-Belt area in US. Present study focuses on developing crop-specific parameters for corn and soybean to estimate crop productivity and yield mapping using satellite remote sensing data. We utilized a 10-km spatial resolution daily meteorological data from WRF to provide cloudy-day meteorological variables but in clear-say days, MODIS-based meteorological data were utilized to estimate daily GPP, NPP, and biomass. County-level statistics on yield, area harvested, and productions were used to test model predicted crop yield. We assumed that the dates for seeding and harvest were 140 and 260 days of year (DOY), respectively. We developed county-specific crop conversion coefficient, i.e. ratio of yield to biomass on 260 DOY and then, validated the estimated county-level crop yield with the statistical yield data. The estimated corn and soybean yields at the county level ranged from 8.68 t/ha to 11.43 t/ha and from 2.58 t/ha to 3.40 t/ha, respectively. The county-specific yield estimation mostly showed errors less than 10%. Further analysis for crop conversion coefficient was conducted for 200 DOY and 280 DOY. It can be provide a useful tool for early forecasting of crop yield. For the case of 280 DOY, Crop yield estimation showed better accuracy for soybean at county level. Though the case of 200 DOY resulted in less accuracy (i.e. 20% mean bias). Then we also calculated crop conversion coefficient for 240 DOY and applied to early forecasting in 2013. We conducted evaluations of the estimated crop yields with NASS forecasts derived from the 2013 November Crop production report at state level. The model could estimate state-level crop yields with high accuracy. The estimation error was 0.12% for corn and 0.66% for soybean in Iowa State. For the case of Illinois State, the estimation error was 0.09% for corn and -5.78 % for soybean. This study improved the spatial accuracy of estimated crop yield at county level by developing county-specific crop conversion coefficient. Our results indicate that the above-ground crop biomass can be estimated successfully with the simple LUE and respiration models combined with MODIS data and then, county-specific conversion coefficient can be different with each other across different counties. Hence, applying region-specific conversion coefficient is necessary to estimate crop yield with better accuracy. Also the model can predict the crop yield with high accuracy in the study area. There remain many other problems to solve in order to estimate an early forecasting crop model that could predict crop yield with consideration for crop growing period and condition.

Keywords：*Crop yield, LUE model, MODIS*

P1-241

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Participatory Soil Health Management and Food Security in Hundred Climate Vulnerable Districts of India

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Indian Agriculture covers 141 million hectares, in arid, semiarid, and sub-humid and humid climatic zones covering Vertisols, Alfisols, Inceptisols, Aridisols, Oxisols, Mollisols and associated soil types.. The demand for food grains would increase from 230 million tonnes in the last year to 355 million tonnes in 2030 to feed ever increasing population in India, with this availability of land per person decreased rapidly. Contrary to increasing food demands, various crop production systems are showing declining trends in yields due to deterioration in chemical, physical and biological health of the soil. Also, the factor productivity of the applied fertilizers is declining and continuous cropping without application of organic manures leads to decline in organic C which is one of the strong determinants of soil quality and crop productivity. Hence, a nation-wide project 'National Initiative on Climate Resilient Agriculture (NICRA) project was implemented in 130 vulnerable districts (100 KVKs in eight zones; 23 AICRP on dryland agriculture centres and 7 technology transfer divisions of ICAR core institutes) involving 0.1 million farm families across the country with an aim to demonstrate integrated package of proven technologies for adaptation of crop and live stock production systems to climatic variability which includes maintenance and improvement of soil health for ensuring national food security as well as to ensure sustained livelihoods of farmers even in the extreme weather events. The selection of districts was done based on the climatic vulnerability data of past 30 years. In all the villages, soil test based nutrient management was recommended. Other interventions include: reduced or zero tillage, crop residue recycling instead of field buring, green and green leaf manuring, tank silt and bio-fertilizers etc. For example, in Punjab state viz Killi Nihal Singh and Badaushi Kalan villages paddy straw recycling was promoted against farmers practice of paddy straw burning. Zero tillage in wheat was promoted in 30 ha area, where sowing was done using happy seeder machine in the standing stubbles of rice. As a result, the farmers were able to get 4.0 to 4.5 t/ha grain yield with an average increase by 9.5% over check plots.. Zero tillage and conservation agriculture (CA) was promoted in wheat in Amwakhash, Uttar Pradesh State where the farmers harvested 4.55 t/ha wheat yield and also in Nidhan and Jigan villages of Madhaya Pradesh farmers could get 10% higher than farmer's practice. In case of Jhangha, Uttar Pradesh, farmers were motivated to go for green manuring by facilitating the availability of sesbania seeds, as a result 125 farmers got improved grain yield of rice by 0.32, 0.16 and 0.18 t/ha. Green gram (legume) and wheat residue incorporation and earned a net returns of Rs. 24300/ha. Moreover, in order to promote residue incorporation in the fields, the district magistrate was convinced to issue an order banning residue burning. In Nandyalagudem village of Andhra Pradesh, large scale awareness was creased among farmers against residue burning and encouraged residue incorporation. Sesbania brown manuring was practiced in Shandabbar, Uttar Pradesh as the soils are poor in organic carbon (0.2-0.3%). In Durgada Nagenahalli, Karnataka stage, tank silt application (soil sediment) was done on 20 ha of 25 farmers for improving the productivity of light textured degraded soils. In Sipni, Arunachal Pradesh, liming was promoted in about 20 ha of acid soils, also in-situ green manuring was taken up with greengram and black gram. About eight vermicomposting units of size 10x4x2.5 ft3 were established for efficient recycling of farm residues and twenty five vermicompost units in North Pulinpur, Tripura state. In Gunia village of Jharkhand, improved seed along balanced fertilizer application were promoted there by grain yield was 3.0-3.5 t/ha with Rs. 12600 net returns obtained. Thus, to enhance sustainable food production, it is necessary to maintain soil health and by implementing national level integrated soil health management strategies with farmer participation in order to have self sustainability and food security of the country.

Keywords：*Soil health management, Zero tillage, Residue burning vs Incorporation, Brown manuring, Vermicompost, Tank silt, Green leaf manuring, Food security, India*

P1-242

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Correlation Studies On Secondary Nutrients and Soil Properties in Soils Under Rubber Plantations in Cameroon

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Secondary soil nutrients are necessary for plant growth but they are rarely determined on a routine basis because of interpretative problems. Information on their levels and particularly their relationship with soil pH and organic carbon is however, very important but rare. The levels of secondary nutrients and the relationship between soil properties were studied in some soils from Hevea plantations in Cameroon. Exchangeable Mg and Ca were positively and significantly correlated with soil organic matter and soil pH. Available S on the other hand showed positive both non-significant correlation with soil pH and organic carbon. Variation in soil pH and organic carbon content would affect the levels of the secondary nutrients which is important for nutrient management purposes. Available Ca, Mg and S contents ranged from 33.9 to 3143.6, 4.5 to 566.6 and 9.3 to 77.8 mg kg-1 with mean values of 417.4, 76.0 and 24.1 mg kg-1, respectively. Soil pH and organic carbon content ranged from 3.7 to 5.7, and 0.56 to 8.2% with an average value of 4.3, 1.8% respectively. Thus soils under study were all acidic. The soil samples from these Hevea plantations were generally well supplied with micro nutrients.

Keywords：*Secondary nutrients, pH, Organic carbon*

P1-243

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Soil Phosphorus Fractionation of Two Oil Palm Fields with Different Planting Age in Pahang, Malaysia

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Introduction

Because highly weathered soils in Malaysia such as Oxisols and Ultisols are inherently low in phosphorus (P), most crops require much P-fertilizer application for good production. In oil palm plantation, P-fertilizer (mostly phosphate rocks) is applied around the canopy circle of palm trees where undergrowth is slashed-cleared (weeded circle). On the other hand, some portion of the plant P could be expected to return to soil through the decomposition of threshed fronds that are piled up in-between palm trees (frond heap). Meanwhile, no P is applied at the operation path for harvesting and transporting (harvesters' path). Although it can be assumed that P dynamics is different among such micro-sites of weeded circle, frond heap and harvest path, there is no detailed information on P status of soil in oil palm plantation. With the aim of developing a better strategy in P management, the purpose of this study is to investigate the P status and its fractions in oil palm field with special reference to micro-sites and different planting age. In this study, we hypothesized that 1) Prolong P-application at weeded circle will result a high accumulation of P; 2) Some P is returned to soil from organic matter decomposition at frond heap.

Materials and Methods

This study was conducted at an oil palm plantation in Tun Razak Agricultural Services Centre located in Pahang, Malaysia. Oil palm fields with 5 years and 10 years of planting age were selected, as well as the adjacent secondary forest. Soils were sampled from the micro-sites including frond heap, weeded circle and harvesters' path at 3 soil depths (0-3cm, 3-10cm, 30-40cm). Bray-2 P (Bray and Kurtz, 1945) and total P were determined. Modified sequential P fractionation method (Tiessen and Moir, 1993) was performed to fractionate soil P. In brief, samples were first extracted using 0.5M $NaHCO_3$ as a labile pool, then 0.1M NaOH as a non-labile P-fractions, and lastly 1.0M HCl as a calcium associated primary-P (Ca-P_i). The inorganic P (P_i) and organic P (P_o) of $NaHCO_3$ and NaOH fractions were determined.

Results and Discussions

Soil P and its fractions were markedly different in terms of micro-sites as well as planting age: At 0-3 cm depth, total P and Bray-2 P in the 5 and 10 years age planting fields were higher (both were more than 1000 mg P kg^{-1}) at the weeded circle than harvest path and frond heap. However, at 3-10 cm depth, the 5 years age planting field showed the highest level of these forms of P at harvest path with the contents of 614 mg P kg^{-1} and 271 mg P kg^{-1} respectively. At 30-40 cm depth, the P was low in any sample. On the other hand, 10 years age planting site showed higher total P, Bray-2 P, labile P and Ca-P_i level at the weeded circle than 5 years age planting site. This can be attributed to P-accumulation due to continuous application of phosphate rocks. Despite our expectation that organic fractions of P were higher at frond heap, P_o level at frond heap tended to be similar compared to the harvest path and lower than that at weeded circle. At 0-3 cm, both 5 years and 10 years planting age fields showed at least two times higher of P_o level in labile and non-labile fraction at weeded circle than those at frond heap. In this study, we found out that abundance of soil P and its fractions were greatly heterogeneous due to the P-application limited around weeded circle. Judging from the high level of P at weeded circle, the accumulated P would be carried over to the next rotation which may affect the growth of replanted palm trees. We suggest broadcast application of P corresponding to the growth stage of the palm tree for effective use of P resources.

Keywords：*oil palm, soil phosphorus fractionation, Malaysia*

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[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Chemical and Leaching Characteristics of Lead Smelting Slags from Four Open Contaminated Sites in Nigeria

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Four samples of lead smelting slags collected from four different open lands were characterized using X-ray Diffraction (XRD) and X- ray Florescence (XRF) analyses. Multi-elemental analyses were done using acid digestion followed by inductively coupled plasma-optical emission spectrophotometry (ICP-OES) determination. Leaching and toxicity potentials were investigated by NEN 12457-4 Dutch Compliance test, USEPA Method 1311: Toxicity Characteristics Leaching Procedure (TCLP) and USEPA Method 1312: Synthetic Precipitation Leaching Procedure (SPLP). It was found by XRF that Fe2O3, PbO, SO3, SiO2, Al2O3 in the order are the main oxides of the wastes. XRD results showed that PbSO4 (anglesite) was a major mineral in the four slags. The chemical components imply that the slags can be recycled. Altogether, 26 major, minor and trace environmentally soluble elements were determined by ICP-OES analysis. The levels of the metals leached exceeded the Dutch regulatory limits for Pb, Sb, Se; USEPA's toxicity characteristic threshold for Pb (5 mg/L) and Cd (1 mg/L) classifying the slag as environmentally unsafe. In addition, Fe, Mn and Pb concentrations in the SPLP leachate were above the Nigerian and other international drinking water quality standards posing potential risks to groundwater. Hence, there is an urgent need for remediation of the contaminated sites to reduce Pb and Cd transfer to air, soil, water bodies and ultimately the human body system.

Keywords：*Lead smelting slag, contamination, composition, leaching, recycling, remediation*

P1-245

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Partitioning of Different Elements to Solid and Liquid Separates with Solid-Liquid Separation of Swine Slurry Using Different Separation Techniques

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Solid-liquid separation is a manure management option for processing swine manure whereby N-rich liquid is separated from P-rich solid, allowing the separated liquid to be used as a source of N to crops without over-supplying P. Different techniques have been developed for solid-liquid separation, but there is limited information on their efficiency in separating various elements that are agronomically and environmentally important to solid and liquid separates. This study evaluated the efficiency of three techniques; centrifuge without a flocculant, centrifuge with a flocculant and rotary press with a flocculant, for solid-liquid separation of swine manure. Four raw swine manures and their liquid and solid separates were used for the study, which included three raw manures with a solid content between 2.5-4.5%, each of which was separated either using a centrifuge without a flocculant, centrifuge with a flocculant or a rotary press with a flocculant, and one additional raw manure with a solid content >5% that was separated using a rotary press with a flocculant. All manures and separates were analyzed for solid and water contents, and elemental composition.

Separated liquid from all three techniques contained about 1% dry matter. In contrast, separated solids had over 25% of solid dry matter content with the greatest in the solid separated using the rotary press with a flocculant, irrespective of the initial solid content in slurry. Separation using the rotary press with a flocculant increased the dry matter content by 29-33% relative to the raw manure, compared to a 22 to 23% increase when separated using a centrifuge with or without a flocculant. Percentage of elements partitioned into separated solid and separated liquid varied among separation techniques as well as with element. Approximately 20 to 50% of TKN was in the separated solids; the lowest percent separation was with the use of centrifuge without a flocculant. Separation of dry matter (manure solids) to separated solids was at least 50%, and was about 75% with a flocculant. Thus, TKN did not separate as well as dry matter in manure. This is because most of the ammonium N, which is highly soluble and comprised over 50% of the total N, remained in the separated liquids. Approximately 50-70% of the total P was partitioned into the separated solids by the various techniques. Separation of very soluble elements in manure, such as Na and K was very low and varied from about 5 to 15%. Separation of Ca and Mg followed patterns similar to that noted for P, with separation of Ca and Mg being less than for dry matter. Separation of Cr was very high (varied from about 80-90%) with separation being much greater than separation of dry matter. Separation of Cu, Fe, Mn, B and Zn varied from 40 to 100% and exceeded separation of dry matter per se, except for separation using the centrifuge without flocculant where separation of the metals approximated separation of dry matter. Separation of Ni varied from 30 to 70% and was similar to or somewhat less than separation of dry matter whereas separation of Pb, Mo, Cd and S were less than that of dry matter.

The results indicate that for soluble elements such as Na and K, about 85 to 95% of the element in manure would separate to the separated liquid. In contrast, for metals such as Fe, Mn, B, Al, Zn, Cr and Cu, as much as 85 to 90% of the element present in raw manure separated to the separated solids. Separation varied greatly with separation technique and element. This indicates that analysis of separated solids and separated liquids is essential for both the management of major nutrients such as N and P and management of other elements such as Cu, Zn, Fe and Mn.

Keywords: *Swine slurry, Solid-liquid separation, separation efficiency, nutrients, elements*

P1-246

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Studies on Application of High Se and Co Alfalfa Forage on Animal Production

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This study conducted a seris of field trials and animal experiments from 2007 to 2008 in order to study the multiple effects of high selenium (Se) and Cobalt(Co) of alfalfa forage on animal feed conversion efficiency and production, and established a set of effective technical ways to solve trace element gaps of animal diets, i.e. by basal fertilization of Se and Co fertilizers in soil.The results showed as following: When additive content of alfalfa meal (rich in Se and Co)account for 5% of ration,Se contents of meat, liver and lung of rabbit could enhance significantly,milk qualities was enhanced greatly. There were more significant conrelation(P?0.01)among Se contents in animal products,Se contents in pasture and that in soil.

Keywords：*Animal, Co, Se*

P1-247

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Studies on Growth Characteristics and Productivities of Mixed Sowing Forage Plants

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According to biological characters, alfalfa, tall fescue and smooth brome were sowed together in order to analyze biological characteristics and production capabilities. Aims of experiment were to seek utilizing principle of mixed grassland. The results showed that mixed or single forage had 90-100 day duration and 220-230 d green period ,Compared with single sowing, mixed sowing could raise stem to leaf ratio(S/L ratio) and tillering number of grasses, decrease fresh to dry ratio(F/D ratio), no apparent effects on leaf area index(LAI). Aboveground biomass of mixed or single sowing forage appeared“S”dynastic model with the fastest growth rate in heading and flowering period and had biomass peak in ripening period, but it was optimal for forage to harvested in wax ripening period. By the way,mixed sowing had greater production levels than single sowing of tall fescue or smooth brome, but lower than single sowing of alfalfa

Keywords：*alfalfa, brome*

P1-248

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Migration Effect of Selenium in Soil-Grass System

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This paper studies the migration effect of Se in soil-grass system using alfalfa as a carrier by the way of Se application. The result indicated: the content of Se in the soil can be improved at the stages of seedling, branching period, pregnant bolls, initial flowering and bloom by applying selenium. The content of available selenium in soil was highest when the amount of selenium was 1.05kg hm-2 at each stage, which was significantly（P<0.05）higher than no applying selenium in soil. And the content of available selenium in soil was correlated with the amount of applying selenium. When applying 1.05kg Se hm-2 or more,the content of available selenium in soil was decreased with the extended growth of alfalfa which fell 24.75%～40.84%, and it was significantly（P<0.05）at the stage of seedling and branching higher than bloom. For alfalfa, applying the moderate selenium base fertilizer could significantly (P<0.05) improve the absorption of selenium and the content of selenium in it. The ability of absorption of selenium showed inverted “V” pattern of rising first and falling then with the growth of alfalfa, and the peak was at the initial flowering, while the content of selenium in alfalfa was decreased with extended growth. The linear relation between the content of selenium and the application of selenium was significant（P<0.01）, the linear equations were: y=1.9912x+0.1827(R2=0.9696) at the seedling stage, y=1.7394x+0.1724(R2=0.9670) at the shooting stage,
y=1.5045x+0.1542(R2=0.9694) at the budding stage,
y=1.2547x+0.1588(R2=0.9835) at the early flowering stage,
y=1.0044x+0.1500(R2=0.9904) at the open flowering stage.
However, the migration effect of selenium in soil-grass system was very low, which was highest when the amount of selenium was 0.45kg hm-2 in the whole time, but it no more than 1.5%. The migration effect of Se was first rising and falling then with the extended growth of alfalfa, and it was highest at the initial flowering stage.

Keywords：*migration, grass, alfalfa*

P1-249

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Value Adding of Animal Wastes to Reduce Environmental Liabilities and for the Improvement of Soil Health

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The swine and poultry sub-sectors are among the top economic contributors of the agriculture industry in the Philippines. As such, the 'wastes' generated from these animals and the potential damaging effects to the environment should be given priority considerations. Utilization of animal wastes as fertilizers or soil amendments offer a number of advantages to society in that the quality of the soil can be enhanced and water quality will improve as a result of decreased disposal into rivers, lakes, and streams. However, the Philippine agricultural sector remains conservative in accepting and practicing manure composting due to slow soil recovery and the culture itself. A research and extension project was conducted to produce quality organic fertilizer or soil conditioners from livestock and poultry wastes which are safe for agricultural use and to rehabilitate problem soils (acidic, saline) while improving the environmental performance of the animal farms. Environmental waste audit was conducted in 6 sites in Southern Luzon Philippines to study the organic wastes generated from animal farms and the damaging effects to the environment. Open and close ended survey was used to gather animal production information, waste disposal scheme, and the possible on-site and off-site effects of animal wastes.

The study highlighted the development of organic fertilizer or soil conditioner from the project sites with qualities conforming to the Philippine National Standards for Organic fertilizer that could be utilized by certified organic farms. Results showed that increased swine and poultry production in the selected provinces, both backyard and commercial operations, generates serious odor nuisance, causes pollution of the soil and surface water and poses great risk to human health. Odor nuisance creates social conflict between animal owners and communities, to such extent that it is easily the most common cause for aggravation against commercial animal production. However, these farm operators seem more engrossed with the economic objectives and they hardly pay attention to the environmental aspects of their operations. Manure, wastewater and unwanted products are discharged to lagoons or dumped nearby or into waterways and rivers and made to percolate to the groundwater or drift elsewhere. Appropriate waste management practices and techniques were developed to efficiently utilize these potentially damaging by-products of animal production.

The initial pot experiments on acidic and saline soils provided the benefits of molding composted animal wastes into pellets. The pelletized organic fertilizer provided a gradual nutrient supply for the corn and lettuce plants, which improves N fertilizer use efficiency and reduces N leaching losses. The fertilizer efficiency of pelletized composts was not statistically significant from dried animal manures because when soaked in water, the pellets retained their stability and shapes that persisted in the soil longer than the non-pelletized manures and compost. The soil quality indicators used to measure the improvement on soil health showed promising results. Development of more or less closed-loop pattern of recycling of nutrients in the manure into an organic fertilizer and recovery of energy from animal waste is the key to sustainable development of animal production system. The results of this project will also be relevant to livestock and poultry raisers in the rural areas.

Keywords: *organic fertilizers, soil health, animal manure, pelletized fertilizers, problem soils*

P1-250

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Postagrogenic Dynamic of Soils on Abandoned Croplands of Cryolithozone

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Yakutia is a 1/5 of the Russian Federation, the territory of the republic is located within the zone of continuous permafrost, which depth reaches 1500 m and with a temperature of frozen grounds -7-10°C. The central part of the republic, mainly the middle basin of the Lena river is within a zone of risky agriculture. Here, in severe climatic conditions on a territory with long and very cold winters, and short hot summers under insufficient moisture there was started cultivation of ripening varieties of crops about 350 years ago.

At the beginning, the croplands were located in the valleys of the river basins and alases, but because of their large early frost danger gradually moved to the watershed areas. To create the arable lands the forests on the pale soils were destroyed. Around villages the area of stubbings reached 1000-1500 hectares. As a result of the change to a market economy and the collapse of the large agricultural enterprises, currently there was an abrupt reduction in the area of arable land. Thus, if the area of arable land in the early 1990s was more than 140 thousand hectares, today there are not more than 90 thousand hectares. About 50 thousand hectares of arable land were abandoned, converted into fallow land or whether overgrown with weeds territory.

To assess the cropland soils transformation and restoration in Central Yakutia there were studied the soils of functioning and abandoned arable lands of different ages. Totally there were studied 9 sites, made 22 soil profiles on an abandoned arable lands of 20 and 50 years old. As reference soils there was studied forest soils under natural condition near the croplands. The study included a detailed description of the morphological structure of the soil profile with the determination of density and moisture, and soil samples were collected for chemical analysis.

The studying of abandoned arable lands on the pale soils of the region showed that the recovery of forest vegetation goes very slowly, due to the fact of salinization during the functioning of the arable land in one case, in another case it is the alkalinization of the upper soil layers. Composition of salts consists mainly of carbonate and bicarbonate of sodium and magnesium. Insufficient precipitations and close -lying waterproof bed in the form of frozen grounds prevent removing of salts from thawed soil layer after the exploitation of arable land for agriculture. The presence of soda in salts composition leads to implementation of sodium ions in the soil absorbing complex, which gives solonets properties of soil. High rates of soil pH, as well as an unfavorable composition of exchangeable bases prevent forest regeneration on abandoned arable lands. As a result, the duration of transformation process in former postagrogenic arable soils in permafrost has been lasting tens and hundreds of years.

It was found that under the influence of plowing the humus content in arable land soils is reduced compared with forest soil. But abandonment of tillage contributes the gradual increase of the humus content in soils. Structuring of the top plowed horizon in all abandoned lands has not formed, and it may require a longer time. It is noted the deeper A horizon is on the croplands abandoned 20 years ago. On the old cropland, abandoned 50 years ago and being used at this time for hay harvest, due to human influence, the restored sod horizon has less depth compared to fallow of 20 years old having no anthropogenic pressure as haying or grazing. Arable lands, abandoned 20 years ago have faster regrown forest vegetation. Age of tree stands is 9-13 years and presented by Larix cajanderi. As a result, there appearing a new organic horizon of forest litter - Ao. In cropland, abandoned 50 years ago, is begining successional reforestation stage, the age of new forest stand is only 3-5 years. There were indicated that dynamics of restoration succession depend on the usage of arable land after their abandonment.

On arable lands withdrawn from agricultural use are often observed the initial stages of the thermokarst degradation of soil cover. Herewith the transformation of soil morphology, composition and properties leads to a change in classification appertain.

Keywords：*Abandoned arable lands, cryolithozone, Central Yakutia*

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[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Forestry Species Effects on the Characteristics of the Poor South-Eastern Soils of Nigeria

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Soil is the complex expression of physical,chemical and biological processes occurring across spatial and temporal scales.Soil properties at a specific location integrate and reflect both past and present conditions.Based on this premise,the poor soils of Calabar in the eastern Nigeria planted with five different tree species of Gmelina spp,Teak,Kolanut,Indian bamboo and Wild shrubs for 25years were assessed in 2012 for the current status of the physical,chemical and biological properties.

Composite soil samples were collected from each of the plantations and the adjacent unplanted soil using a steel soil core sampler of Mcfee and Stone (1965) within the 0-20cm top soil.The samples collected at each location were divided into two,and the one for the biological properties were kept in an iced box before the analysis,while the second part meant for the determination of physical and chemical properties were kept normal before the analysis.The analysis of the soils' physical chemical and biological parametals were carried out using global standard methods.

The results of the analysis showed that the populatios of bacteria in the soil under adjacent plot were higher than the main plantation plots.While Kolanut and Wild shrubs showed higher populations of fungi than the adjacent plot.The PH value in Gmelina spp ,Teak and Kolanut plots(i.e 6.1,6.3 and 6.7 respectively compared with the adjacent of 6.0)were enhanced,while the Wild shrub and the Indian bamboo values were reduced to high acidic level.The sand properties were the most affected by the species with Gmelina,Wild shrub,Teak Kolanut and Indian bamboo having higher sands of 71.80%,80.90%,89.90%,79.90%and 77.90% respectively compared with the adjacent of 59.90%.The clay and the silt content were reduced drastically in the planted species compared to the adjacent plots.The percent organic matter were higher in all the planted species except in the Wild shrub species.The percent total Nitrogen were higher in all the species except the Wild shrubs and Indian bamboo,while the Available P(mg/kg) values were enhanced in all the species except the Indian bamboo.The insitu element ,Potassium values were greatly enhanced in all the species except Gmelina.

From the results,it appears that most of the physical and chemical properties were enhanced in Gmelina,Teak and Kolanut plots while Wild shrubs and Indian bamboo had lower values than the adjacent plot.These three tree species had links with and affects the physical ,chemical and biological characteristics of the site.

Therefore, a good knowledge and understanding of this research will assist farmers to determine a sustainable management of the poor fertility soils using these tree species.

Keywords：*Forestry species,Soil characteristics,Poor soils,Sustainable management and Soil properties.*

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[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Soil Properties, Their Impact On Citrus Tree Loss and Their Management.

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Citrus is one of the most important fruit tree crops in Nigeria. It is widely grown all over Nigeria even on marginal soils. However, different soil properties have affected the production the performance of Citrus thereby leading to poor yield and in some cases Citrus tree loss.

An assessment of soil properties was carried out in two agro ecological zones of Nigeria located in Ibadan (Oyo state), Mbato (Imo State). Soil and yield data from 12 varieties of Sweet Orange were obtained and used to determine soil factors relevant to Citrus yield and tree loss.

There was over 30% yield reduction in Citrus yield between Ibadan and Mbato which is located on the acid sands of Nigeria. Soil properties which correlated with Citrus yield include pH, Bulk density, Coarse sand and moisture content. However, some other soil properties were location specific. There was 16.66% tree loss in the orchard with concretionary/gravelly soils compared to 2.78% tree loss in the non concretionary soils both having a Citrus orchard of 18years.

One of the key factors limiting Citrus production is the acidity of the soils especially in Eastern Nigeria. Therefore, liming and other soil fertility programmes should be put in place to aid production.

Keywords：*Soil acidity, Citrus, tree loss, concretionary, non concretionary.*

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[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

A Study on the Cadmium Sorption by Two Different Humic Acids: Effect of Ionic Strength on Cadmium Sorption and Description of Isotherm Data by Different Empirical Models

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Ionic strength effects on cadmium sorption by two different kinds of humic acids, namely, a humic acid extracted from the surface horizon of a soil under a coniferous forest located in North of Iran, and a humic acid extracted from a commercial humic acid amendment, was studied in this investigation. It was indicated that for both kinds of humic acids and at all three pH values, cadmium sorption was decreased when ionic strength increased. However, the effect of ionic strength on sorption tended to decrease with an increase in pH. The effect of ionic strength on sorption was ascribed to one or a combination of several factors, namely, more competition of competitive ion (Ca2+) with cadmium at higher ionic strength; reduction in the stability constant of the Cd-surface complex at higher ionic strengths; contraction or flocculation of humic acid at higher ionic strengths; and preventation of cadmium precipitation at solid-solution interface at higher ionic strengths. It was shown that the effect of ionic strength on the reduction of cadmium adsorption is higher in humic acid extracted from the commercial humic acid amendment. This observation was ascribed to the higher amounts of total acidity and phenolic groups in humic acid extracted from the soil. Empirical models, namely, Fruendlich and Langmuir single-site and double-site equations were employed to describe isotherm data. Isotherm data for both humic acids were described adequately by Fruendlich equation, however, single-site Langmuir model was not adequately fitted to all isotherm data, which probably is the result of the surface heterogeneity of sites on humic acids. Whenever single-site model did not fitted properly isotherm data were described by a double-site Langmuir model, and the equation parameters were calculated by two different methods.

Keywords：*Fruendlich equation, single-site Langmuir equation, double-site Langmuir model*

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[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

A Study on the Cadmium Sorption by Two Different Humic Acids: Effect of Ph on the Cadmium Sorption

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This investigation was conducted to study the sorption of cadmium by two different kinds of humic acids, a humic acid extracted from the surface horizon of a soil under a coniferous forest located in North of Iran, and a humic acid extracted from a commercial humic acid amendment. The sorption experiments were carried out at three pH values of 5.0, 7.0, and 8.6. Calcium nitrate as a background electrolyte was used for ionic strength adjustment. The chemical characteristics of the two humic acids were significantly different. Total acidity and percentage of phenolic functional groups in the soil humic acid were higher than the amendment humic acid, whereas, the carboxylic functional groups were of a higher percentage in the latter one. The soil humic acid tended to sorb more cadmium at all three pH values, probably due to the higher total acidity and phenolic functional groups in the soil humic acid. Results indicated that calcium as an alkaline earth metal competitor, did not compete effectively with cadmium for sorption sites especially at higher pH values (i.e., pH=8.6), however, at lower pH values (i.e., pH=5), the competition was relatively more effective. It was concluded that these two cations did not compete for the same sorption sites, especially at higher pH values. At constant ionic strength, the sorption was increased with pH, but the effect of pH on the sorption was higher in soil humic acid, probably due to the higher total acidity and phenolic functional groups in this humic acid. It was concluded that even at elevated concentrations of alkali and alkaline earth metals in the soil solution, heavy metal contaminants such as cadmium could be sorbed strongly and effectively by the humic acid present in the soil, therefore, their downward movement towards the ground water could be effectively hindered.

Keywords：*isotherm, ionic strength, functional groups*

P1-255

[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

The Attribution Study on Salinisation Soils in Northern Hebei Based on Chinese Soil Taxonomy

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According to the 'Chinese Soil Taxonomy (3rd Edition) ' and ' Principles and Criteria for Establishment of Soil Family and Soil Series of Chinese Soil Taxonomy (1st Draft) ', 7 saline alkali soil profiles in Northern Hebei was divided into 4 Orders, 6 Suborders, 6 Groups, 7 Subgroups and established 7 Soil series. Research results showed that :(1) Did not found the corresponding relation between CST and CSGC at subgroup.(2) Part of saline alkali soils did not reflect salinity characteristics in the advanced unit, but in the basic soil classification the salt content and position was indexed, this showed soil taxonomy is more strict and standard.(3)Finally discusses the determination of diagnostic horizons and diagnostic characteristics of the salinization soil analysis methods.

Keywords：*Chinese Soil Taxonomy; soil series; salinization; Northern Hebei; Diagnostic horizons; Diagnostic ch*

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[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Land Use Conversion and Soils Degradation in a Lowland Tropical Landscape of Papua New Guinea

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A comparative study of the effect of three main types of land use (systems) on soil erosion levels was carried out in a traditionally farmed lowland forested region of Morobe province, PNG.

Land use conversion affects natural soil processes, and can potentially decrease soils productivity. A representative area was selected to study the effects of land use conversion in Unitech campus, Southeastern lowlands of Papua New Guinea (PNG). Area selected for the study was once covered by tropical rainforest and has been subjected to various land use types over time. Nine erosion plots were built at three sites at almost the same altitudinal level, area corrections were done to eliminate the effect of varying slopes. Volumes of runoff and the concentration of sediments and of soil main nutrients collected by the plots were measured on a weekly basis. The parameters measured closely depended on rainfall amounts along the time. Significant differences were found among them, explained mainly by the land cover type and their soil particularities such as infiltration rates, bulk density and texture. Although forest and grassland systems proved to be more effective in controlling soil losses, their areas are rapidly been converted into croplands, raising concerns for the sustainability and improvement of land use planning in the region. Representative soil samples were collected under four main land use types (secondary forest, plantation forest, grassland and agricultural garden) at two depths (0-0.15 m and 0.15-0.30 m) with three replicates per land use. Soil bulk density, water infiltration rate and cumulative water infiltration values were significantly greater ($p<0.05$) under grasslands than under secondary and plantation forests. Among soil chemical properties, extractable potassium content and pH showed significant differences ($p<0.05$) between the four land uses, pH values increased upon conversion of forested lands to grassland or agricultural gardens. Conversion of secondary forests into grasslands or agricultural gardens leads to depletion of Bray's phosphorus and extractable potassium. Tree-based land uses were optimum due to better nutrient cycling conditions and lower bulk density compared to grassland and agricultural garden despite the low pH conditions and lower water infiltration.

Keywords：*Effects of land use, soil physical and chemical properties, land productivity decline, laminar erosion, soil degradation, tropical soils*

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[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Variation in Heavy Metal Accumulated in the Edible Part of Nine Different Crop Plants and Their Response to the Changes in Phytoavailable Metal Pools in Soil

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Many agricultural land are located nearby the abandoned mining area being affected by the mine tailings and acid mine drainage worldwide. As a result, the soils showed elevated concentration of heavy metals and consequently crop plants produced from the metal contaminated soils are likely to accumulate excessive heavy metals in the edible part. Hence, an appropriate management protocol for metal contaminated agricultural lands should be introducted for agricultural food safety. The current study was carried to select proper crop plants (hypoaccumulators) to be cultivated in the metal contaminated soil. Also, metal uptake responses of each crop plant on the changes in phytoavailable metal pools in soil were examined. For this, nine different crop plants (red pepper, egg plant, carrot, potato, bean, sesame, Chinese leek, spring onion, and corn) were cultivated in the pots containing three different soils contaminated with heavy metals. Soil A showed high concentration in Cd (8 mg kg^{-1}) and Zn (346 mg kg^{-1}) with soil pH 6.4 and Soil B were high in Cd (13 mg kg^{-1}), Pb (1212 mg kg^{-1}) and Zn (780 mg kg^{-1}) with soil pH 8.1. Additionally, soil C was composed from the soil A being treated with CaMg(CO3)2, of which soil pH elevated to 7.4. The experiment was conducted in three replicates and all the crops were cultivated by the harvesting stage for the edible part. At harvesting stage, the edible part of each crop and the corresponding soils were collected for analysis. The collected crop and soil samples were analyzed to determine the metal concentration in edible part of crop and soil. Also, 1 M NH4NO3 extractable metal concentrations were determined as a phytoavailable pool of metals in soil.

Among the crop plants examined, corn, sesame, and bean of which seeds are used for food, appeared to accumulate remarkably higher amount of heavy metals in edible part than the other types of crop plants. In contrast, spring onion, potato, red pepper showed comparably lower accumulation of heavy metals in edible parts. In particular, carrot showed extremely high concentration in Pb in root compared to other crop plants. The elevated soil pH from 6.4 (soil A) to 7.4 (soil C) by application of CaMg(CO3)2 resulted in significant decline in phytoavailable metal pools. Subsequently, metal accumulation in edible part of the crop plants decreased. For instance, the concentrations of Cd in the seeds of sesame and bean decreased from 0.38 and 0.43 mg kg^{-1} to 0.21 and 0.23 mg kg^{-1}, respectively. From these results, it can be conclusive that cultivation of hypoaccumlating crop plants such as spring onion, potato, and red pepper would be advantage for safer food production in metal contaminated soil. Also, the technique to decline the phytoavailable metal pools in soil would be additionally applicable.

Keywords：*cadmium, contamination, food safety, lead, phytoavailability*

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[DS6] Soils in the Anthropocene Era: Global Health, Food Security, and Human Health

Variation in Heavy Metal Accumulated in the Roots of Eleven Different Medicinal Plants and Their Bioconcentration Factors

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Recently, an international market scale and a trade of herbal medicines are getting increased as people are getting interests in not only oriental medicinal practices for curing disease but also routine intake of health food made of herbal plants. In a mean while, safety issues of medicinal plants are on the rise due to hazardous substance possibly being accumulated in the plant materials such as heavy metals. For instance, there was an incident for a man to be in health trouble after taking herbal medicine for a week and then it was revealed that the herbal medicine contained high concentration of Pb. Therefore, the current study was conducted to monitor the level of metal concentrations in roots of 11 different medicinal plants widely cultivated in Korea. In this study, root medicinal plants were targeted given that in general, the root among the plant organs accumulated the highest concentration of heavy metal and hence, root based medicinal plants are more likely to come across with heavy metal related safety issue. The root samples of each plant were collected at harvesting stage in national wide scale to cover different region and province in Korea. The collected plants and the number of samples for each plant were Platycodon grandiflorum (71), Angelicae Gigantis (20), Codonopsis lanceolata (33), Panax ginseng (30), Dioscorea batatas (31), Paeonia lactiflora (7), Acyranthes bidentata (5), Scutellaria baicalensis (3), Lithospermum erythrorhizon (3), Rehmannia glutinosa (3), and Bupleurum falcatum (3). Soil samples were also collected from where the plant samples were collected. Collected plant root samples were analyzed for the concentrations of Cd, Cu, Pb, and Zn in dry weight base while total (aqua regia digestible) and phytoavailable (1 M NH4NO3 extractable) concentration of the corresponding heavy metals were determined using the soil samples.

The ranges of total heavy metal concentrations in the investigated soils were n.d. ~ 0.4 mg kg^{-1} for Cd, 1.4 ~ 77 mg kg^{-1} for Cu, 1.4 ~ 45.6 mg kg^{-1} for Pb, and 20 ~ 100 mg kg^{-1} for Zn of which the concentration were all below the guideline values in Soil Conservation Act 2009, Korea. The extent of metal accumulation in roots was variable depending on the type of the plant when evaluated with average concentration and bioconcentration factors (BCFs). For instance, when the comparison was made among the five plants which were collected more than 20 samples, the average concentration of Pb was in the order of Platycodon grandiflorum > Codonopsis lanceolata > Panax ginseng > Angelicae Gigantis > Dioscorea batatas, while the BCFs showed Codonopsis lanceolata > Platycodon grandiflorum > Angelicae Gigantis > Panax ginseng > Dioscorea batatas. This indicated that Platycodon grandiflorum and Codonopsis lanceolata accumulated more Pb and Dioscorea batatas accumulated less Pb in their roots. Therefore, cultivation of hypoaccumulating medicinal plant such as Dioscorea batatas, if cultivation practice has to be carried out in the heavy metal contaminated land, is more likely to produce safer medicinal herbal materials.

Keywords：*bioconcentration factor, food safety, heavy metal, herbal plant, medicinal plant*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Establishing Environmentally Safe N Fertilizer Rates in a Dystric Leptosol Using Castor (ricinus Communis L.) as a Test Crop

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A field study was undertaken to (i) determine the amount of N that could be applied in excess of that needed for maximum yield for a particular crop without resulting in increased soil profile N accumulation; and to (ii) use this information to set environmentally safe N fertilizer rates in places where farmers use blanket extension fertilizer recommendations which are often sub-optimal or excessive. The study was carried out in a Dystric Leptosol at Abakaliki, southeastern Nigeria. A total of 12 treatments comprising two commonly grown cultivars of castor (Ricinus communis L.) ('Ugbaugo' {UGU} and 'Ugbaisinwankpi' {UGK}) and six rates of N fertilizer (urea) (0, 30, 60, 90, 120 and 180 kg N ha -1) was set up in the field using a randomized complete design replicated three times. Results show that optimum N fertilization rate for both varieties was 60 kg N ha-1 . Rates above 90 kg N ha -1 resulted in increased soil N content without necessarily increasing crop yield. This places soil-plant-N buffering as defined as ability of the soil-plant system to limit the amount of nutrient accumulation in the rooting profile when fertilization rates exceed that required for maximum grain yields at 90 kg N ha ?1 for the study soil under castor plants. For this soil, the portion of N fertilizer applied beyond 90 kg N ha -1 is susceptible to leaching losses and may cause eutrophication of rivers, lakes and other forms of environmental pollution.

Keywords：*N application-soil-plant continuum - priming effect - N accumulation - Nigeria*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Fertility Capability Classification of Soils of the Sokoto-Rima Flood Plain, Nigeria

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The study was conducted in the Sokoto-Rima flood plains at Sokoto Nigeria, with the aim of identifying appropriate fertility management strategies for the soils in the flood plain for productive and sustainable agricultural landuse. Morphological data and soil samples (three depths: 0-10cm, 10-30cm and 30-50cm) were collected at various locations in the sample area for laboratory analysis of those pertinent physical and chemical properties of soils that are directly related to plant growth. Results showed that three (3) Fertility Capability Classes (FCC) dominate the study area: (i) Lgm- Loamy soils low in organic matter with gleying limitations (ii) Lghm Loamy soils, low in organic matter with gleying and pH limitation (iii) Sgm Sandy soils low in organic matter, with gleying limitations. The three classes were then resolved to form the three mapping units shown in the FCC map. Soil class Lghm has higher fertility/yield potential followed by the class Lgm then Sgm class. Periodic monitoring of soil quality, adding organic manure and applying ameliorative measures such as liming can improve and sustain productive capacity of the soils.

Keywords：*Fertility; Classification; Soils; Floodplains.*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Wet Lands' Valorisation with Oil Palm: A Response to Land Scarcity and Rainfall Rarefaction in Southern Cote D'ivoire

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The growing of oil palm in Cote d'Ivoire is facing two major problems : (1) Land scarcity and (2) poor satisfaction of water needs of the crop.

Land scarcity is mainly due to the over population of the rane forest area in the southern part of the country wich is the growing area of most of the national cash crops. This problem, created by a natural fast increasing demography, as been worsened by the socio-political crises of the last decades.

Poor satisfaction of water demands, already being a major problem in the year 60 when the first oil palm plantations were created, is now crutial basically due to a decreasing rain fall in southern Cote d'Ivoire these last years.

To tackle these problems, the oil paml Research Station of LaMe, in 1987, develloped an original technic for the growing of oil palm in swampy wet land areas. Thereafter, oil palm fileds have been created on wet land soils at different sites of the country by rural small farmers as well as by large industrial oil palm growers. Social and environmental impacts of these plantations in this fragile ecosystem which is the swampy wet land is not completly known. A comparative study, thus, was conducted.

The objectives of that research work was to underline the positive as well as the negative parts of oil palm plantations in wet land areas as compare to those in uper areas were the oil palm is usually cultivated. Productions and impacts on the environment of the two types of fields ? the ones on wet lands and those on normal upland areas ? were recorded, measured and compared. The study was conducted at two sites: the research station of La Me and Divo, the region of one of the Ivorian rural oil palm cultivation communities.

The following main results were obtained :

Oil palm fields in wet land areas yield better than those in upper areas in term of Fresh Fruts Bunchs (FFB); increases of more than 60 percent were observed at some sites.

Fields in wet land areas are as sustainable as those in upper areas for, they are not harmfull to the environment. All the farmers stated that planting oil palm in swampy wet land areas is easyer less labor and time consumming. No dammages on the soil was observed. In rural areas, growing palm oil on wet lands had a significant improving effects on livelywood of the the small stakeholders. More investments for equipments and housing were made by farmers that were exploiting the wet land areas than the others.

Keywords： *Wet land, oil palm, sustainable, natural ressources, Cote d'Ivoire.*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

An Innovative Eco-Garden System for Sustainable Food Crop Production for Resource-Poor Households in South Africa

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Food security, especially amongst the poor and vulnerable groups and communities is one of the key priorities of the South African government. As a way to capacitate households in these communities to produce quality nutritious food with low-external inputs, an eco-gardening system was developed using the principles of permaculture. This food garden system (PAT 2012/04201) is suitable for planting vegetables and fruit trees with a very innovative irrigation system. The vegetables together with fruit trees are planted in a plant capsule a round planting bed with a concrete kerbing and a 'water scorpion' which is the main source of water for the planting bed. A plastic pipe is inserted into the concrete when the kerbing is casted (3m for trees and fruit shrubs and 1,5m high for vegetables.) The erected plastic structure is used as basis for a shade cloth dresses to pull over, encapsulating the planting bed. Apart from its unparalleled eco farming qualities, the Eco Capsule Circle system allows for the planting of legume plants (like lucerne & clover) or tufted grass between the crop circles to allow for organic crop and poultry combo-farming. Such a project will include vegetables, fruit, free range chicken eggs and live chickens for the local market. Crops are grown for specific needs including subsistence, as a community outreach program, and as a highly profitable commercial enterprise.

The system uses mainly compost and manure, or a combination of the two, as the source of plant nutrients. The soil within the bed is mixed with the organic fertilizer (compost and manure) and covered with an organic mulch which provides ground cover. Plants in each circular bed are watered according to their water requirement through a 'water scorpion' that uses low pressure and saves up to 85 % water when combined with the effects of the shade cloth and mulch making the system ideal for dry areas with limited water resources. A diversity of crops are planted on one bed to enhance the nutritional mix and ensure a balanced diet for the household. The practice of crop rotation is recommended for the eco-gardening system. Indigenous fruit trees such as the Kei apple (Dovyalis Caffra) have been intoroduced into the cropping sequence to enhance the ecosystem through benefits of agro forestry and reduce carbon foot prints. In areas with high levels of solar and wind energy, a hybrid system of the two sources of energy is adopted as cost effective and environmental friendly technologies for pumping water from a borehole

The possibility of integrating a wormery for vermi-composting to the system is considered a solution for waste disposal in areas where large amounts of organic wastes are available for recycling. For most smallholder and informal settlements conditions in South Africa, a small wormery can contain over 30000 earthworms and produces 500-900 grams of vermin-humus per day. The liquid from the vermin-humus (compost tea) also makes an excellent fertilizer.

The social benefits of the system relate to its contribution to improvement in peoples livelihoods through creation of employment opportunities for producers and sellers of the products, income generation and increasing the household food and nutritional security.

The contribution of the eco-garden system to improvement in the livelihoods of the people has been achieved through its ability to reduce poverty, create employment and increase the food and nutritional security. The system can be used by any sector to engage in farming on very limited space throughout the year, thereby ensuring food and nutritional security of the households. It is also possible, under this system, to expand into commercial niche crops such as flowers, herbs, fruits and vegetables with export potential in many rural and urban conditions of not only, Southern Africa but sub-Saharan Africa at large. The production of organic foods has been vital to the system and this has contributed to its adoption by many communities and schools. Apart from its being used as an outdoor classroom for teachers, food gardens have helped to provide fresh food/snacks for learners at lunch time, and helped to encourage learners to respect the environment and provide them with farming and entrepreneurial skills.

Keywords：*Food and nutritional security; Soil water and nutrient management; Smallholder farmers; Flood irriga*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Using Conservation Agriculture to Intensify and Stabilize Agricultural Production in Southern Africa

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Soil erosion and degradation jeopardize food security in many sub-Saharan countries. Many common farming systems employ tillage methods that result in inordinate rates of sheet and gully erosion while achieving maize (Zea mays) yields of less than 1 Mg per hectare in many areas. Farmers often respond to these low yields by farming more land in an effort to achieve household food sufficiency and security. The objectives of this research were to use conservation agriculture to intensify production onto more manageable smaller plots of land of less than one hectare. Results of fertilizer N,P, and K research studies suggest that with adequate fertilizer (100-60-30 kg of N-P-K per hectare), plant population of 45,000 plants per ha, and early planting prior to late December can result in consistent yields in excess of 7 Mg per hectare over the four year study period. Cover crops that include oat (Avena sativa) and vetch (Vicia villosa) can reduce weed infestations by winter annuals by approximately 90 percent, further reduce soil erosion and have the potential to provide winter forage for livestock. Monitoring of C sequestration rates of these contrasting tillage systems is ongoing. This research suggests that conservation agriculture can sustainably intensify subsistence food production in this region and possibly mitigate global production of carbon dioxide, a significant greenhouse gas implicated in climate change.

Keywords：*Conservation Agriculture; Carbon Sequestration; Food Security; Subsistence Agriculture*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Sustainable and Efficient Land Management Practices in the Sahel

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To develop sustainable and efficient land management practices with reference to the reality on which sedentary pastoralists and crop farmers stand in the Sahel, West Africa, we have conducted a series of investigations and field experiments in Niger since 2004.

An investigation revealed livestock management practices based on the relationship between farmers and sedentary pastoralists to promote efficient use of livestock excreta through corralling in the Sahel region. Corralling, parking herds in harvested fields at night, by the sedentary pastoralists was carried out mainly in fields rented from farmers. Another type of corralling was performed on a contract basis in farmers' fields, on the condition that the farmers provide food for the pastoralists staying for corralling. About half of the sedentary pastoralists were not engaged in the practice of contract corralling or contracted livestock, suggesting the existence of a loose relationship between the farmers and sedentary pastoralists in terms of corralling and livestock grazing. In half of the households with contract corralling, the practice changed in two consecutive seasons. This implies that contract corralling is a flexible practice to compensate for the shortage of millet production and forage resources.

A 4-year field experiment on the effect of livestock excreta on millet production clearly showed that the effect was proportional to the amount of livestock excreta and the years after the application. Soil nitrogen loss during 4-year cultivation could be attributed to crop uptake and erosion by water and wind. Considering the actual amount of livestock excreta applied in the field and the residual effect on millet production clarified by the experiment, a few households of sedentary pastoralists had the potential to promote contract corralling for more efficient use of livestock excreta.

Thus, crop farmers with a few livestock should seek for another land management practice to improve crop production. To achieve this goal, we have developed "Fallow Band System" (FBS) (Ikazaki et al. 2011). This practice, considered as a shifting herbaceous windbreak, arranges 5-m-wide herbaceous fallow bands at a right angle to the erosive wind direction in a cultivated field during the rainy season. Crops are cultivated in the remainder of the field. Fallow bands are maintained during the subsequent dry season so that they will trap wind-blown soil materials and control wind erosion in the field. During the next rainy season, new fallow bands are established windward of the former fallow bands, where in turn crops are cultivated as well as in the cultivated bands. As reported elsewhere (Ikazaki et al. 2011), we could enhance crop production and control wind erosion. Nevertheless, we cannot deny the possibility of nutrient mining from the soil since no external input is taken. To improve this practice, we have conducted another field experiment to incorporate the means of external input into FBS. As external input, we considered application of NP fertilizer by micro-dosing and rock phosphate since they are expected to be applicable for resource-poor farmers and tried to extend by several aid agencies. We found that micro-dosing could enhance crop yield with FBS, although rock phosphate did not. Application of rock phosphate could increase available phosphorus in the soil, but since no nitrogen was applied, no yield increase was achieved. On the other hand, micro-dosing with FBS let aboveground biomass of the crop absorb more nitrogen than applied by micro-dosing. This "excessive" enhancement of nutrient uptake by micro-dosing could be explained by observation that stimulated root growth with micro-dosing could reach to soil available nitrogen farther from the plants than without micro-dosing. Thus, micro-dosing could improve nutrient efficiency when combined with FBS. However, considering that the farmers tend to remove not only grains but all the stalks as building materials or animal feeds, it should be noted that micro-dosing might accelerate nutrient mining under such tendency.

Keywords: *livestock, micro-dosing, nutrient budget, Sahel*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Short-Term Effects of Compost and N-Fertilizer Inputs on Maize Performance and Nutrient Uptake in Agroforestry Parklands of Burkina Faso, West Africa

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We investigated the effects of urea and compost on maize (Zea mays L.) yield and soil characteristics in Faidherbia albida and Vitellaria paradoxa agroforestry parklands at Dossi, Burkina Faso. The recovery of 15N-labelled ammonium sulphate was also investigated on parkland soils under greenhouse conditions. Urea and compost were applied separately underneath and outside the canopy of each tree species studied at the rate of 80 kg-N ha-1, or in combination each at the rate of 40 kg-N ha-1. The fertilized areas were compared with unfertilized control treatments. The field experiment was conducted in 2004, 2005 and 2006.

In both F. albida and V. paradoxa parklands, all the treatments resulted in higher maize yield than the control at the same canopy position. In the F. albida parkland, the urea treatment had the greatest effect on maize yield (2.2 times the control). In the V. paradoxa parkland, the combined compost and urea treatment produced the highest increase in yield (2.6 times the control) in the driest year. In the wettest year, the urea only treatment resulted in the highest maize yield (2.1 times the control).

Maize yield under the canopy of F. albida ranged between 1.0 and 2.3 times the yield recorded outside the canopy. In contrast, maize yield under the V. paradoxa canopy ranged between 0.6 and 0.8 times the yield outside the canopy. Yield under canopy was relatively better in dry year.

The total nutrient uptake was lower in the control treatments than in any of the treatment plots, and ranged from 31 to 131 kg ha-1 for N and from 6 to 26 kg ha-1 for P. In the greenhouse study, maize shoot biomass had similar pattern than from the field. Also, soil borne N dominated the N uptake by maize shoot biomass. Recovery of 15N-labelled ammonium sulphate (Ndff) was 12% and 17% with soil from the F. albida and V. paradoxa parkland respectively. The recovery of compost-N (Ndfc) was 13% and 11% with soil from the F. albida and V. paradoxa parkland respectively. Ndff and Ndfc were lower in the soil collected from under the F. albida canopy than outside the canopy, but were similar for the soil under and outside the canopy of V. paradoxa. Total N and total C were generally higher under both trees, compared with areas outside the canopy.

Although urea performed best, compost gave higher yield than the control. Our results indicate that combining compost and urea is an effective way of reducing the need to apply expensive fertilizer. Our results also suggest that the application of compost may alleviate problems of future climate forcing, since compost application was found to increase maize yield in dry years.

Keywords：*Canopy, Faidhebia albida, N recovery, Vitellaria pardoxa, yield, Zea mays*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

The Position of Acessibility to Fertilizer in Farming Activities in the Sub Saharan Africa Region: A Case Study of the Nigerian Rural Areas

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Since the 1940s when the use of fertilizers in farming activities was introduced by the colonial societies in Nigeria, many farmers adopted the use of fertilizers in their farming activities in order to boost their agricultural output and to maximize their profits. But however this was made possible by the fact that due to the abject poverty existing among many rural dwellers in this part of Africa manyof the farmers were able to sustain the use of this fertilizers in their farming activities because of the existence of subsidies provided by the governments since 1940s until the year 2006 when the subsidies were removed due to some World bank policies. Between the years 1940s to 2006 Farmers were buying these fertilizers at less than 60% of its original prices.

However since the year 2007 many farmers have return back to the use of the locally or traditionally known system of using the composed manures in place of fertilizers in their farming activities. As at the year 2011, 66 % of the Nigerian farmers are now using the composed manures instead of the fertilizers in their farming activities and the numbers keep growing.

Standing facts:

Many elderly members of the Nigerian societies are known to have been complaining that the use of fertilizers in our farmlands are the main causes of the emergence or coming of so many types of different diseases unknown to the societies prior to the 1940s before the application of these fertilizers started in our farmlands.

Although these claims have no any scientific prove, but it hasin it some elements of truth because of some recent discoveries linking elements found in some fertilizers and some diseases affecting the modern societies living in today's World.

Conclusion:

This paper cited on the applications of fertilizers and its negative related impacts and also explain the reason why the Nigerian farmers rushed for it and the reason why they are turning away from it now. It concluded on linking fertilizers on the springing up of some diseases.

Keywords：*fertilizers,farmers,africa,rural,Nigeria*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Sahel Development through Lands Capabilities Surviving in Harsh Conditions

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World awareness to save the Sahel is repeatedly registered in a periodic base that is more and more tight. Sahel decision makers often believe that the region did not have land capacity to respond to people food demands. This justify this work that has been motivated by the 2008 threefold crises (food, finance and economic). It complements some studies done by the author before 2008, always in the same objective, with the aim to propose an economical and social strategy for Sahel, oriented by a proper land knowledge.

Land evaluation done with new methodology demonstrates that land availability is not a constraint for Sahel to feed their population. Senegal is the chosen country case study as all land evaluation methods have been tried in its territory.

Keywords：*Key words: Land, evaluation, food , production , security*

P1-268

[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Indigenous African Soil Enrichment as Climate-Smart Sustainable Agriculture Alternative

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World agriculture must feed growing populations while shrinking its environmental footprints, and sustainable soil-management is critical for achieving this. Yet, in food-insecure regions such as Sub-Saharan Africa, economically and environmentally sustainable soil-management practices that replenish soil fertility and increase crop productivity, while enhancing long-term soil carbon storage remain elusive. Here we report on a hitherto entirely overlooked indigenous African soil-management system that produces enduringly fertile, carbon-rich black soils from original highly-weathered, nutrient- and carbon-poor tropical soils. These improved soils, here called “African dark earths, AfDE”, store 200-300% more organic carbon with 2-26 times more black carbon, which is highly resistant to decomposition and important for climate-change mitigation. Compared to the strongly acidic infertile original soils in which they developed, AfDE display a pH conducive for plant growth; a greater ability to attract, retain, and exchange plant nutrients and much larger concentrations of plant-available nutrients critical for crop production normally lacking in tropical agro-ecosystems. Despite their limited extent, AfDE make disproportionately high contributions to total household income of vast number of people in West Africa. 14C radiocarbon ages of AfDE indicate that these unique soils developed recently (115-692 years BP) through anthropogenic activities. These findings reveal an indigenous soil-management system that improves soil fertility and creates a long-term deep-soil carbon sink on otherwise infertile and carbon-poor agricultural soils in an ecologically- and socially-sustainable manner. This system therefore exemplifies an appropriate “climate-smart” agricultural alternative to conventional agriculture to tackle the “trilemma of soil degradation and food-security and climate-change challenges” in resource-poor, highly food-insecure regions of the world.

Keywords：*African Dark Earths, Climate Smart Agriculture, Food Security, Climate Change, Carbon Sequestration*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Relationships Between Soil Fetility Indicators and Toposequence: in the Soudano Sahelian Area : Case of the Watershed of Koutango in the Southern Peanut Basin of Senegal

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With the increasing use of watersheds in the semi-arid zones due to land degradation, pressure on land and cultivation on marginal lands, there is a need to better understand the role of watershed as a provider of nutrients for soil quality improvement and hence to ensure food security. In this study, we seek to highlight relationships that can exist between the soil and his environmental variables in the sudano sahelian watersheds. The zone of study is the watershed of Koutango located in the peanut Basin of Senegal. We consider that the general shape of the 173.3 km2 watershed has an impact on the variability of the soil physical and chemical properties. A method used to establish transects, enabled to collect 156 soil samples. In the sampling procedure, we have taken into account the gradient of the toposequence with upland, colluviums, terraces and lowlands as geomorphologic components. Principal Component Analysis (PCA) and the Chi-square test were statistical methods applied to the analytical data used for the validation of the research hypothesis. For all horizons (surface horizons, intermediate and deep horizons), PCA showed a significant correlation between soil properties such as organic matter, cation exchange capacity (CEC) and exchangeable bases, and no correlation between the soil texture components (sand, silt and clay contents). This result attested that the soil sampling protocol was conducted under optimal conditions. The chi-square test confirmed the influence of toposequence on almost all physical and chemical soil properties measured. An exception was noted however with phosphorus content in the surface horizons, then with phosphorus and silt in the intermediate horizons, and phosphorus and calcium in the deep horizons as well. The prospects of this study show the need to include other environmental variables of soil (vegetation, slope, moisture index) for a much finer characterization of variability factors of the physical and chemical properties of the soils for better cropping in the sudano-sahelian area.

Keywords：*indicators of fertility, soudano sahelian area, toposequence, watershed*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Effect of Application Method and Quality of Crop Residues on Soil Nitrogen Dynamics in Maize Croplands With Contrasting Soil Textures in Tanzania.

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Application of crop residues is one of the most important low cost strategies for improving crop productivity in Africa. Therefore it is necessary to evaluate the effect of crop residue management on soil nitrogen (N) dynamics. The application method of crop residues (i.e. incorporation or mulching) will change the water retention or permeability of the soil surface, and the contact area of the residue with soil, which results in different mineralization rates. The quality of the applied crop residues, which is represented by their C:N ratio, also regulates their decomposition rate and N release patterns. Thus, the application method and quality of crop residues will cause different water and N dynamics during the crop growing period. However, it has not been clearly evaluated how these factors affect soil N dynamics in surface soil under a tropical climate with a high decomposition rate. Therefore, the objective of this study was to evaluate the effect of application method and quality of crop residues on soil N dynamics in surface soil in a dry tropical cropland in Tanzania.

The field experiment was conducted from March to June (110 days) in 2012 and 2013 at two sites, one with sandy (3% clay) and one with clayey (28% clay) soil texture. Four treatments were established; maize residue (C:N=60) incorporation (M-In plot), maize residue mulching (M-On plot), cowpea residue (C:N=21) incorporation (P-In plot), and control (C plot). All crop residues were applied at the 40 kg N ha^{-1} equivalent before seeding, and triple super phosphate (20 kg P ha^{-1}) was used as basin fertilizer on all plots. During the experimental period, soil samples from 0–5, 5–15 and 15–30 cm depths were collected seven times and inorganic N (NO_3^--N and NH_4^+-N) was measured. Rainfall and soil moisture content at 5, 20 and 40 cm depths were also monitored in the In, On and C plots at intervals of 10 minutes.

The soil moisture contents at 5 cm in the M-In and M-On plots were clearly higher than the C plot in both soil types through the whole period. Soil moisture content at 5 cm in the M-In plot was not obviously different from the M-On plot in the sandy soil but was generally higher in the M-On plot than the M-In plot in the clayey soil. The inorganic N content in all layers was higher in the order of: M-On > M-In > C throughout the experimental period in sandy soil. In contrast, inorganic N content at 0–30 cm was higher in the M-In plot than the M-On plot throughout the period in clayey soil. These results indicate that incorporated maize increased the soil moisture content and their contact area with soil, and subsequently increased the inorganic N content in surface soil through their decomposition, while mulched maize residues increased and maintained a higher soil moisture content for a longer period compared with being incorporated, especially in clayey soil and therefore increased the inorganic N content. In the P-In plot, inorganic N was promptly released after application in both sites, and the highest inorganic N content at 0–30 cm was observed in the earlier crop growth stage (0–17 days after seeding), compared with M-In in both sites. Conversely, NO_3^--N content especially at 0–5 cm in the M-In plot decreased immediately after the application, and recovered 7–26 days after application. These results show that incorporated cowpea residues were immediately decomposed after application, because of their low C:N ratio, and released their N. Incorporated maize residues with a high C:N ratio, first assimilated soil inorganic N after application, and then released it gradually after seeding.

These results suggest that N dynamics in surface soil are varied by crop residue application management. The soil moisture content and physical contact area between crop residues and the soil change with application method, and the decomposition rate is regulated by their quality. Nitrogen leaching and crop uptake should also be taken into account when choosing the appropriate crop residue management technique.

Keywords：*Application of crop residues, Soil nitrogen dynamics, Soil texture, Sub-Saharan Africa*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Assessing the Long Term Sustainability of Fertilizer Micro-Dosing in the Sahel

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Crop production in the Sahel of SSA is mainly limited by drought and poor soil fertility. In both 2005 and 2010, drought-related crop failures were attributed to acute food shortages in Niger. However, innovative technologies such as fertilizer micro-dosing and rain water harvesting (RWH), which concurrently improve soil nutrients and moisture, can reduce famine by increasing crop yield. Micro-dosing involves addition of small doses of fertilizers to crops at sowing or shortly after seed germination and establishment. Although this approach has the potential to double crop yields, there are concerns on the long term sustainability of the technology. Indeed, it is not known whether substantial yield increase after micro-dose application may, in the long-term, deplete soil nutrients through crop harvest and removal of more nutrients from the field than are actually applied/returned.

Long term trials comparing different management regimes including micro-dosing have been established over the last 15 years to assess the evolution of crop yields, soil physical and chemical characteristics (soil organic matter, N, P, K, pH, CEC) over time. Synchrotron analysis of collected soil samples provides an accurate picture of soil clay decomposition under the different treatments The objectives of this paper are to assess the long term sustainability of the fertilizer micro-dosing and its contribution in reducing livelihoods vulnerability to climate variability and in promoting climate resilience. Micro-dosing combined with crop residues application and rain water harvesting appears to be the best option for sustaining crop productivity for the resource constrained farmer of the Sahel.

Keywords：*Micro-dosing, sustainability, synchrotron, climate variability, resilience*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Effect of Organic and Inorganic Fertilizers on Potassium Status, Uptake and Yield of Sweet Potato (ipomea Batatas (l) Lam) in an Ultisol in South Eastern Nigeria

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Field trials was conducted at the research farm of the National Root Crops Research Institute, Umudike, Abia State, Nigeria, to evaluate the effects of organic and inorganic manure amendments on the status of soil potassium (K), K uptake and yield of sweet potato under rain-fed agriculture in a tropical Utisol in South Eastern Nigeria. Field growth and yield responses of three sweet potato varieties (Ex-Igbariam, TIS 87/0087 and TIS 2532.OP.115) to organic manure from different sources (poultry manure, rice mill waste and cow dung manure) each applied at an agronomic rate calculated to supply an equivalent of 30 kg K/ha were assessed using a randomized complete block design with three treatment replications. Results showed that the poultry manure, rice mill waste and cow dung manure have varying capacities for improving the fertility, growth and yield of sweet potato on the highly weathered soil of South Eastern Nigeria. However, the growth and yield response of sweet potato was a combined function of sweet potato variety and organic manure source. TIS 87/0087 variety and poultry manure consistently gave higher responses in terms of vegetative ground coverage, dry matter accumulation, N, P, and K uptake, total root yield, saleable and un-saleable root numbers and number of leaves produced per plant than TS 2532.OP.113 and Ex-Igbariam varieties. TIS 87/0087 sweet potato variety grown on soil amended with combinations of four levels (0, 5, 10 and 15t/ha) of poultry manure and four levels (0, 45, 90 and 135 kg K2O/ha) of inorganic fertilizer K resulted in significant increases in vine length, dry matter yield, number of leaves per plant, saleable and un-saleable root numbers and total root yield relative to the control. Optimum field growth and yield performances were obtained using 10 t/ha poultry manure and 90 kg K2O /ha of inorganic K fertilizer. In addition, the various soil K (total K, exchangeable K, difficultly exchangeable K, researve K, 1 N HN03-K, and residual K) pools were significantly influenced by amendment with poultry manure and fertilizer K. Sweet potato root yield significantly and positively correlated with all the various soil K forms except the 1N HN033 K which though positive, but was insignificant. Residual nutrients after one cropping cycle from the application of the treatments produced lower root yield response but with significantly increased number of un-saleable roots relative to values obtained in the first round of cropping.

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Effects of Organic Manures and Urea on Soil Properties, Nutrient Uptake and Yield of Amaranthus Cruentus in a Rainforest Ultisol in Nigeria

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Field experiments were conducted in 2005 and 2006 cropping seasons to determine the effects of different organic manures and urea on soil properties, growth, yield and nutrient uptake of Amaranthus cruentus. The first and second experiments were laid out in split-plot arrangement in RCB design with three replicates, while the third experiment was laid out in RCB design with four replications. Results obtained showed that organic manures, irrespective of the source, significantly ($P < 0.05$) increased soil organic matter relative to urea treatment. On the average, pig manure increased the soil available P content while goat manure and urea treatments recorded low available P values. Pig manure at 90 kg N/ha produced the tallest plants (60.30cm) while urea source of N at 90 kg N/ha produced the highest number of leaves per plant (39.79) in both years. The highest yield was obtained at 90 kg N/ha rate of application which was equivalent to 3.14 tonnes/ha of the pig manure while that of urea was at 60 kg N/ha. Fresh yield was significantly ($P < 0.05$) increased by urea treatment with mean value 33.67 t/ha, while pig manure with mean value of 5.16 t/ha significantly ($P < 0.05$) increased dry matter yield relative to other nitrogen sources. Organic manure, particularly pig manure, significantly increased the uptake of nutrients more than urea. The crude protein content in Amaranthus was optimum at 4 WAP and decreased significantly from 15.09% to 11.43% as the time of harvest was prolonged. The combination of 30kg N/ha of urea and 45kg N/ha of pig manure gave significant ($P < 0.05$) increases in yield and nutrient uptake of Amaranthus than sole application of either urea or pig manure and was recommended as the best for maximum yield of Amaranthus.

Keywords：*Organic manure, Amaranthus, urea, Nutrient uptake, ultisol*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Soil: The Forgotten Resource of Africa. The Need For Policy Relevant Assessments of the State of Soil Across Africa.

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In most people's mind, soil does not rank highly in a list of the natural resources of Africa. However, healthy and fertile soils are the cornerstones of food security, key environmental services, social cohesion and the economies of most African countries. Unfortunately, soil tends only to reach public awareness when it fails – often with catastrophic consequences as seen by the famine episodes of the Sahel in the 1980s and more recently in Niger and the Horn of Africa. Regrettably, soil is taken for granted by most politicians and decision makers. In reality, Africa has some of the most fertile land on the planet but in general, the soils over a significant part of the continent are fragile, often lacking in essential nutrients and organic matter. With a population of over 1 billion people and growing, aridity and desertification affecting more than half of land surface, conflicting or competing demands on the use of the land (e.g. cash crops, biofuel, ecological reserves, carbon sequestration, mineral extraction, urban expansion), high levels of rural poverty and climate change, there are intense and increasing pressures on the remaining soils.

As identified by the first ever Soil Atlas of Africa, developed by the European Commission's Joint Research Centre, in collaboration with the UN FAO, the African Union and soil scientists from both Africa and Europe, there is a lack of current and policy relevant soil data for almost all of the African continent. The paper will outline specific challenges and a potential roadmap to define and implement a strategic pan-African approach to soil management and protection through an improved knowledge base. At the core should be scientifically sound and regular set of harmonised assessments of the state of soil resources throughout Africa that provide an inventory of current state, highlight key pressures that drive land and soil degradation, identify trends, the impact on soil functions and actual/potential policy responses. Such assessments could be developed under the FAO Global Soil Partnership Initiatives (Pillar 2) or other instruments of the Africa Union Commission.

Keywords：*Africa, soil policies, Global Soil Partnership, EU*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Long-Term Effects Prescribed Burning and Livestock Exclosure Management on Soil Carbon in Dry Savanna Ecosystems of Africa

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We investigated the effects of nineteen years (1992-2011) of exclosure and annual prescribed burning on soil organic carbon (SOC) in Sudanian savanna ecosystems of Burkina Faso and the effectiveness of long-term (14-36 years old) livestock exclosures in changing soil carbon in the semi-arid savanna of southern Ethiopia. Fire has been used as important management tool in African savanna and grassland systems for both livestock herders and wildlife managers who use it regularly to control bush encroachment and to remove dead and dying vegetation that has low forage quality and is unpalatable to animals. Although regular burning has been reported to have consistent long-term negative effect on SOC in grassland soils, we found no significant difference in SOC concentration between burned vs. unburned plots in two study sites in Burkina Faso. The result can be partly explained by the fact that the study area is dominated by perennial grass species (Andropogon gayanus and Dieteron amplectans) that fire burned the above ground biomass reducing the litter inputs into the soils while it encourages the turnover of root materials.

The objectives of the study in Ethiopia were to investigate the differences between exclosures vs. adjacent open-grazed rangelands and age of exclosures on soil carbon. We selected four replicates of three age categories of exclosures, i.e. < 20, 20-30 and >30 years old, each paired with adjacent open grazed lands as control in the study in Ethiopia. We found no significant ($P > 0.05$) differences between exclosures and open-grazed lands in all the three age categories. The age chronosequence further suggested no significant ($P > 0.05$) changes in soil carbon content with increasing duration of exclosures.

The result suggested that exclosure does not increase and on the other hand burning did not reduce the carbon sequestration potential in savanna ecosystems as expected. Projects targeting at mitigating climate change in dry savanna ecosystems should thus reconsider maintaining the traditionally used prescribed fire as a management tool. Therefore, projects targeting at mitigating climate change by sequestering more carbon in the soils though livestock exclosure management and in dry savanna ecosystems should be carefully designed and reconsider maintaining the traditionally used prescribed fire as a management tool in dry Savanna ecosystems of Africa.

Keywords：*Soil carbon, grazing management, restoration, ecosystem services, carbon sequestration*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Crusting and Mode of Seedling Emergence as Affected By Rainfall Intensity in Some Quartz Dominated South African Soils

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Changes in climate are projected to cause variations in rainfall characteristics which are likely to influence key soil health parameters especially the structural attributes and crop growth. Global climate models have shown that global warming will increase the intensity of precipitation in most places. In South Africa, work simulating effects of climate change on soil structural attributes such as crust formation is scant. The effects of rainfall intensity on soil crust formation and mode of seedling emergence in soils dominated by primary minerals were studied. Three maize seeds of equal size were planted in plastic pots, pre-wetted by capillary action and then subjected to simulated rainfall at three intensities 30, 45 and 60 mm h-1 for 5 min. Rainfall intensity significantly ($P < 0.05$) affected crust strength and mean emergence day (MED) but not emergence percentage (EMP) and shoot length ($P > 0.05$). The 60 mm h-1 rainfall intensity resulted in the highest crust strength and MED. The strength of crust for all three rainfall intensities was influenced by quartz content, soil organic matter, clay and hematite. Most seedlings emerged through cracks, which resulted in rainfall intensity having no significant effects on seedling EMP and shoot length. It was concluded that soils with extensive cracking are likely to have higher EMP and lower MED and more vigorous seedlings despite the strength of the crust.

Keywords：*climate change, mineralogy, penetration resistance, soil organic matter*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Crust Formation, Infiltration and Erosion in Some South African Soils

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Crust formation, infiltration rate and erosion depending on intrinsic soil properties such as texture and mineralogy. This study investigated crust strength, steady state infiltration (SSIR) and erosion in soils with various texture and minerals. Soil samples from the top 0.2 m layer were exposed to 60 mm h^{-1} simulated rainfall. The rainfall was applied either as an eight minute single rainstorm (SR) or four-two minute intermittent rainstorms (IR) separated by a 48 h drying period. Rainfall pattern significantly ($p < 0.05$) affected crust strength, SSIR and erosion. The IR resulted in higher crust strength and SSIR than SR. The effect of rainfall pattern on SSIR was mostly influenced by the primary minerals namely, quartz. Therefore, the predicted shift from long duration to short duration rainstorms due to climate change is likely to enhance crust formation and soil loss in semi-arid areas such as Eastern Cape Province in South Africa.

Keywords：*Rainfall partern, Penetration resistance, Quartz, Soil organic matter*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Use of Farmer Indigenous Knowledge to Strengthen Soil and Water Management Skills by Farmers in an Irrigation Scheme in Nigeria

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Research aimed at improving farmer capacity to sustainably manage soil as a resource need to pay particular attention to farmer indigenous knowledge. A project was undertaken by the National Agricultural Extension and Research Liaison Services, Ahmadu Bello University to document farmer indigenous knowledge in an irrigation scheme and use this as a baseline to design interventions aimed at strengthening farmer soil and water management skills. One hundred and sixty five farmers were interviewed and their knowledge of soil and water management recorded. The result of the study was used as a baseline to design a participatory dual method plan of scientific and indigenous methodologies with the farmers over a two year period on soil and water management in the irrigation scheme. The result of the intervention revealed more willingness by the farmers to adopt some recommended practices that tallied with their indigenous knowledge, and which were cost effective and sustainable: Signs of planting time, amount of water to apply and mulching. Scientific recommendations on these aspects tallied with the farmer's knowledge and were wholly adopted. Alternate furrow irrigation was not adopted by the farmers as a water conservation technique. The intervention succeeded in strengthening the farmer's skill to sustainably manage the soil without much additional costs.

Keywords：*Farmer indigenous knowledge, soil and water management, irrigation, strengthening skill*

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[DS7] African Eco-efficient Solutions to Food Insecurity and Climate Change

Sustainability of Crop Residue Allocation Options in Smallholder Cereal-Legume-Livestock Farms in the Dry Savannas of West Africa

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Crop residues are vital resources for improving the productivities of cereal-legume-livestock systems in savannahs of West Africa. The competing demands for their uses as fodder or soil amendments present a tradeoff between increasing crop yields and sustaining livestock productivity. An agricultural sustainability framework was used to evaluate the ecological benignity, economic viability, social acceptability and sustainability of five crop residue allocation options at Cheyohi (Ghana), Sarauniya (Nigeria) and Garin Labo (Niger). The crop residue allocation options were: 0, 25, 50, 75 and 100% of haulm with 0, 75, 50, 25 and 100% of stover, respectively, as soil amendment or fodder. The ecological benignity was assessed on the basis of the impact of the allocation option on soil quality, performance of crops and livestock. Indicators such as net benefit from crop or livestock units of the farm and the value cost ratio for the allocation option were used to estimate the economic viability. The indicators used to appraise the social acceptability were the indigenous knowledge of farmers on the alternative uses of crop residues, the perceived constraints and physical stress associated with the allocation option. The most environmentally friendly options were the allocation of 75% haulm and 25% stover as soil amendment at Cheyohi (ecological benignity index = 6.2) and Garin Labo, (ecological benignity index = 6.8) and the total retention of crop residues (100% haulm and stover as soil amendment) at Sarauniya. The allocation of 25% haulm and 75% stover as soil amendement was the most economically viable option at Cheyohi and Sarauniya (economic viability index = 7.0). At Garin Labo however, the removal of all crop residues for use as fodder was the most economically viable option (economic viability index = 9.9). The total retention of crop residues on field while being the most acceptable option to farmers at Cheyohi (social acceptability option = 6.8) was the least acceptable option to farmers at Sauraniya (social acceptability option = 4.9) and Garin Labo (social acceptability option = 4.5).

The most sustainable crop residue allocation options were the use of 75 % of haulm and 25 % of stover as soil amendment Cheyohi and total removal of crop residues for use as fodder at Sarauniya and Garin Labo.

Keywords：*agricultural sustainability ecological benignity, economic viability, social acceptability, soil qua*

P1-280

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Interactions of Soil Structure and Soil Organic Matter in Paddy Soil and Upland Soil under Long-Term Fertilization

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Long-term fertilization practices generally improve soil aggregation through associated increases in organic matter over time. In this paper, we investigated the C input, SOC stabilization, and aggregate micro-structure in paddy soil and upland soil under different long-term fertilization practices. Our objectives were to determine i) the response of SOC stock to C input under different fertilization practices, ii) C sequestration efficiency in the two contrasting agroecosystems, iii) interaction between soil structure and SOM. The long-term fertilization experiment with paddy soil started in 1981, while the adjacent upland soil experiment commenced in 1986. Each experiment consists of 9 treatments: CK (no fertilization), N, P, K, NP, NK, NPK, 2NPK (double dose), and NPKOM (NPK plus organic manure). Physical SOC fractions (cPOM, silt+clay_f, fPOM, iPOM_m, silt+clay_m) were isolated by density flotation, dispersion, and sieving. Aggregate structure was determined by with synchrotron based X-ray micro-computed tomography (SR-μCT) and digital image analysis techniques. Fertilization increased crop yield and C input, but it did not change the quality of SOC as revealed by CPMAS-13C-NMR spectra. During the period of the experiment, SOC stock was improved by 6.7 15.3 Mg ha-1 in paddy soil for all fertilization practices, while in upland soil the CK, N, P, K, and NP fertilizations reduced SOC by 1.2 3.8 Mg C ha-1 and the other four fertilizations increased it by 0.5 7.4 Mg C ha-1. The change in SOC was mainly ascribed to the POM fraction, whereas the two silt + clay sized fractions were independent of fertilization practice except the NPKOM treatment. At a given C input, the C sequestration efficiency was greater in paddy soil than in upland soil, which may be attributed to lower microbial activity but greater chemical (i.e., oxalate-soluble Fe) and physical stabilization (i.e., soil structure) in paddy soil. Aggregate stability was highest in NPK+OM, and lowest in NPK. The number of pores, number of pore throats, and number of paths between adjacent nodal pores were all significantly decreased by the NPK+OM treatment relative to the NPK and CK treatments. However, microstructural pore properties were mostly not different between NPK and CK treatments. Our results indicate that paddy soil may sequester more SOC, with higher efficiency, than upland soil does, while organic fertilization can improve soil aggregation, while inorganic fertilization is ineffective.

Keywords：*Soil Structure, Soil Organic Matter, synchrotron based CT, Fertilization*

P1-281

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Effect of the Fresh Waste Mushroom Beds of *pleurotus Ostreatus* on the Microstructure and the Physico-Chemical Properties of Soil in Brazil

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Introduction

Disposal of waste mushroom beds (WMB) that are co-products in the making of mushrooms is a problem. WMB can be good materials to develop soil aggregates because fresh WMB are composed mainly of sawdust and contain fungus. The addition of fresh organic materials to soil promotes aggregate formation, for which fungal hyphae are also necessary. Soil structure and aggregate stability have an effect on the water-holding capacity and permeability of soils. It has been reported that soil erosion is reduced by aggregate formation. However, little is known about the impact of fresh WMB on soil properties, especially soil microstructure, in the short term. In this study, we investigated the short-term effect of the application of fresh WMB of *Pleurotus ostreatus* on the microstructure and physico-chemical properties of soil in Brazil.

Materials and methods

This study was carried out in a cabbage field in the city of Suzano, Sao Paulo. Fresh WMB (total carbon, 6.64–8.86 t ha^{-1} $crop^{-1}$; total nitrogen, 0.22–0.29 t ha^{-1} $crop^{-1}$) was added to 10 cm of surface soil using a rotary tiller. No other fertilizer was used. This field was managed under this agricultural method for four years. We selected a neighboring farmer's field as a control field. No materials including WMB and fertilizer were added to this control field. We collected horizontal and undisturbed soil samples, and measured soil total C, total N, bulk density and saturated hydraulic conductivity (SHC). Glass slides of thin soil sections were made from soil core samples at depths of 10–15 cm and 45–50 cm in accordance with Nagatsuka and Tamura (1986), and findings were recorded in accordance with Bullock et al. (1985). The applied threshold between coarse and fine particles was 10 ㎛.

Results and discussion

The soil colors of A horizon in the WMB field (7.5YR4/4 and 3/4) were darker than that in the control field (5YR4/4). At A horizon in the WMB field, the concentrations of total C (48.22–67.95 g kg^{-1}) and total N (3.43–4.68 g kg^{-1}) as well as SHC (> 10^{-1} cm s^{-1}) were higher, and the bulk density was lower than those in the control field. These results showed that the input of WMB into soils decreased bulk density and increased the permeability of surface soil.

The soil microstructure of Ap2 (10–15 cm) in the WMB field was dominated by a strongly developed granular structure with a large amount of void space (total 50%; compound packing voids), whereas that of Ap2 in the control field was dominated by a weakly developed subangular blocky structure with a small amount of void space (total 10%; planar voids). Granules contained

some organic fine materials such as WMB and roots, and some excrement was observed in organic materials in Ap2 of the WMB field. This result showed that the formation of a strongly developed granular structure in the surface horizon was associated with WMB, and that the formation of this structure was affected not only by soil humus that developed due to the decay of WMB, but also by the fine materials of WMB directly.

The soil microstructure of Bw1 (45–50 cm) in the WMB field was dominated by a spongy structure mainly consisting of crumbs, whereas that of Bw1 in the control field was a subangular blocky structure with crumbs. The total void space in the WMB field (45%; packing voids, vughs and channels) was greater than that of the control field (10%; vughs and channels). Transparent fungal filaments (10 ㎛ in diameter) numbered 72/25 cm^2 on glass slides of thin soil sections in the WMB field, whereas the number was 6/25 cm^2 in the control field. This result showed that more fungal filaments were found in the Bw1 horizon dominated by sponge structures, indicating that the formation of these structures was related to the fungi.

This study showed that the addition of fresh WMB promoted the formation of both A and B horizons, indicating that short-term soil formation was related to WMB and soil fauna in the A horizon, and to fungi in the B horizon.

Keywords：*Soil microstructure, Fresh waste mushroom beds, Fungal filament, Physico-chemical properties of soil, Brazil*

P1-282

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

How Soil and Sediment Features affect the Growing and Vitality Conditions of Populus Euphratica?

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Problem situation:

Overdimensioned withdrawal of water for farmland irrigation, as well as water losses from water reservoirs and channels have caused water deficit problems along the Tarim River (Northwest China). Especially the lower reaches of the Tarim River are severely threatened since the 1950s and experience a drastic increase in the mineralization of the river water. Additionally, large scale deposition of aeolian sand and dust is another threatening consequence for the Tarim Riparian Ecosystem. This development reached its “climax” with the desiccation of the Taitema Lake in 1972 and severe degradation of Populus euphratica stands along the rivers floodplain. These developments led to the initiation of the “Ecological Water Diversion Project” (EWDP). The main objective of this project was an additionally water supply to the lower reaches of the Tarim River via the water transfer both from the Bosten Lake catchment and the Tarim’s upper and middle reaches. The processes and trends of the vegetation change during the period of intermittent water transfer have been ruled out on the basis of remote sensing data. The results show that in consequence of the water transfer some of the Populus euphratica trees reached a more vital status, some didn’t. Common hypotheses about factors influencing the tree vitality under stress conditions deal with the water level in the river, the groundwater level and the distance of the trees from the river. Soil and sediment factors influencing Populus euphratica growing and re-vitalzation conditions have not been taken in consideration until now.

Objective:

The main objective of the recent study was to analyze the function of soil and sediment features for water passage and water storage processes in near surface and subsurface sediment and soil layers of the lower Tarim Riparian Ecosystem. For that purpose field and laboratory analyses of soil and sediment profiles were realized in dependence of a site (micro-relief and tree vitality) monitoring.

Methods:

Tree hight, DBH, crown and leave features of the trees were surveyed and classified to determine growing and vitality status of the studied trees. Micro-relief, sediment layers and soil horizons were identified by field survey. Laboratory results comprise grain size measurements, pore size distribution, total organic content (TOC) and data from XRD-measurements on the soil’s mineral composition for 34 studied sites within the lower Tarim study area and for selected ecosystem types. These parameters allow

conclusions about water storage and water passage features, which play a key role for water availability and water supply of Populus euphratica trees.

Results:

Besides single soil and sediment parameters, for instance, such as salt content and mineral composition, layer types (vertical sequence of soil horizons and sediment layers), its genesis, thickness, grain sizes and porosity have been identified as leading factors determining near surface and subsurface water passage and water storage features, and in consequence of that the growing and vitality conditions of Populus euphratica within the Tarim Riparian Ecosystem. It depends on the layer type, weather Populus euphratica stands are able for revitalization and surviving after artificial water transfer or not. Arenosol over Fluvisol profiles with sediment layers and fossile humus horizons deeper as two meters and reach in fine silt and clay increase water storage and water transfer ability of the Populus euphratica sites. The corresponding features in near surface positions function as a barrier and let to higher water losses by evaporation and reduced water transfer from the ground water.

Keywords：*sediment and soil layer types, water storage, water transfer, Populus euphratica, Lower Tarim (Northwest China)*

P1-283

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Microscopic Genesis Diagnosis of the Desert Varnish and Biogenic Crusts in Arid Soils of Central Asia

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A relatively thick “desert pavement” is a specific genetic horizon of many desert soils in the world. In arid regions the endolithic organisms (photobiontic components of lichens, cianobacteria, etc.) described as biogenic crusts are widely distributed as confined to hard rock outcrops. The analysis of macrofabric of desert varnish on pebble surfaces of varying mineralogical composition in Yermic Regosol, and Yermic-Gypsic Regosols of Mongolia and Kazakhstan has shown the presence of black glossy coatings. In Uzbekistan the endolithic organisms at the surface of gypsiferous-carbonate crusts being strongly coherent with the rock are very diverse in color (bluish, yellowish-brown and black). This study was conducted using microscopes Olympus and SEM JSM-6610LV combined with a system of X-ray microanalysis INCAx-act. Micromorphological and mineralogical investigations of pebble samples with desert varnish allowed distinguishing three different types of biomineral coatings.

(1) One-layered biomineral coatings consisting of a thin layer enriched in Fe and Mg and containing cells of iron bacteria between grains of polymictic sandstone. Such coatings were described for sandstone debris in Kazakhstan. The bio-mechanical disintegration of rock fragments was identified for them.

(2) Two-layered biomineral coatings with the upper layer consisting of fine silica grains, and the lower layer enriched in Fe and Mn oxides. The latter is characterized by heterogeneous distribution of oxides being enriched in Mn to a lesser extent as compared to the upper layer. The detailed study of these layers permitted to diagnoze biomorphes. Peculiar microfabric of such layers cannot have a single meaning about their genesis (accretionary or weathering in situ) but serves as evidence of microorganism participation in their formation. Such biomineral coatings were described in soil samples taken in Mongolia.

(3) Thick multi-layered coatings in fragments of biogenic micritic carbonates with microfauna consisting of alternating biomineral layers of varying thickness and enriched in silica, Fe and Mn oxides. The presence of the same paleomicrofauna within all the layers enriched only in Fe and Mn oxides or Si permits to suppose that the desert varnish can be formed due to weathering in situ and eluvial-illuvial redistribution of oxides. It is probable that multi-layered endolithic biomineral coatings are relict formations inherited from pluvial periods of the soil development. For sandstones with poikilitic gypsiferous cement the microfeatures of its biological destruction were identified: the soil microbiota tends to use hygroscopic minerals (gypsum and bassanite) for its activity. These coatings were also found in soil samples from Mongolia. Microscopic investigations of microorganisms on gypsiferous-carbonate rock outcrops allowed diagnozing different stages of mineral substrate weathering resulted in the formation of microhorizons in nanosoils.

The SEM analysis of all biomineral coatings has shown the presence of diverse microbial cells. In the cavities on pebble surface the amorphous coatings have clear microlayers cemented by filamentous bacteria. On the surface of desert varnish there are abundant and diverse bioliths originated from fungal mycelium, bacteria, actinomycetes, and diatomic algae. They are found in close contact with rock minerals and penetrate into fissures. The obtained results allow us to consider such formations as biomineral coatings created by the transport of amorphous substances and growth of microorganisms. These coatings are formed rather quickly in short periods of rains, when the desert pavement is covered with water. After drying, they become very hard owing to presence of amorphous silica as cement. The ecological microniches under the biomineral coatings are filled with microbial communities rather than separate microorganisms. Biomineral coatings on pebble surfaces are enriched in iron (1.7%) and manganese (to 4%) oxides in comparison with the inner material of pebbles. We suppose that the black color of biomineral coatings is related to the increased content of pyrolusite (MnO2) and the presence of pigment of soil algae. The features of silicification of bioliths have been described. Thus, the relative accumulation of iron and manganese in desert varnish is related to the microbiological activity rather than to mineralogical composition of the substrate. Microscopic investigations permit to diagnoze the polygenetic pattern of desert varnish and the possible development of endolithic microsoils on gypsiferous-carbonate crusts in arid regions of Central Asia. This study was supported by Russian Foundation for Basic Research, project 12-04-0990.

Keywords：*Arid soil, micromorphology, pedogenetic processes*

P1-284

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Does Rhizosphere and Litter Diversity Mediate the Biogeochemistry of Restoration Soils?

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This research focuses on the effects of plant diversity on soil biogeochemistry, rather than the more commonly explored and opposite effects of soil biogeochemistry on plant diversity. Biological modification and mediation of the soil environment is well known; plant detritus and organic exudates from litter inputs and rhizosphere processes affect the chemical, physical and biological properties of soil. Plant foliage, litter and rhizospheres are highly variable between species, in terms of spatial structure, chemical contents, microbial and faunal associations, but there is little knowledge of how native New Zealand plants may modify soil physico-chemistry. Potentially, this variability has significant implications for a wide range of soil properties and topical environmental issues. In particular, we seek to understand the biogeochemistry of marginal agricultural and restoration soils.

We investigated the variability of leaf litter, litter decomposition and rhizospheres between 10 plant species, through laboratory and glasshouse experiments. We selected eight endemic species, commonly used for riparian zone and marginal land planting (Kunzea ericoides, Olearia paniculata, Carex secta, Cortaderia richardii, Dodonaea viscosa, Phormium tenax, Sophora microphylla and Coprosma robusta) and 2 exotics (Pinus radiata and Lolium perenne). Soil-litter incubation experiments using 0.5, 1, and 1.5 g litter mixed with 100 g nutrient-poor sandy loam Templeton soil were incubated at 16 ^{o}C at 60 % of maximum water holding capacity for 30 days. Rhizospheres were studied using pot trials. Plant and litter analyses included fibre, trace elements, pH, NH_4-N, NO_3-N and Olsen P. Greenhouse gas (N_2O & CO_2) emissions were measured in both types of experiments, and analysed using GC.

Generally, leaf litter nutrient concentrations were lower in monocotyledonous plants than in dicotyledonous plants. Herbaceous plants had acid detergent higher fibre contents. High variability existed between species in foliar chemistry, including N, P, K, Mg, Ca, Sr, Fe, B, Cu, Zn, Mn, Ni, and Cd. For example, Coprosma robusta had 10-fold more B and Ca than Cortaderia richardii whilst, vice versa, C. richardii had around 10-fold more Ni than C. robusta. After 30 days of soil-litter incubation, soil pH changed significantly. In general, soil pH and nutrient status increased with increasing litter additions. Leaf Ca content was positively correlated with soil pH in some species. Mineral nitrogen concentrations were strongly influenced by the additions of leaf litter from 8 plant species. In general, the more litter we added the lesser was the amount of mobile NO_3-N and Olsen P; across all treatments, soil concentrations were lower than the control. Different species and additions of litter increased soil cation exchange capacity. Litter additions also had a profound effect on emissions of N_2O from soil.

We interpret these findings in the context of the opportunities to use selective planting of native species as a component of soil management in agricultural and restoration landscapes.

Keywords: *leaf litter, decomposition, rhizosphere, restoration, soil*

P1-285

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Biogeochemical Role of Native and Exotic Earthworms in New Zealand Soil

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Earthworms play an essential role in improvement and maintenance of soil quality and support of plant growth. In New Zealand, more than 187 species of endemic earthworms in the family Megascolecidae dominate the soil fauna in native forests and tussock grasslands, but have largely been replaced by a small number of European Lumbricid species following conversion to agriculture and intensification of land use. Despite the known lack of resilience of native species to soil disturbance, little is known of their role in New Zealand soils; there is no evidence that exotics are more beneficial than endemics. Besides an obvious interest in the conservation of native species, all of which are endemic and found nowhere else, it is possible that native species of earthworms could have presently unknown benefits in low-tillage agricultural soils. We investigated the difference between endemic and exotic earthworms in the context of their influence on the physico-chemical properties of soils.

We focussed on three endemic (Octochaetus multiporus, Dendrodrilus sp., and Maoridrilus transalpinus) and two introduced species of earthworms (Octolasion cyaneum and Aporrectodea caliginosa), collected from natural and agricultural regions. Following hand-sorting, the earthworms were maintained in field-collected soils with added sawdust as a food sources (0.8% by weight) in plastic containers at 15 ℃. Species were identified through DNA barcoding. Experimental work was conducted following an acclimatisation period that provided us with confidence of survivorship and assurance that weight gain was being maintained. A series of laboratory and glasshouse experiments were conducted to compare native and endemic species by investigating their preferences for different soils and conditions, interactions with native plant rhizospheres and modification of soil physic-chemical properties following inoculation of a range of field-collected soils. We were also interested to explore field situations where both native and exotic species co-existed. The significance of size differences and ecological grouping (epigeic, endogeic, and anecic burrowing and feeding behaviours) between different earthworm species were critical.

In choice chambers, both native and exotic species had a clear preference for fertile agricultural soils. Soil moisture and pH were the most critical determinants of survivorship. In pot experiments, there were notable differences between species on their influence on the morphology and spatial occupancy of plant root systems. All earthworms substantially modified soil properties during these experiments and the amounts of organic matter consumed differed; native species consumed the largest (M. transalpinus) and smallest amounts (O. multiporus). Soil pH tended to decline following earthworm occupancy. Available nitrogen (NH_4^+ and NO_3^-) largely increased in the presence of earthworms; O. multiporus enhanced NH_4^+ by 25 mg kg^{-1}, with concentrations was 12 times higher than in bulk soil (2.2 mg kg^{-1}). Soil NO_3^- content following earthworm occupancy was up to 90 mg kg^{-1} (O. multiporus) compared to 69 mg kg^{-1} in bulk soil. Indigenous species, especially O. multiporus and M. transalpinus, were distinctly more beneficial than introduced species (e.g. O. cyaneum) in terms of increasing available N in the soils. Olsen P also substantially increased, up to the 36 mg kg^{-1} (M. transalpinus) compared to 34 mg kg^{-1} in bulk soil. Different species significantly enhanced other soil properties including CEC (Deinodrilus sp., A. caliginosa), exchangeable-Ca (M. transalpinus, A. caliginosa), and exchangeable-S (O. multiporus, M. transalpinus, A. caliginosa) compared to bulk soil. Exchangeable fractions of some other elements such as Cu and Ni (A. caliginosa) were significantly reduced by earthworm activity. Earthworms significantly altered emissions of N_2O from soil, the native species (O. multiporus, Dendrodrilus sp., and M. transalpinus) released less N_2O per unit biomass than exotic species (O. cyaneum).

We interpret the findings of this study in the context of potential benefits of incorporating native earthworm communities into agricultural landscapes and other human-modified soils. The likely probability and consequences of native and exotic species coexisting in New Zealand soils is discussed.

Keywords : New Zealand earthworms, soil quality, soil properties, available N, N_2O

P1-286

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Soil Macroaggregate Self-Assemble as a Feedback to Process "Macroaggregates Breakdown by Tillage"

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Soil macroaggregate play a major role in carbon sequestration. Generally macroaggregate physically protect soil organic matter (SOM) from decomposition. In this connection in case of involvement in to agricultural process formerly no-tillage soils part their aggregates destroy because of tillage. As a consequence, intra-aggregate SOM turn out without protection and decompose. As a result the soil loses carbon. The feedback for this process could be self-assemble of particles having an origin from destroyed owing to tillage aggregates.

Work was carried out on tillage and no-tillage (forest more than 80 years) Sod-podzol soils. Distance between sampling place was about 100 m. In model experiments there was demonstrated possibility particles of macroaggregates after mechanical breakdown to size <0.25 mm to form aggregates > 0.25 mm after wet-dry cycle.

The particles from soil macroaggregates (3?1 mm) (initially aggregated particles, APs) and initially free particles (FPs) of <0.25 mm in size were isolated. The aggregates of 3?1 mm were ground and passed through a 0.25 mm sieve. Then, the aggregates and free particles were poured with water and dried, and the content of the formed aggregates and their water stability were determined.

FPs from the untilled forest soil are not formed macroaggregates. At the same time, the APs from these soils manifested the ability for the spontaneous formation of macroaggregates, including water stable aggregates. In the arable soil, on the contrary, both FPs and APs demonstrated the capacity for spontaneous self-assemble into macroaggregates. The water stability of the self-assembled aggregates from the arable soil was similar regardless of their source (APs or FPs). It was supposed that the ability of the FPs from the arable soil to form macroaggregates reflects the mechanical degradation of the aggregates in the soil: tillage results in the degradation of the sizes of aggregates, and the particles capable of spontaneously aggregation temporarily fall in the fraction of <0.25 mm.

Thus particles of mechanical breakdown macroaggregates can self-assemble in new water proof aggregates. This fact demonstrated presence in soils feedback for process "macroaggregates breakdown - carbon emission".

Acknowledgment: this work has been supported by The Russian Fund of Basic Research, grant RFBR # 13-04-01753 a.

Keywords：*macroaggregates self-assemble, soil structure, restoration of soil structure*

P1-287

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Functional Groups of Organic Matter in Soils Podzolization - Upper Negro River Basin- Amazon

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The soils of upper Negro River are gradually undergoing processes of impoverishment, turning Oxisols into Podzols (Lucas et al., 1987; Dubroeucq and Volkoff 1988; Righi and Bravard, 1990). During the podzolization process occurs the dissolution, transport and precipitation of the organic matter. Due to the high porosity of Podzols, the extremely low pH and high humidity in the Amazon region, the organic matter in the form of organometallic complexes may or may not be easily transferred from the soil to the drain networks (Bardy et al., 2008; Nascimento et al., 2008), contributing to the existence of the black waters of the Rio Negro Basin. Studies of organic matter by infrared spectroscopy has been shown effective in determine the functional groups (Stevenson, 1994; Bardy et al., 2008). The knowledge about the organic matter dynamics contributes to understand the mechanisms of Podzolization in tropical and the dispersion of metal complexes in aquatic environments. This study aims to investigate the distribution and transformation of the functional groups of soil's organic matter in Well Drained Podzol and Hydromorphic Podzol in the upper Negro River Basin. The study site is located in São Gabriel da Cachoeira, municipality of Amazonas state, Brazil. We described and sampled two kinds of a podzol: well drained located at the top of a hill and poorly drained located in a slightly concave slope of the hill. Four samples were analyzed in the first profile and five in the second one. Samples were separated in two aliquot of earth air-dried ground with a 150 mesh. The ground aliquot was divided into two parts. One part was submitted into a Citrate-Bicarbonate-Dithionite (CBD) treatment (Mehra and Jackson, 1960) to remove iron and organometallic complexes. The other part was not pretreated. Both the aliquot were analyzed in Fourier Transform Infrared (FTIR) - "Varian -IR 640 FT-IR Spectrometer". The spectrum obtained for the aliquot pretreated with CBD was subtracted from the spectra of the non-pretreated aliquot. The procedure was performed following Bardy et al. (2008). In well drained Podzol, we observed aromatic C-H functional groups (780 cm^{-1}), C-O stretching (1080-1180 cm^{-1}) and alcohols, in all horizons. The A and Bh horizons showed functional groups in 1625 cm^{-1} (C = C) and 1715 cm^{-1} (C = O). The A-horizon is the unique where the aliphatic groups (CH) (2850 and 2920 cm^{-1}) and carboxylate (COO -) (1425 cm^{-1}) occur. The horizons AE, E1 and E2 do not exhibit the carboxylic functional groups (C = O and C = C), carboxylate (COO-) and aliphatic CH. The Podzol Hydromorphic presented aromatic functional group (CH) 600-780 cm^{-1} and alcohols (CH) 1080 and 1175 cm^{-1} in all the horizons. Only the horizons A, AE and Bh showed the carboxylic 1640 cm^{-1} (C = O). The stretch in -OH (3450 cm^{-1}) is clearly the surface horizons A and AE. Comparing the spectra of the profiles represent: The Well Drained Podzol showed the aliphatic functional group only on the soil surface horizon while this functional group was not present in Hydromorphic Podzol ; Podzol Hydromorphic also present carboxylate group COO^- a (1425 cm^{-1}) and benzene ring C = C (1625 cm^{-1}). The same happens in other horizons of well drained Podzol. The aliphatic groups represent fresh and mobile organic material (Bardy et al., 2008) which may reflect on the distribution of this group in well drained Podzol and it's absence on the Hydromorphic Podzol. The high porosity of the horizons AE, E1 and E2 suggests migration in well drained podzol through porosity, while the fluctuation in the Hydromorphic Podzol water may contribute for the migration on the horizon E. In both profiles occurs detention of Al complex in Bh horizon. The carboxylate group only appears on the top of the Well Drained Podzol profile and may reflect the ionization of carboxylic groups only on the surface of this soil, followed by immobilization of the grouping COO^- metal complex as aluminum or iron.

Acknowledgements: FAPESP (2010/03401-8 and 2012/07600-0 process) and CNPQ for the financial support

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Keywords : Amazon basin, podzolization, soil organic matter

P1-288

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Forest Humus Forms, Carbon and Nitrogen Stocks in Boreo-Nemoral Ecotone

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Over the last several years, due to global climate change, increasing attention has been paid to the carbon and nitrogen content in different environments, including forest soil. However, large spatial variability of soil organic matter content and properties complicates calculations of soil carbon and nitrogen content.

In Latvia, in boreo-nemoral ecotone, differentiation of organic matter content in soil is driven by various factors: soil diversity, hydrological conditions, and forest stands e.c.

A major morphological feature of forest soils is the sequence of surface organic (O, H) and organo- mineral (A, E) horizons, usually defined as the forest humus form, which indicates soil organic matter status and dynamics. So forest humus forms might be used as a tool for carbon and nitrogen content calculation.

In this context, to determine and compare C and N content in different humus forms, the study was conducted in the different forest ecosystems. Forest humus forms were described according to the EHFRB classification system (Zanella et al., 2011). Soil samples were collected from the humus profile diagnostic horizons. Air-dried soil samples were sieved through a 0.02 mm sieve and analyzed for organic carbon (Corg) (Shimadzu VCSN analyzer) and total nitrogen (Ntot) (Modifeid Kjeldahl method) content.

Humus entiform Psammmor humus develops in the dry pine forest on nutrient poor sandy deposit.

Humus terroforms forms on well drained, nutrient richer soils. Mor humus develops on more fertile sandy soils, in pine or pine/spruce forests. Moder humus forms were detected under mixed coniferous forest conditions, on loamy sand soils. Mull humus form develops on nutrient rich, calcareous soils.

Humus hydroforms were detected in territories with poor drainage, in planes or in lower slopes. In moist pine forests Hydromor humus was detected. Hydromoder humus develops on loamy sand, loamy soils, but Hydromull humus develops on moist calcareous soils under deciduous trees.

Humus histoforms were found in peat soils. Histomor humus form corresponded to raised bog topsoil, Histomoder – to transitional mire topsoil. On fen peat soils, mostly, under birch stands, develops Histomull humus.

The lowest Corg and Ntot content were in the Psammomor humus forms. Mean Corg content in the psammomor humus was 18.4 t C ha-1, but Ntot was 0.47 t N ha-1.

Corg and Ntot content in humus forms increased with the increase of soil fertility. Mean Corg in Mor humus was 32.5 t C ha-1, but mean Ntot – 0.75 t N ha-1. In Moder humus Corg and Ntot content increased to 40.5 and 1.5 t ha-1. The highest Corg and Ntot content in the humus terroforms was in the Mull humus. Mean Corg content in the Mull humus reached 76.9 t C ha-1, but Ntot was 6.3 t N ha-1.

As well as soil fertility, soil moisture conditions increases the carbon and nitrogen content in the forest humus. In the moist forests, in the humus hydroforms, carbon and nitrogen content was higher than in the terroforms. Corg and Ntot content increased in order

Hydromor < Hydromoder < Hydromull. Mean Corg content was 55.8, 72.3 and 139.5 t C ha-1. Mean Ntot content in the humus hydroforms was 1.3, 1.9 and 8.5 t N ha-1.

The highest mean organic carbon content was detected in the humus histoforms. Mean Corg content from 94.9 t C ha-1 in the histomor humus, increased to 147.9 t C ha-1 in the histomoder and 190.3 t C ha-1 in the histomull humus. Also the lowest Ntot content 2.1 t N ha-1 was in the histomor humus. In the histomder humus it was 4.9 t N ha-1, but in the histomull humus total nitrogen content reached 5.3 t N ha-1.

Results showed that humus forms as well as the carbon and nitrogen content varies in landscape. Carbon and nitrogen content in forest humus depends on multiple factors. The most significant factor is the soil hydrological conditions.

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Acknowledgment

This study is supported by the European Social Fund No. 2013/0020/1DP/1.1.1.2.0/13/APIA/VIAA/066.

Keywords：*humus forms, carbon, nitrogen, boreo-nemoral zone*

P1-289

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

The Spatial Distribution Pattern of Soil-Dwelling Termites in Primary Forest and Oil Palm Plantation in Sabah, Malaysia

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Introduction

Termites have been recognized as the most important arthropod decomposers in tropical rain forests. There are great influences of termite on soil structure, plant decomposition, nutrient availability and the stimulation of microbial activity. Termites play an important role in the carbon cycle and carbon flux by emitting greenhouse gases such as carbon dioxide and methane. Nitrogen fixation has been demonstrated in all families of termites and most of the feeding types except for soil-feeders. To date, there has been extensive research on the contribution of termites to decomposition processes, their impact on soil properties, community response to habitat disturbance , and stimulation of microbial decomposer communities.

Oil palm-based industries have positive contribution to economic growth, reduced poverty and improved income equity which encourage massive conversion of forest into oil palm agriculture in Malaysia. The community ecology of termites at the local scale has been poorly studied in both the primary forest and oil palm plantation ecosystems, and there are little ecological processes operating within them. In contrast, substantial literatures have supported that termite species and composition decline when natural and semi-natural habitats are cleared. Therefore, termite assemblages are claimed to be sensitive indicators of anthropogenic habitat disturbance, and show characteristic changes in species richness and functional group composition along disturbance gradients, including those imposed by logging and the conversion of natural forest ecosystems to plantations or subsistence crop fields. The purpose of this study is to investigate actual termite distribution patterns in primary forests and oil palm plantations. Likewise, ecological interactions of termites responding to biotic factors and abiotic factors that affect its spatial structure were compared under different ecosystems.

Material and methods

This study was conducted in Lahad Datu region located at the eastern part of Sabah, Malaysia. Two study sites had been selected which were Lipad Virgin Jungle (5°12.60'N, 118°30.58'E) situated in Tabin Wildlife Reserve (TWR) and the adjacent Permai Oil Palm plantation (5°08.64'N, 118°28.28'E) that was converted into plantation in 1987. Termites sampling was conducted from pits dug and sorted with the size of 25 cm × 25 cm × 10 cm deep which is a standard grain size demonstrated to efficiently capture termites. Pits were sampled at a lag of every 2 m × 2 m and to an extent of 64 m × 64 m made up a total of 1024 pits located at each sampling site and pits were assigned with Cartesian x-y coordinates. When termites were encountered, a representative sample of each species were collected and stored in 95% alcohol, collecting both worker and soldier termites when they were present to facilitate identification. Termites were identified to species or morpho-species using available taxonomic literature and the reference collections of ITBC BORNEENSIS. Ants collected from soil pit were identified using keys. Earthworms encountered in

soil pits were recorded as well during the sampling period. Spatial pattern was measured using the SADIE (Spatial Analysis of Distance Indices) red – blue method, which identifies areas in which observed counts are either arranged effectively at random or form clusters of units in local neighbourhoods with consistently large or small counts. SADIE analysis was employed using the program SADIEShell v2.0 on termites, ants, earthworms and all the environmental data that measured in this study.

Results and discussion

In this present study, termite abundance and species richness had shown dramatic decline after conversion from primary forest to oil palm plantation. Out of a total of 29 species of termites that were encountered in this study, 26 species were found in the primary forest while only nine species in the oil palm plantation. Nevertheless, the spatial patterns showed that both soil and non-soil feeding termite groups distributed differently in which large gaps of termite distribution area are detected in oil palm plantation. These suggested that the oil palm plantation possibly poses physical barrier that resists the colonization of poorly dispersing termites. Significant association between soil-feeding termite and non-soil-feeding termite was detected at both ecosystems. However, termites at both sites responded differently in the association and dissociation between biotic factors (earthworms, non-predatory and predatory ants) along with environmental variables (fallen branches, dead tree logs, mounds, trees, grass, soil pH, soil organic carbon and total soil nitrogen).

Keywords：*primary forest, oil palm plantation, termites, environmental variables, spatial distribution*

P1-290

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Effects of Different Organic Materials on Fractal Features of Micro Aggregate and Available Nutrients in Chao Soil

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Fractal features of micro aggregate and available nutrients in Chao soil were studied by mixing organic materials （bean stalk, corn stalk, chicken manure and pig manure） into the soil samples on low-yielding fields in Henan Province. The results indicated that 0.1~0.053mm proportion of particles was higher 7%~13% than the CK treatment by the increase of organic material added and reached the significant difference, and <0.053mm size of the corresponding proportion is less than the CK treatment. Fractal dimensions of soil particle were between 2.52 and 2.72 by the Fractal Model, and there was a very significant negative correlation with 0.1~0.053mm contents of soil particle size (R= -0.945) and a very significant positive correlation with <0.053mm soil particle size (R=0.981). Distribution of micro aggregate was changed from the single application to the mixed treatment of stalk and manure, and the fractal dimension decreased. Compared with the CK treatment, the available nutrient contents in the size of particles and the soil itself were significantly increased by organic materials added. The contents of available nitrogen and potassium and phosphorus increased by 168%~528% and 141%~1000% and 16%~81% more than the CK treatment in 0.1~0.053mm particle, and 13.4%~44% and 17%~170% and 21%~66% more than the CK treatment in <0.053mm particle, respectively. The contents of available nitrogen was in order for the application of stalk (73.1mg/kg) > application of double mixing of stalk and manure (69.3mg/kg) > application of mixing of stalk and manure, application of pig manure (63.0mg/kg) > application of chicken manure (59mg/kg) > the CK treatment (49.9mg/kg), and that of available potassium in order for the application of the bean stalk (140mg/kg) > application of double mixing of stalk and manure, and corn stalk (120mg/kg) > application of mixing of stalk and manure (86.5mg/kg) > application of manure (76.8mg/kg) > the CK treatment (56.5mg/kg), and that of available phosphorus in order for corn stalk (40.9mg/kg) > application of manure, s application of mixing of stalk and manure (35.91mg/kg) > application of bean stalk (30mg/kg) > the CK treatment (26.8mg/kg). Both the nutrient content of different size and the soil itself is increased by adding of organic materials into sandy soil.

Keywords：*organic materials; Chao soil; soil micro aggregate; fractal dimension; available nutrients*

P1-291

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Net Effect of Liming on Soil Organic Carbon Stocks: A Review

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Liming is a common agricultural practice worldwide, used for increasing productivity in acid agricultural soils, since it reduces Al saturation and toxicity and/or increases pH up to values where the availability of nutrients is higher. Although the effect of liming on soil properties has been extensively studied, the focus of most studies has been set upon pH, exchangeable cations and productivity. Thus, the effects of liming on soil organic C (SOC) stocks still remain poorly known. The net effect on SOC can be the result of several factors: first, liming increases the soil biological activity, thus favouring the mineralization of organic matter, which should result in CO2 losses and a decrease of the SOC stocks. Second, liming ameliorates soil structure, increasing the stability of clay assemblages and clay-organic matter bonds, which should bring an increase in SOC physical and physicochemical protection. Finally, as liming ameliorates soil conditions to plant growth, an increase of plant productivity is also observed, which increases the return of C inputs to the soil, thus potentially increasing SOC concentrations. The net effect of these opposite trends is not well understood yet, and more experimental data are needed to assess and predict this effect across soils with different properties and under different managements. Still, some overall trends can be deduced from data currently available in the literature. Liming does modify SOC stocks, increasing them in most cases, which seems caused by higher C inputs to limed soils due to increased productivity. Reductions in SOC, which have also been reported, could be temporary and due to increased mineralization, but this trend should be reverted progressively by the influence of the increased C inputs. The improvement of aggregation and soil structure has also a positive effect on SOC accumulation in limed soils, although the extent of this effect is small in comparison to that of productivity. Overall, these insights are deduced from published data which are still scarce, so the scientific community is encouraged to synthesize unpublished SOC data from existing in situ experiments, in order to enlarge the span of soil types and properties and gain knowledge about the role of edaphic properties on the effect of liming on SOC stocks.

Keywords：*soil organic matter, lime, acid soils, C stocks*

P1-292

[C1.1-2] Interactions between Soil Structure, Living Organism and Organic Matter

Balance of Organic Matter in a Maize Agroecosystem

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Since soil organic matter (SOM) is one of the essential drivers for the ability of soils to perform ecosystem functions, its decline has been identified by the European Commission as a threat for sustainable soil management. The balance of organic matter in soil is the main criterion of sustainability of a farming system. This is particularly important in the case of maize-based cropping systems, where management effects can increase the mineralization of soil organic matter.

The paper presents an assessment of the SOM balance at field level in a maize agroecosystem.It was found that factors negatively affecting the balance of soil organic matter are connected with insufficient biomass input. The obtained data suggested that the incorporation of organic materials such as maize residues, as well as the application of mineral fertilizers, influenced organic carbon accumulation. Measures protecting and increasing the SOM pool through the application of organic matter are more effective under an improved soil water regime.

Keywords：*Keywords: soil organic matter, balance, biomass, maize*

P1-293

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Phosphorus-Arsenic Interactions in Volcanic-Ash Soils in Relation to Arsenic Mobility and Bioavailability

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Soils derived from volcanic ash are enriched with variable charge components such as allophane, imogolite and organic matter. These variable charge components influence the reactions and bioavailability of anions such as phosphate and arsenate. In this work, the difference in the adsorption between arsenite [As(III)] and arsenate [As(V)] species, and the effect of phosphate (P) on the bioavailability of As species were examined. The adsorption and desorption of As species and the effect of P on these reactions were compared using a number of non-allophanic and allophanic soils. The bioavailability was examined using germination, phytoavailability, earthworm and soil microbial activity tests. Both As-spiked soils and As-contaminated sheep dip soils were used to test bioavailability. The sheep dip soil which contained predominantly As(V) species was subject to flooding to reduce As(V) to As(III) and then used along with the control treatment soil to compare the bioavailability between As species.

Adsorption of As(V) was much higher than that of As(III) and the difference in adsorption between these two species was more pronounced in the allophanic than non-allophanic soils. The addition of P resulted in an increase in As desorption, and the effect was more pronounced in the case of allophonic soil. In the solution culture, there was no significant difference in the bioavailability, as measured by germination and phytoavailability tests, between these two As species. Whereas in the As-spiked soils, the bioavailability was higher for As(III) than As(V), and the difference was more pronounced in the allophanic than non-allophanic soils. Bioavailability of As increased with the flooding of the sheep dip soils. In the case of both As-spiked soils and field contaminated sheep-dip soil, application of P increased the desorption of As, thereby increasing its bioavailability. The effect of P on As uptake was more pronounced in the high anion adsorbing allophanic than low adsorbing non-allophanic soil. In the case of solution culture, As phytoavailability decreased with increasing concentration of P which is attributed to the competition of P for As uptake by roots. While increasing P concentration in solution decreased the uptake of As, it facilitated the translocation of As from root to shoot.

The results in this study have demonstrated that while in solution, the bioavailability does not vary between As(III) and As(V), in soils the latter species is less bioavailable than the former species because As(V) is more strongly retained than As(III). The net effect of P on As phytoavailability in soils depends on the extent of P-induced As mobilization in soils and P-induced competition for As uptake by roots. The P-induced mobilization of As could be employed in the phytoremediation of As-contaminated sites. However, in the absence of active plant uptake, the mobilized As may be subject to leaching, thereby resulting in groundwater and off-site contamination.

Keywords：*Arsenic, Adsorption, Phosphorus, variable charge soil, Bioavailability*

P1-294

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Distribution, Properties, and Genesis of Nonallophanic Andosols in Central Kyushu, Japan

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Nonallophanic Andosols contain large amounts of crystalline clay minerals and show strong acidity that inhibits plant growth. Therefore, for appropriate soil management, it is important to determine the distribution and properties of nonallophanic soils in Andosols areas. Kyushu, one of the four larger islands of Japan, is located in the southwest of the Japanese archipelago, and it has several active volcanos in its central and southern areas where Andosols are distributed widely. Most of the Andosols in Kyushu are allophanic Andosols that show weak acidity. Although some studies have shown that nonallophanic Andosols are locally distributed in central and northern Kyushu, a detailed analysis of the distribution, properties, and genesis of nonallophanic Andosols in Kyushu has not been reported.

The study area is on the Kuju Plateau of central Kyushu. We conducted soil surveys in a grass field, in which grass growth was inhibited by soil acidity, and determined that the upper part of the melanic epipedon was nonallophanic. Further investigations of the areas of Andosols around Kuju and Aso volcanoes, including surface soil analyses at 133 sites and profile surveys at 10 pedons, revealed the following results. 1) The distribution of nonallophanic surface horizons that satisfied the criteria of $Si_o < 6$ g kg^{-1} or $Al_p/Al_o \geq 0.5$ or exchangeable acidity $y_1 \geq 6$ in this area was at least 340 km^2. 2) The histogram of Al_p/Al_o of the surface horizons showed a symmetric one-peak distribution centered around 0.5, the border between nonallophanic and allophanic. This suggests that nonallophanic and allophanic soils in this area are not essentially different, and soils with boundary characteristics between nonallophanic and allophanic are distributed widely. The scarcity of allophane and the dominance of an aluminum-humus complex in non-crystalline aluminum varied and probably reflected the soil formation environment of each site. Al_p/Al_o values revealed an intimate positive relationship with soil acidity indicated by $pH(H_2O)$ and y_1. 3) Nonallophanic horizons were continuously accumulated from the surface to a depth of 12 to 36 cm, and the horizons below them were allophanic. The age of the appearance of nonallophanic Andosols, i.e., the age of the bottom of the nonallophanic horizons, was estimated at around 2.5 to 3 ka by ^{14}C dating. 4) Nonallophanic surface horizons showed total silicon contents larger than those of the allophanic subsurface horizons. This suggests that the change of chemical composition of the volcanic ash to felsic rock type, which enhances the genesis of nonallophanic Andosols through the decrease of soil solution pH, occurred at 2.5 to 3 ka, possibly triggering the onset of nonallophanic soil formation. 5) Nonallophanic Andosols were observed at higher rates in those areas with cool and humid climatic conditions, which also enhance nonallophanic soil formation. 6) Nonallophanic soils showed larger carbon contents (177 g kg^{-1} on average) in comparison with the allophanic soils (136 g kg^{-1} on average). The rate of black color (1.7/1 or 2/1) in nonallophanic soils was also larger than that in allophanic soils. Thus, even without detailed analysis, nonallophanic and allophanic soils in this area could be distinguished to a large extent based on $pH(H_2O)$ and soil color. 7) The amount of lime for the neutralization of nonallophanic Andosols and its variations was larger than for the allophanic Andosols. Lime requirement was closely related with soil pH and total carbon content, and multiple correlation analysis provided an explanatory variable based on pH and total carbon that correlated the measured lime requirements for neutralization with a determination coefficient of 0.731 (n = 53).

Keywords：*Andosols, nonallophanic, acidity, distribution, Japan*

P1-295

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Significance of Aluminum-Humus Complexes in Andosols

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Andosols (or Andisols) possess several distinctive properties that are rarely found in other groups of soils. This is largely due to the formation of short-range ordered materials, such as allophane, imogolite and metal-humus complexes (Al/Fe-humus complexes). This paper examines the genesis, characteristics and management implications of Al-humus complexes, especially in non-allophanic Andosols where Al-humus complexes are the primary form of active Al. While non-allophanic Andosols share many common properties with allophanic Andosols, they display some distinctive properties, such as strong acidity and high exchangeable Al contents that may lead to severe Al toxicity in sensitive crops. Therefore, from a soil management perspective, non-allophanic Andosols often require acidity amelioration to assure crop productivity.

Andosols abundant in allophanic clays (allophanic Andosols) form preferentially in weathering environments with pH values in the range of 5 - 7 and low content of complexing organic compounds. In contrast, non-allophanic Andosols are dominated by Al-humus complexes formed mainly in pedogenic environments that are rich in organic matter and have pH values less than 5. Preferential incorporation of Al into Al-humus complexes has been termed the anti-allophanic effect due to their suppression of allophane formation.

Solid-state cross polarization magic angle spinning (CRMAS) ^{13}C-nuclear magnetic resonance (NMR) spectra of Andosol A horizons demonstrated an abundance of aromatic C and carboxyl C in humic substances extracted by pyrophosphate or NaOH. This supports the perspective that Al-humus complexes are formed primarily by Al complexation with carboxylic functional groups. Regarding the origin of organic carbon in humic substances of Andosols, especially for very dark colored A horizons, such as melanic epipedons, grass vegetation (e.g., Miscanthus sinensis; C4 plant) is often found as the source of the organic matter. However, the carbon stable isotope ratio (δ^{13}C) of humic substances in Andosol A horizons showed that C3 plants, including forest vegetation, may also be important humus sources.

Non-allophanic Andosols often accumulate large amounts of organic carbon. It is suggested that the accumulation and stabilization of humus is, in part, due to the formation of metal-humus complexes. To examine factors affecting organic carbon accumulation, we determined the relationship between soil organic carbon (OC) concentrations and various soil properties in our Andosol database containing 293 A horizons. Results indicated that Al-humus complex concentrations are strongly correlated with OC accumulation along with low pH and high KCl-extractable Al concentration, which may preserve humus by depressing microbial activity.

Aluminum solubility and release/retention kinetics closely relate to the form of active Al and soil productivity (i.e. Al toxicity). In soils containing hydroxy-Al polymers (interlayered 2:1 layer silicates), allophane/imogolite, Al-humus complexes, and exchangeable Al, the Al appears to be in a simultaneous equilibrium with all these constituents. Among them, it is assumed that hydroxy-Al polymers ultimately regulate Al solubility with a pAl/pH slope near 3.0, consistent with equilibrium with a gibbsite-like hydroxy-Al polymer. In non-allophanic Andosol A horizons, the pAl/pH slope is significantly lower (1.3 - 2.4). This suggests

that exchange of Al^{3+} with humic substances (Al-humus complexes) controls the relationship between Al^{3+} and pH. Studies of Al^{3+} release/retention from Al-humus complexes showed rapid release and retention kinetics consistent with being able to control aqueous Al^{3+} activities.

Allophanic Andosols are moderate to slightly acidic ($pH(H_2O)$ = 5 - 7) and generally have low base saturation; however, they rarely contain toxic levels of KCl-extractable Al. In contrast, non-allophanic Andosols are strongly acidic (pH < 5) when the base saturation is low and possess high KCl-extractable Al that is toxic to sensitive plants. Because Al-humus complexes are considered to control the Al solubility of these soils, the KCl-extractable Al is considerably influenced by soil pH and Al-humus complex concentrations. Our Andosol database containing 105 humus horizons from non-allophanic soils revealed that KCl-extractable Al values have a strong negative correlation with soil pH and a positive correlation with the amount of the Al-humus complexes. Thus, it is considered that Al-humus complexes are an important source of phytotoxic Al. Liming of the plow layer can effectively reduce soil acidity and Al toxicity in A horizons while surface applications of gypsum, phosphogypsum, and organic calcium have proven successful for amelioration of subsoil acidity in non-allophanic Andosols.

Keywords：*Al-humus complexes, Al-toxicity, Andisols, Andosols, organic carbon accumulation*

P1-296

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Exhuming Buried Allophanic Soil Horizons and Mixing Them with Vitrands in Central North Island, New Zealand: Impacts on Soil Moisture Availability

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Typic Udivitrands (Pumice Soils) in the Galatea Basin in the eastern central North Island of New Zealand tend to experience dry spells in summer and so summer pasture production is limited by moisture availability. The modern soils in the Galatea Basin are formed on very weakly weathered, coarse textured, glassy, pumice deposits of the Kaharoa Tephra (deposited 636 ± 12 calendar year BP), which overlie older tephra deposits including Taupo Tephra (1718 ± 10 cal. yr BP), Whakatane Tephra (5526 ± 145 cal. yr BP), Rotoma Tephra (9423 ± 120 cal. yr BP) and associated soil horizons (now buried) that were developed on each of these tephras when they were at the land surface.

Farmers in the Galatea Basin had noticed that refilling holes resulted in better pasture growth in the disturbed materials compared with that on the adjacent undisturbed soils. These observations led to experimental trials where the underlying finer-textured, allophanic, buried soil horizons (paleosols) on Taupo and Whakatane tephras were incorporated into the pumiceous surface horizons, forming a mixed soil at the land surface, using a mechanised digger, in a process referred to as “flipping”.

The main objective of our study was to investigate the differences between the mixed soils and the undisturbed pumiceous soils to understand why there are differences in pasture growth. Our hypothesis was that the mixing of the exhumed paleosols into the pumiceous surface soils will give increased water holding capacity in the modified surface horizons and thus improve moisture availability to plants during dry summer periods.

Four paddocks were investigated, each of which had a “flipped” area comprising mixed soil materials and an “undisturbed” control area comprising natural Vitrands. Site A was flipped 3 years ago, and site B 10 years ago, to depths of ~1.8 m. At both sites A and B the topsoil was preserved and placed back on top of the mixed sub-soil materials. Sites C and D were flipped 3 years ago to a depth of ~0.6 m. At C the topsoil was mixed in with the sub-soil; at D the topsoil was placed back on top of the mixed soil materials. In each of sites A-D, 3 pits were excavated in the mixed soils and 3 in the undisturbed soils. Detailed soil descriptions were made and undisturbed soil cores were taken from all horizons (natural and mixed) in each pit to a depth of 0.7 m. The cores were taken to determine moisture retention using the Haines apparatus and a pressure plate extractor. Paleosols formed on the Taupo, Whakatane, and Rotoma tephras in a matching profile exposed in a nearby cutting were sampled to measure their allophane contents (fine-earth basis) using the acid ammonium oxalate and pyrophosphate extraction methods.

Profile readily-available water (PRAW) contents ranged from 7 to 8 % (v/v) in the natural (undisturbed) pumiceous soil materials whereas they ranged from 25 to 30 % (v/v) in the mixed soil materials. PRAW contents (relating to a soil depth of 600 mm) were

greater ($p < 0.01$) in all the mixed soil materials compared with those in the undisturbed pumiceous soil materials. The mean PRAW content (for soil depth of 600 mm) in the undisturbed pumiceous soil materials was 105 mm whereas the mixed soil materials had a mean PRAW content of 156 mm.

From the literature, it is found that the <2-µm clay contents in the paleosols formed on Taupo, Whakatane, and Rotoma tephras average ~5-10 % whereas the pumiceous horizons in Kaharoa Tephra average ~1-2 %. The allophane contents of the (buried) soil horizons formed on the tephras were ~2 % (Taupo), ~3 % (Whakatane), and ~5 % (Rotoma).

We conclude that bringing the finer-textured paleosol materials - which have higher clay and allophane contents than the natural pumiceous surface horizons - to the land surface means that the mixed soils are able to hold more readily-available water than the undisturbed Vitrands, thereby improving moisture availability to plants during dry summer periods. The physical process of mixing also loosens the relatively dense Kaharoa pumice materials, allowing easier root penetration.

Keywords：*Pumice soils,Vitrands, improving profile readily-available water, flipping,*

P1-297

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Elemental Composition of Agricultural Soils in Japan in Relation to the Genesis and Inherent Fertility of The Soils

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Agricultural soils interface directly with agricultural crops and are linked with the atmosphere, hydrosphere and lithosphere. Accordingly, they affect agricultural productivity directly and also determine the status of the terrestrial environment through biogeochemical cycling of the elements. In this context, information on the elemental composition of agricultural soils is essential not only for the evaluation of inherent soil fertility from an agricultural point of view but also for the understanding of the sink and source of the elements from an environmental viewpoint. Based on this understanding, we carried out a series of experiments to investigate the elemental composition of agricultural soils in Japan where the influence of volcanic activities is clearly observed. The objectives of this research were 1) to evaluate representative elemental composition of agricultural soils in Japan and 2) to investigate the relationship between elemental composition of agricultural soils and their selected physico-chemical properties, soil type and region in Japan, with the emphasis on volcanic soils.

One hundred eighty soil samples were collected from the surface layer of paddy or upland fields in Japan and their total contents of twenty-five elements were determined. Total concentrations of Al, Fe, Ca, Mg, Ti, P, Mn, Ba, V, Sr, Zn, Cu and Ni were determined by ICP-AES and those of K, Na and Rb by atomic absorption spectrophotometry after wet digestion of the finely ground samples with HNO_3, HF and $HClO_4$. The concentration of S was determined by ICP-AES after wet digestion of the finely ground samples with HNO_3 and $HClO_4$. The concentration of B was determined by curcumin-acetic acid method after fusion at 550°C with Na_2O_2. Those of Br and I were determined by HPCL as 2–bromo–3–pentanone after heating at 500°C with NaOH solution, and by ICP–MS after extraction with tetramethylammonium hydroxide solution, respectively. That of Se was determined by HPLC after treatment of the wet digested solution (HNO_3 and $HClO_4$) of the samples with 2,3-diaminonaphthalene and extraction with cyclohexane. Total concentrations of C and N were determined by the dry combustion method, and those of Si and O were determined by calculation.

The medians of the total concentrations of the 10 major elements were 504 gO/kg, 291 gSi/kg, 76.6 gAl/kg, 36.8 gFe/kg, 24.8 gC/kg, 15.0 gK/kg, 14.3 gNa/kg, 11.9 gCa/kg, 8.78 gMg/kg and 3.82 gTi/kg, which accounted for 98.7% of the total. The medians of the others were 2.15 gN/kg, 1.43 gP/kg, 705 mgMn/kg, 560 mgS/kg, 394 mgBa/kg, 140 mgV/kg, 125 mgSr/kg, 119 mgRb/kg, 90.5 mgZn/kg, 24.5 mgCu/kg, 23.7 mgB/kg, 14.3 mgNi/kg, 5.53 mgBr/kg, 2.49 mgI/kg and 0.42 mgSe/kg. These data can be the representative elemental composition of agricultural soils in Japan, and reflected parent materials, degree of weathering and influence of volcanic materials. In relation to general physico-chemical properties of the soils, total C content correlated significantly with N, Br, P, Se and I ($p < 0.01$), suggesting considerable contribution of organic matter to the accumulation of these elements. An index of amorphous materials, Alo + 1/2Feo, correlated significantly with Br, I, V, Al, Fe, C, N, Se, P and Mn ($p <$

0.01), suggesting strong influence of volcanic materials on the behavior of these elements. In terms of soil type, volcanic soils had relatively high Al, Fe, C, N and P contents and alluvial soils had relatively high Si, K and Ba contents whereas red yellow soils had extremely low Ca, Mg and Na contents. Cluster analysis grouped regions in Japan into three groups in terms of elemental composition of agricultural soils: 1) Hokkaido, Tohoku, Kanto, Chugoku and Kyushu regions, 2) Hokuriku-Chubu, Kinki and Shikoku regions and 3) Okinawa region. These regions corresponded roughly to those with volcanic soils, those with less weathered non-volcanic soils and those with relatively weathered non-volcanic soils, respectively.

In conclusion, elemental composition of the agricultural soils based on 180 soil samples collected all over Japan enabled to evaluate inherent fertility of the soils in Japan under temperate climate, and the extent to which soils were affected by volcanic ash was considerably responsible for the elemental composition. These results can be used as the basic information on which development of sustainable agriculture and promotion of environmental conservation is to be established on the similar soil environment with volcanic influences.

Keywords：*agricultural soils, elemental composition, Japan, soil type, volcanic soils*

P1-298

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Physical and Chemical Properties of Volcanic Ash Influenced Soils on Mount Rainier, Washington, Usa

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Mount Rainier is a 4,390m (14,410 ft) stratovolcano in the Cascade Range of Washington, USA. Mount Rainier National Park encompasses 95,700 hectares (236,400 ac), ranging from the ice-filled crater to the surrounding alluvial lowlands. A Soil Resources inventory was conducted from 2009 to the present with over 700 observations of soil characteristics. This investigation has discovered six different soil orders and over 30 soil series new to Soil Taxonomy. The majority of the soils in the park are Spodosols and Andisols, with some Inceptisols, Entisols, Histosols and Gelisols. Podsolization is the dominant process in forested, low elevation mountain flanks. Typical soil profiles consist of an elluvial/illuvial horizon sequence formed in volcanic ash overlying andesite colluvium and residuum from Mount Rainier. Ascending into subalpine parklands, melanization is the dominant pedogenic process. Typical profiles consist of dark-colored, organic rich layers inter-bedded with numerous tephra deposits. In alpine environments soils are thin, weakly developed and dominated by coarse fragments (>2mm). Active erosional and/or depositional surfaces, such as alluvial channels, recently de-glaciated areas, and areas influenced by lahars and jökulhlaups show various levels of disruption in these pedogenic patterns. Samples from 36 sites were selected for laboratory analysis. Physical and chemical data include particle size distribution, bulk density, water-holding capacity, cation exchange capacity (CEC), pH, various chemical extractions and optical mineralogy. Particle size distribution was calculated for 118 horizons. Textures are sandy, with an average sand content of 76%. Clay content ranges from 0 to 8% with an average value of 2%. These lab results are consistent with field textures but tend to favor coarser textures. This is likely a result of poor dispersion of soil colloids. Bulk density was measured on 27 clods with an average value of 1.05 g/cm3. Horizons formed in volcanic ash have an average bulk density of 0.98 g/cm3, while all other parent materials have an average bulk density of 1.20 g/cm3. The significant decrease in bulk density is due to the vesicular nature of volcanic ash. Available water holding capacity was determined from 20 clod samples, with an average value of 17.4%. However, water holding capacity showed no significant differences across parent materials. CEC values range from 0 to 50 cmolc/kg with an average value of 8.6 cmolc/kg for mineral soils. CEC shows significant differences across soil orders. Horizons from Histosols showd the highest mean CEC value (23.2 cmolc/kg) due to the influence of organic matter. Andisols and Spodosols have values of 11.1 cmolc/kg and 8.9 cmoc/kg. Samples from all other orders have an average value of 2.0 cmolc/kg. Inceptisols, Entisols and Gelisols are younger soils with weakly developed profiles and low clay contents, hence the reduction in CEC. Values of pH ranged from 4.2 to 6.9 with an average of 5.4. Samples from active geomorphic surfaces showed less acidity when compared to samples from stable landform positions. Results from optical mineralogy indicate volcanic glass is the dominant primary mineral in these soils. Of the 63 individual horizons analyzed, the average glass content is 62%. Glass content was compared across common types of parent materials. Within the park there were no significant differences as all parent materials are rich in glass. There is almost no correlation between volcanic ash content and horizon depth, also due to the fact that all samples are rich in glass. Selective dissolutions were used to gain a qualitative understanding of clay mineralogy for 12 Spodosol profiles. Iron is most abundant as ferrihydrite although goethite is present lower in the profile. Aluminum is most abundant as allophane and imogolite with minor quantities of organically-complexed aluminum in spodic horizons. Estimated aluminum to silica ratios are between 1.88 and 1.93, consistent with values for allophane and imogolite. Iron and aluminum concentrations from all dissolutions were higher in Bhs and Bs horizons when compared with overlying E horizon. The above data aids in understanding the diverse soils of Mount Rainier National Park. Our findings will be available through a soil survey manuscript and on-line through Web Soil Survey.

Keywords：*Mount Rainier, tephra, volcanic glass, Andisols, Spodosols,*

P1-299

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Effect of Organic Matter Application and Conventional Tillage on Soil Organic Carbon Content of a Volcanic Ash Soil in West Java, Indonesia

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Organic matter application and conventional tillage are effective way to increase soil fertility. To evaluate the effect of organic matter application and conventional tillage on the soil organic carbon, a field experiment was carried out during 2010 through 2013 in a volcanic ash soil in Lembang, West Java, Indonesia. Treatments are combination of two factors, namely, fertilizer application and management tillage. Fertilizer application factor was combination of inorganic fertilizer and horse manure (HM-0: 113.0 kg N/ha, 96.0 kg P2O5/ha, 120.0 kg K2O/ha + horse manure 0 ton/ha; HM-20: 56.5 kg N/ha, 48.0 kg P2O5 kg/ha, 60.0 kg K2O/ha + horse manure 20 ton/ha; HM-40: 28.3 kg N/ha, 24.0 kg P2O5 kg/ha, 30.0 kg K2O/ha + horse manure 40 ton/ha). Dosage and sources of organic matter were changed with horse manure 10 and 20 ton/ha and chicken manure (CM) 10 ton/ha. Management tillage factor included conventional tillage and minimum tillage. Soil organic carbon (SOC) content was determined before the experiment and after each harvest. Cropping pattern by the year 2013 consisted of tomato ?cabbage followed by green bean ? sweet corn. Results showed the trend of soil organic carbon increased with application of horse manure and minimum tillage although the changes were not statistically significant. The SOC changes after experiment increased more in the sub-surface soil (20-40 cm) than surface soil (0-20 cm). Soil organic carbon content at HM20 (6.39%), and HM40 treatments (6.52%) were higher than HM0 treatment (6.22%) after the crop season 2010 under the minimum tillage, suggesting soil organic carbon can be increased by applying the organic matter and conventional tillage practice. After corn harvesting, SOC contents at HM10 and HM20 rates were 5.98% and 5.74%, respectively which were higher than CM10 treatment (5.57%). This is attributed to organic C content of chicken manure was lower than horse manure. The corn and bean yields of HM20 were significantly higher than CM10 due to manures residue effect. Due to the fluctuation of soil organic carbon content, it is necessary to propose a practical farm management such as application of manure, returning crop residue and implementation of minimum tillage to increase soil organic carbon while maintaining soil fertility and crop yields.

Keywords：*manue, soil organic carbon, volcanic soil, conventional tillage*

P1-300

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Soil Genesis and Mineralogy in Volcanic Materials in the Mediterranean Climate of California, Usa

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Soil formation in Mediterranean climates (xeric soil moisture regime) is influenced by sharp contrasts in temperature and moisture conditions characterized by cool-wet winters and hot-dry summers. The Mediterranean climate results in two extremely contrasting chemical weathering environments each year: Intense winter leaching regime and a hot/dry summer period of extreme soil profile desiccation. The purpose of this paper is to examine several unique characteristics of soil genesis and mineralogy occurring in volcanic soils forming in the xeric soil moisture regime of California.

In terms of soil genesis, chronosequence studies indicate a generalized soil genesis pathway of Entisol → Andisol → Inceptisol → Alfisol. Andisols often transition to Inceptisols as short-range order (SRO) aluminosilicates (allophane/imogolite) transform to crystalline kaolin minerals. However, clay translocation (lessivage) is hindered until the SRO materials have been largely transformed to kaolin minerals due to their poor dispersion. Along an elevations gradient (250 – 3000 m) that incorporates hot/dry to cold/moist environments, the soil genesis progression followed: Mollisol/Inceptisol → Alfisol → Andisol → Inceptisol/Entisol. Along this sequence, weathering, mineralogical transformations and soil development are limited by water availability at low elevation, whereas low soil temperature is the major limitation at high elevation. Andisols and the prevalence of SRO materials were favored in the mid-elevation zone having cool temperatures (with a winter snow pack) and higher moisture conditions.

Soils with andic properties tend to have appreciably higher soil organic matter concentrations than associated soils formed on other parent materials. This organic matter enrichment is attributed to associations of organic matter with SRO minerals and Al-humus complexes, along with physical protection of organic matter in stable silt-size aggregates. A common feature in many Andisols formed under forest vegetation in California is a melanic (or near melanic) epipedon. Research attributes the occurrence of the melanic epipedon, in part, to the accumulation of charcoal. The dry summer conditions within the xeric soil moisture regime contribute to a regular wildfire regime (20 to 30 year return frequency) in many California forests. The percentage of charcoal in Andisols with melanic epipedons ranged between 12 to 16% of the total organic matter concentration.

Kaolin minerals (halloysite and kaolinite) tend to predominate in the crystalline clay fraction of soils formed in volcanic materials in the xeric moisture regime of California. Halloysite (expandable to 1.0 nm with or without formamide) and kaolinite concentrations show an inverse relationship with depth, the content of halloysite increasing deeper in the profile. Transmission electron microscopy indicates a predominance of particles with tubular morphology for both the kaolinite-dominated surface horizons and the halloysite-dominated subsurface horizons. We ascribe these findings to profile desiccation in the summer, which causes halloysite in the upper soil horizons to convert to a 0.7-nm basal spacing, tubular kaolinite that does not expand with

formamide. Repeated cycles of desiccation may also contribute to the transformation of SRO weathering products to kaolin minerals in the upper soil horizons. Appreciable concentrations of kaolin minerals also occur in the silt and sand fractions and are attributed to pseudomorphic replacement of feldspar by halloysite.

Several Andisols dominated by halloysite show a strong cation exchange selectivity for potassium vs. calcium. Changes in K^+-Ca^{2+} selectivity of the clay fraction were evaluated following drying and selective dissolution treatments to ascertain factors contributing to the high K^+ selectivity. Results showed that removal of iron oxides (by citrate-dithionite extraction) and freeze drying of the clays significantly reduced the K^+ selectivity. In contrast, air drying and removal of organic matter had little effect on K^+-Ca^{2+} selectivity dynamics. These results suggest that iron oxides block exchange sites that have a higher selectivity for Ca^{2+} and freeze-drying causes an irregular collapse of the tubular halloysite structure that increases Ca^{2+} access to exchange sites.

Volcanic soils in the xeric soil moisture regime of California generally have high physical fertility (tilth) and mature soils are relatively resilient to erosion and compaction. The high organic matter content, rapid weathering and excellent water holding characteristics often make soils derived from volcanic ejecta among the most productive in the xeric moisture regime of California.

Keywords：*Anidsols, allophane, imogolite, weathering, halloysite, melanic epipedon*

P1-301

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Effects of Heating on the Formation of Black Humic Acids

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Andisols in Japan have very thick and dark color A horizons with large amount of soil organic matter (SOM) containing black humic acids (alkali soluble and acid insoluble fraction in SOM, HAs), which develop under grassland vegetation. In Japan, the climax vegetation is forest and artificial burning or wildfire is needed to maintain of grassland vegetation for long period. Black HAs in Andisols are characterized by high carboxyl group and aromatic C content, darker color, and stable structure against biodegradation. There are various theories on the formation of black HAs in Andisols. Plant charred materials which were produced by artificial burning or wildfire have been thought to be important materials to form of black HAs in Andisols. On the other hand, the genesis of black HAs by thermal denaturation of SOM has not been investigated. The transformations exerted the soil HAs by fire have been modeled and studied in detail by Almendros et al. (1990) and Gonzalez-Vila and Almendros (2003). In those studies, the simulation laboratory experiments using a mineral soil mixed with isolated HAs were submitted to heating (350 °C) at variable time periods, and increment of aromatic C and reduction of chain length of alkyl compounds in HAs structure were observed. In this study, we investigated qualitative and quantitative change of SOM due to different heating temperature for bulk soil in laboratory model experiment.

We collected 3 Andisols, 3 Entisols and 3 Inceptisols from various regions in Japan. About 50 g of the soil samples were heated in a controlled process on three temperature levels, 200, 250 and 300 °C for 1 to 12 h. HAs and fulvic acids (alkali and acid soluble fraction in SOM, FAs) were extracted from the pre- and post- heating treatment soil samples with 1:1 mixture of 0.1 mol L-1 NaOH and 0.1 mol L-1 Na4P2O7 under N2 gas overnight. HAs were precipitated from extracts by acidification with H2SO4 and purified using the methods of Yonebayashi and Hattori (1988). HAs and FAs content of soil samples were determined according to the methods of Ikeya and Watabe (2003). Humin (alkali insoluble fraction in SOM) content was calculated by subtracting HAs and FAs contents from TC content. Optical property, elemental composition, XRD, 13C NMR and C and N stable isotope ratios of HAs were analyzed.

TC and TN of soil samples were reduced by heating treatment. The loss of C was accompanied by lower N decrease and the C/N ratio also reduced, consequently. Heating treatment caused drastic change in solubility properties of humic substances. A part of HAs were transformed into humins by carbonization and the proportions of HAs to TC decreased at high temperature (> 300 °C). On the other hand, at low temperature (< 250 °C), the proportions of HAs to TC increased with increasing of heating time and the proportions of humins to TC decreased. The parts of humins were changed in solubility by thermal denaturation and incorporated into HAs fraction. The contents of HAs on C basis were negatively correlated with those of humins ($r = 0.96$, $p < 0.01$). The proportion of FAs to TC decreased with increasing of heating time and temperature, especially 300 °C. Pyrolysis and/or incorporation into HAs or humins fraction may occur. The degree of darkness of HAs increased with increasing of heating temperature and was increased rapidly in initial 3 h and become constant after 5 h. From XRD patterns, heating treatment induced the incensement of condensed aromatic rings in HAs structure. We concluded that the increase of condense aromatic rings gave rise to blackening of HAs.

Keywords：*Andisols, humic acids, soil organic matter, heating treatment*

P1-302

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Stable Isotope Analysis for Evaluating Origins and Exchangeability of Sulfate in Deep Andisols in Ibaraki and Kagoshima, Japan

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Sulfate (SO_4^{2-}) competes for anion exchangeable sites with nitrate (NO_3^-) that is a common contaminant in groundwater in agricultural areas. Maeda et al. (2008) reported that NO_3^- was less retained in deep soil layers with a higher SO_4^{2-} content in a Japanese Andisol. However, there is little information available on the behavior of sulfate in Andisols. The objectives of the present study were to determine the origins and exchangeability of SO_4^{2-} existing in deep Japanese Andisols in different regions under different cropping systems by using the stable isotope ratio of sulfur ($\delta^{34}S$ values) in SO_4^{2-}.

We collected deep Andisols to a depth of 500 cm in a corn–Chinese cabbage cropping field of Yawara, Ibaraki on 26 August 2008, to 180 cm in a tea field of Chiran, Kagoshima on 22 October 2008, and to 310 cm in a sweet potato–wheat/barley field of Osumi, Kagoshima on 20-21 October 2008. After extraction from field-moist soil samples with 0.01 *M* NaOH at a soil to solution ratio of 1:100, SO_4^{2-} content in soil was determined with an automated continuous flow analyzer (BLTEC, QuAAtro2-HR). Barium sulfate precipitate, obtained from SO_4^{2-} extracted from air-dried soils with 0.01 *M* NaOH, were prepared for isotopic analysis of $\delta^{34}S$ values in SO_4^{2-} (GV Instruments, Isoprime EA). Samples of chemical fertilizers used in the fields, together with unfertilized soils from outcrops near the fields, were also subjected to the isotopic analysis. An isotopic exchange kinetics technique was used to evaluate the exchangeability of adsorbed SO_4^{2-} inherent in each soil. Two grams of air-dried soil samples at depths where soil SO_4^{2-} content was the highest in each sampling sites (90-100 cm in Yawara, 53-58 cm in Chiran, and 128-138 cm in Osumi) were equilibrated with 20 mL of 1 *mM* K_2SO_4 with a known $\delta^{34}S$ value (–6.0‰). Sulfate concentration and $\delta^{34}S$ in SO_4^{2-} in the supernatants were determined after shaking the mixed solutions for 1, 4, 10, 40, 100, or 400 minutes. The amount of exchangeable SO_4^{2-} (*E* value) was then calculated based on the mass balance of ^{34}S initially present in the solution and soil.

Regardless of the sampling sites, $\delta^{34}S$ values in SO_4^{2-} (–0.8 to +1.8‰) in soil layers where soil SO_4^{2-} content was the highest were similar to those in the chemical fertilizers (–4.8 to +1.4‰). On the other hand, $\delta^{34}S$ in SO_4^{2-} was +9.4‰ in the further deeper soil layers with lower SO_4^{2-} contents of the Yawara field, and was in the range of +7.5 to +11.8‰ in non-fertilized soil near the experimental fields. These $\delta^{34}S$ values were significantly higher than those in the chemical fertilizers. Our results strongly suggest that the dominant source of SO_4^{2-} accumulated in the Andisol profiles of the three experimental sites was chemical fertilizers, and that SO_4^{2-} in the further deeper layers and in non-fertilized soils with lower contents had different external sources such as wind-borne sea salts. In the experiment to estimate *E* values, SO_4^{2-} concentration in the supernatants did not change after 10 minutes. In the SO_4^{2-}accumulating layers, *E* values were in agreement with 0.01 *M* NaOH extractable SO_4^{2-} contents in each soil, indicating that most of SO_4^{2-} derived from fertilizers was rapidly exchangeable. In conclusion, most of SO_4^{2-} accumulated in the Andisol profiles in the studied sites was derived from chemical fertilizers, and was in an easily exchangeable form with respect to the isotopic exchange.

Keywords: *adsorption, E value, stable isotope, sulfate, volcanic ash soil*

P1-303

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Factors Influencing Carbon Availability and Metabolic Quotients in Temperate Volcanic and Tropical Forest Soils

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There is limited knowledge about the differences in carbon availability and metabolic quotients in temperate volcanic and tropical forest soils, and associated key influencing factors. We have studied effects of vegetations, temperature and land uses on soil microbial biomass C (MBC) and metabolic quotients (qCO2, CO2-C / biomass-C) in temperate volcanic and tropical forest soils. From the results obtained, it can be concluded that under similar climatic conditions and soil types, the MBC concentrations and qCO2 values of temperate volcanic forest soils vary with tree species and temperature, and that the high soil C-to-N ratios and low acidity can contribute to decreased soil MBC concentration and to increased qCO2. Factor and regression analysis indicated that the 85% variation of the qCO2 in forest soils could be explained by soil properties such as the C:N ratio and the concentration of water soluble organic C and exchangeable Al ($P < 0.001$). The qCO2 values in forest soils, particularly in temperate volcanic forest soils, decreased with an increasing Al/C ratio in water-soluble organic matter. Soil properties, such as exchangeable Ca, Mg and Al and water-soluble organic C:N ratio, were associated with the variation of MBC. The maximal concentrations of all tested exchangeable metals (excluding Al and Pb) were observed in the 0-2.5-cm soil and varied with tree species. According to the principal component analysis and regression analysis, the distribution of dissolved organic C and dissolved organic N pools in volcanic forest and tropical forest soils at the various depths is a function of the decreasing microbial activity and is partly associated with the metals of concern. Accordingly, MBC concentrations and qCO2 of the soils are useful soil parameters for studying C availability and microbial utilization efficiency under temperate volcanic and tropical forest soils.

Keywords：*Dissolved organic matter; Heavy metals; metabolic quotient; microbial biomass; volcanic soil*

P1-304

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Volcanic Soils Attributes Affecting Forest Productivity in Japan

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Introduction

Moisture condition differences corresponding to the terrain between mainly differences in tree growth, because most of forests are distributed on the mountain slope in Japan. On the other hands, soil parent materials has been considered empirically small effect on tree growth, therefore, this fact have not been defined. In this study, we clarified the growing stock differences in principal tree species between volcanic ash derived soils such as Andosols and other parent materials derived soils such as Cambisols, Umbrisols and other reference soil group on Japanese forest area.

Materials and Methods

The 20*20 km grid points over the forest sector of Japan were systematically selected for the National Forest Soil Carbon Inventory Project, giving a total of 830 grid points. A 1 m depth soil pit was established in each grid point, and the soil sample at genetic horizon was collected in each soil profile. The contents of acid oxalate extractable aluminum, iron and silica were measured in each soil sample, and the soil was classified whether the Andosols according to the World Reference Base for soil resources in each soil profile.

The growth stock, which were investigated to the Forest Resources Monitoring Survey, were compared between the survey point classified to Andosols and other RSG point on the principal tree species such as Japanese cedar, Japanese cypress for plantation forest, fagus and quercus for natural and secondary forest.

Results

About 20% soil profiles in the survey points were classified to the Andosols. The Andosols were distributed about 24% of 133 survey points in Japanese cedar plantation, about 10% of 64 survey points in Japanese cypress plantation, about 24% of 25 survey points in fagus forest, and about 22% of 27 survey points in quercus forest.

In Japanese cypress plantation forests, the growth stock between the survey points classified to the Andosols and ones that classified to the other RSGs, were not difference. On the other hands, the growth stock in Japanese cedar plantation classified to the Andosols less than the cedar plantation that classified to the other RSGs. In natural and secondary forest such as main species for fagus and quercus, the growth stock was not clearly difference between Andosols and other RSGs.

Discussion

The growth stock differences identified only the Japanese cedar plantation forest among the main tree spices in forest sector of Japan. Japanese cedar grow in widely conditions, therefore it has been most widely planted in forest sector of Japan. On the other hands, Japanese cypress grow in a narrow range of conditions compare with Japanese cedar, because wet condition was not suitable to the growth of Japanese cypress. It was not shown that the growth stock difference between Andosols and other RSGs in the principal tree species, it was caused by these species little distributed on the Andosols area. These results suggest that the Andosols are not good for growing these tree species in forest sector of Japan.

Keywords：*tree growth stock, national forest inventory, volcanic soil distribution*

P1-305

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Importance of Physically Protected Organic Matter to Carbon Sequestration in Chilean Volcanic Soils

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Carbon sequestration in soil is an important strategy to mitigate the increase of CO2 concentrations, since it involves the transfer of atmospheric CO2 in more stable soil organic carbon (SOC) fractions (Schimel et al., 1997). The permanence of SOC depends largely on the balance between contributions and the losses by decomposition, however there are factors that play a fundamental role in stabilizing of SOM such as mineralogy, climatic conditions and plowing. One of the most important stabilization mechanisms is the interaction of SOM with soil minerals (Rumpel et al., 2002, Six et al., 2002). But it should be bear in mind that there are other fractions of SOM such as particulate organic matter (POM) and protected organic matter in soil aggregates that may become important at time when a carbon balance should be made. To determine the stabilization capacity of the volcanic soils under different land-use and management, we conduct by density fractionation. We include natural grassland and temperate rain forest soil. The corresponding soil depths to 0-20, 20-80 and >80 cm depth in natural grassland and 0-19, 19-41 and 41-100 cm depth in rain forest. The protocol used is a modification of the methodology described by John et al. (2005). Soil fractions were separated by density using sodium polytungstate. It resulting three fractions of different densities: fPOM, free particulate organic matter (<1.6 g cm-3), oPOM, occluded particulate organic matter (1.6-2.0 g cm-3) and MF, mineral fraction (> 2.0 g cm-3). After separation of different fractions, the samples were dried to analyze the contents of C and N by dry combustion (elemental analysis). The results showed that the MF represented over 90% of the total weight in the natural grassland and. In turn, a lower percentage was observed for oPOM and fPOM. On the other hand the MF of rain forest represents over 75% of total soil weight, but in this case the contribution of fPOM and oPOM are higher than the natural grassland. The concentration of C in SOM fractions isolated shown that the oPOM had the highest concentration of C in natural grassland. On the other hand, the highest concentration of C in rain forest was found in fPOM. A different behavior was noted in rain forest, where the oPOM average the greater concentration, especially in the deeper strata. In summary the weight distribution of fractions followed a similar pattern to those described in the literature, characterized by a higher concentration in the MF and then in POM. The physical fractionation indicates that a large amount of carbon is present in the occluded particulate organic matter (oPOM). The results indicate that a large proportion of organic carbon was found in the oPOM (physically protected) and the MF, showing the both fractions represents a significant percentage of SOC.

Keywords：*Carbon sequestration, volcanic soils*

P1-306

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Soil Genesis and Mineralogy across a Volcanic Lithosequence in Northern California

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Lithology is a master variable of soil formation; interacting with climate, organisms, landscape position and time to define soil physiochemical properties and clay mineral neogenesis. A volcanic lithosequence of varying silica composition, existing in the same late-Holocene climatic conditions, was used to investigate the effects of lithology on soil physiochemical properties and the neogenesis of silicate minerals. The Clear Lake Volcanic Field is an active volcanic center in the northern California Coast Range where regional deformation associated with the San Andreas Fault system activates mafic to silicic eruptions associated with slab window melting. This late-Pleistocene lithosequence, set in a mesic/xeric climate, provides a unique environment for studying mineralogical transformations and pedogenesis across a range of silica compositions experiencing a similar weathering environment. Pedons formed in different lithologies, consisting of rhyolitic obsidian, dacite, andesite, basaltic andesite and basalt, were investigated. Soil samples were collected by genetic horizon, size fractionated, and the clay fraction analyzed via x-ray diffraction. Selective dissolution in acid ammonium-oxalate and citrate-dithionite was used to characterize Fe, Al and Si in pedogenic pools. CEC and exchangeable cation saturation were measured in 1M ammonium acetate, pH was measured in 1:1 in H2O, 1:2 0.01M CaCl2 and 1:1 in 1M KCl, and phosphate retention was determined via the method of Blakemore et al (1981).

X-ray diffraction data showed similar trends in clay mineralogy across the lithosequence, with clay fractions dominated by kaolin minerals (kaolinite and halloysite), with lesser amounts of hydroxy-aluminum interlayered vermiculite and gibbsite. The upper portion of the profiles were predominantly kaolinite (0.7 nm), and clay mineralogy tended to shift from kaolinite to halloysite (1.0 nm), with an increase in the degree of kaolin hydration, with increasing depth. Thus, lithologies of divergent silica compositions converged on clay mineral assemblages dominated by kaolin minerals. However, soils diverged in iron oxide content and phosphate retention. Citrate-dithionite extractable Fe (Fe_d) diverged sharply between lithologies, demonstrating the influence of the initial composition of the parent material on Fe-oxide content. Soils formed from the most mafic end-member, e.g. basalt, had the greatest amount of Fe_d, while soils formed in the most siliceous lithologies, e.g. rhyolitic obsidian, had the least amount of Fe_d. Phosphorus retention also diverged between lithologies; soils with higher amounts of Fe_d retained greater amounts of phosphate. Fe_d and phosphorus retention showed a strong correlation ($P<0.001$), demonstrating that, through the influence of parent material on iron oxide content, soil properties related to management were influenced by parent material. Conversely, CEC was well constrained between soils in the lithosequence, demonstrating the convergence of soil properties most strongly influenced by clay mineralogy, and the unifying influence of climate on silicate clay mineral formation and related soil properties. Despite the divergent initial silica composition of the lithosequence, a common weathering environment results in the formation of a similar silicate clay mineral assemblage, demonstrating the dominance of climatic control on the neogenesis of silicate minerals in the xeric climate of California. Conversely, as silicate clay minerals are formed, Fe is conserved, resulting in soils with a suite of Fe-oxides strongly showing the imprint of the initial parent material composition. Thus, in volcanic soils formed in the mesic/xeric climate of northern California, climate exerts ultimate control on silicate mineral neogenesis and related soil physiochemical properties, while parent material strongly influences pedogenic iron oxide content and related soil physiochemical properties.

Keywords: *volcanic soils, halloysite, soil genesis, weathering, phosphorus retention, Fe-oxide, lithosequence*

P1-307

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

The Physical Quality of Andisols Under a Wide Range of Soil Development and Land Uses in Southern Chile

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Andisols present very peculiar physical properties: bulk densities < 0.9 Mg/m3, a well-defined inter- and intra-aggregate pore system, high hydraulic conductivity (Dörner et al., 2010), stable soil aggregates (Hoyos and Comerford, 2005), great shrinkage capacity and a large resilience capacity (Dörner et al., 2011). These soil attributes are unique and differentiate volcanic ash soils from other soil types. Volcanic soils cover almost 60% of the arable land in Chile (Besoain and Sepulveda, 1985) and, at the same time, present different degrees of soil development and are under a wide range of land uses (e.g. native forest, grasslands, croplands and orchards). This allows us to investigate how the soil development and the land use intensification affect Andisols' soil physical quality. In accordance with the latter, and considering the exceptional physical properties of volcanic soils, the following research questions are relevant: i) which soil physical quality parameters are the most effective when investigating soil physical changes?, ii) are the normally used critical values of soil physical functions applicable for volcanic ash soils and iii) can we use capacity parameters to describe a degradation in soil physical functions? In these terms, this work was aimed to present the effect of soil development and management on soil physical quality parameters of Andisols in southern Chile.

Disturbed and undisturbed soil samples were collected between 1-10 cm depth in a Soil Sequence (SS) of 4 Series from the Andes until the Central Valley (Liquiñe, Los Lagos, Osorno and Valdivia). The soils were under different land uses: Native Forest (NF), Pastures (P) and Crops (C). In order to investigate the effect of different soil management intensities, soil samples were collected from different managed pastures (from degraded till high productive) and NF in the Valdivia Serie. The disturbed soil samples were used to measure general soil properties as organic carbon, soil texture, allophane, particle density, amongst others. The undisturbed samples (n = 7 collected in cylinders of 230 cm3) were used to determine the water retention and shrinkage curves, as well as the air conductivity (kl). From this, physical quality indexes as air capacity (AC) and S-Index were calculated.

In the soil sequence (SS: from Liquiñe until Valdivia) and as a consequence of the soil management intensification (V: Valdivia), changes in soil physical functions were assessed due to changes in soil texture (in SS) and structure (in V). This resulted in an increase in bulk density (SS: 0.39 to 0.93 and V: 0.55 to 0.74 Mg m-3), decrease in air capacity (SS: 27 to 6 and V: 25 to 4%) and S-Index (SS: 0.08 to 0.04 and V: 0.09 to 0.06). On the other hand, while the bulk density (capacity parameter) is a good estimator of changes in intensity parameters (e.g. air conductivity) in the soil sequence, the same was not valid when investigating the effect of different management intensities in one soil Serie (V).
We concluded that volcanic soils present good physical properties; however, depending on soil development and management some physical functions, related to the macroporosity, can reach critical values (AC and kl) concerning soil compaction. In these terms, it was also assessed that i) critical values of bulk density proposed for non-volcanic soils (e.g. > 1.3 Mg m-3) are not valid for Andisols (e.g. values ≥ 0.9 Mg m-3 may reflect soil physical degradation) and ii) the air capacity is a simple parameter to determine changes in the physical quality of volcanic ash soils.

Keywords: *Volcanic ash soils, soil development, soil management, soil physical quality*

P1-308

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Stability of Soil Organic Matter in Particle Size Fractions in Top And Subsoil of Chilean Andisols

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Soils contain about 3-times more carbon (C) than above-ground vegetation which represents 75% of terrestrial C pool. This C may be source or sink of CO2 depending on its degree of stabilization in soil. Most likely stabilization degree is related to particle size with bigger particles containing labile C and the smallest particles such as clay and nanoclay being associated with C more stable to decomposition. In many soils, these small fractions contain the highest amounts of C. In Andisols containing high amounts of C stabilized by mineral interactions, the location and composition of C associated with different particle size fractions has rarely been analyzed. The aim of this research was to evaluate the role of particle size on location of stabilized C in southern Chilean Andisols sampled from two depths. Our conceptual approach included physical fractionation and separation of sand, silt and clay. Then nanoclay was extracted from clay fraction. We determined the elemental content of these fractions and subjected them to biochemical fractionation using a sequence of hydrolysis and oxidation reactions (Rovira et al., 2012). In addition, carbohydrates and phenolic compounds in the liquid fractions were analyzed and solid fractions were assessed by FTIR-spectroscopy.

Our results showed no differences in C content in the different particle size fractions from the topsoil layers of the two soils under different management (agriculture and grassland), whereas the subsoil layer of grassland soil showed lowest C concentrations in all fractions. Highest C concentrations were found in the clay and nanoclay fractions of all soils, supporting the assumption that stabilized C occurs in the finest particle size fractions due to strong mineral interactions. Bulk organic matter characterization by FTIR-spectroscopy showed some differences in chemical composition of the different particle size fractions. Biochemical fractionation removed preferentially N containing compounds. The chemical treatment led to increase of the C content of the small particle size fractions. The coarse particle size fractions showed decrease of the C content in the topsoil layer and no change in the subsoil layer. Considering the mass loss we found that the highest amount of recalcitrant material (up to 50% of initial C) was present in the coarse fractions of the subsoil layer, suggesting higher contribution of aliphatic and aromatic material in these fractions. Similarly low amounts of recalcitrant material were found in the nanoclay fractions of both soil layers suggesting higher contribution of sugars and proteins and also most probably mineral associated stabilized organic material, which was lost during chemical treatment.

We conclude that stabilized C occurs in high concentrations in the nanoclay fraction of Andisols and contributes in similar amounts to topsoil and subsoil layers. Also we observed that in subsoil the contribution of chemical recalcitrant C to physical fraction was not dependent on their size.

Keywords：*nanoclays, soil fractions, soil organic matter, carbon stabilization*

P1-309

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Accumulation and Mobility of Sulfate in Andosol Profiles Under Different Land Use and Fertilization

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Large accumulation of adsorbed sulfate is commonly observed in Andosol subsoils, but its origin and mobility in the soil profile have not been fully elucidated.The objectives of the present study were (i) to compare sulfate accumulation in soil profiles of Andosols derived from the same volcanic tephras but under different land use and fertilizer application, and (ii) to infer the mobility of sulfate and its effects on the downward movement of other anions in the soil profile.

Depthwise sampling of soil was conducted in the non-fertilizer and chemical fertilizer plots of Yawara field receiving zero or 320 kg-N ha^{-1} y^{-1}, and Osumi field and Chiran tea garden, developed on volcanic tephras having a common stratigraphic sequence with different thickness. The N application rate in the Osumi field was 140 kg-N ha^{-1} y^{-1}, whereas the Chiran tea garden had received larger amounts of N fertilizer, with a recent application rate of 500 kg-N ha^{-1} y^{-1}. Soil samples were collected in 5–10 cm increments to a depth of 1.8–5.0 m. Anion contents in soil were determined by ion chromatograhy after extraction with 0.01 M NaOH.

Both the chemical fertilizer (CF) and non-fertilizer (NF) plots of Yawara field exhibited substantial accumulations of adsorbed SO_4^{2-} in the subsoil, but SO_4^{2-} content at any given depth in CF plot was higher than that in NF plot, with the maximum SO_4^{2-} contents of 190 $mmol_c$ kg^{-1} and 138 $mmol_c$ kg^{-1}, respectively. The SO_4^{2-} accumulation extended to a greater depth (≈ 220 cm) in CF plot than in NF plot (≈ 200 cm), and the decreases with depth in the SO_4^{2-} content were accompanied with concomitant increases in the Cl^- and NO_3^- contents. Significant accumulation of Cl^- and NO_3^- in the deep subsoil having SO_4^{2-} content as low as 10–15 $mmol_c$ kg^{-1} implies that the monovalent anions were pushed ahead by SO_4^{2-} arriving from the upper layers.

Sulfate accumulation in the Osumi field strongly reflected anion adsorption characteristics of soil materials, and showed considerable differences among the layers. Except the uppermost 65 cm where the supply of F from chemical fertilizers is suspected, the depth-dependent changes in the SO_4^{2-} content showed a notable resemblance to those of 0.01 M NaOH-extractable F^-. The highest SO_4^{2-} content of 129 $mmol_c$ kg^{-1} was found in 'Akahoya' layer. Similar differences in the SO_4^{2-} content among the layers were observed in the Chiran soil profile. Sulfate contents were, however, several times higher than those in the corresponding layers in the Osumi field. 'Kuroniga' layer, where the highest NO_3^- content in the profile was found, had a high SO_4^{2-} content of 297 $mmol_c$ kg^{-1}.

These results suggest that SO_4^{2-} accumulated in Andosol subsoils has been mainly derived from external sources and possesses a substantial mobility in soil profiles. Depending on the relative rates of tephra and SO_4^{2-} deposition, subsoil lacking SO_4^{2-} accumulation may be developed. Arrival of SO_4^{2-} from the upper layers impairs the soil's capacity for the adsorption of less competitive anions such as Cl^- and NO_3^-. Nevertheless, when compared among different soils, adsorbed SO_4^{2-} content serves as an indicator of positive charge carried by the soil materials, and their propensity to adsorb monovalent anions.

Keywords：*adsorption, nitrate, subsoil, sulfate, tephra*

P1-310

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Effect of Applying Fresh Cow Dung on Phosphorus Pools and Other Soil Properties in an Acid Chilean Andisol

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Acidity, allophanic mineral components and the large organic matter content in Chilean Andisols promotes the immobilization of phosphorous (P) in these soils, thereby decreasing its availability to plants even when total P content is between 1000 and 3000 mg kg-1 in unfertilized soils. The major fraction of the available P in these soils is associated with organic macromolecules having molecular weight less than 30.000 Da. The P fraction immobilized in high molecular weight complexes is more recalcitrant, therefore is less available to plants . This less-available P fraction is associated with humic acid and the humin fraction of soil . In a grazed pasture soil, P transformations into various fractions and the availability of P to plants are influenced by plant uptake and the return of P through animal excreta ? mainly in dung. Grazing animals recycle between 60 and 99 % of the ingested P mainly through excretal transfer. The total P content in dung and manures varies considerable and P is incorporated into soil as organic compounds, mainly inositol phosphates and inorganic forms mainly orthophosphate and other species such as pyrophosphates and polyphosphates. The P cycle in soils is a dynamic process influenced by the relatively slow chemical transformations and the more rapid microbial changes involving soil/plant interactions. P uptake by plants results in changes in the proportions of P in the various mineral and organic fractions. The forms and availability of P in soil is also influenced by microorganisms responsible for mineralization and immobilization processes.

We determine the effect of applying fresh cow dung on phosphorus pools and other soil properties (nitrate, ammonium and pH) in an acid Chilean Andisol are described. The properties were monitored for 6 months in soil columns, on the top of which cow dung was applied. Columns were destructively sampled every month and the soil was divided into 10 cm depth increments.

Soil pH, and phosphate concentration increased in 0-10 cm fraction at 30 days. After this pH decreased from 5.4 to 4.9 at the same depth. P-NaHCO3 fraction increased (69 to 75 mg kg-1) in 60 day. Then this fraction decreased (10 mg kg-1) due to microbial activity and pH change. From the 120 to 180 days the P-NaHCO3 fraction recovered its original level. P-NaOH fraction decrease according to soil depth; this was correlated to the sonicated P-NaOH fraction increase (bivariate correlation=-0.295 $p<0.01$). P-residual increased to 100 mg kg-1 at 40-60 cm depth soil. P-HCl fraction decreased significantly ($p<0.01$) at all depths from 10 to 5 mg kg-1. Only an organic P-form was found (5-10 mg ml-1); in the leaching solution. 31P RMN indicated that this is an orthophosphate diester. Results showed phosphorus diffusion and fixation from 0-10 cm toward 30-60 cm, because of the less organic matter content. A mathematical model for describing the P dynamic is proposed. Its parameters were calculated using the experimental data. No significant differences ($p>0.05$) were observed between experimental and calculated values of P-labil fraction, P-NaOH, sonicated P-NaOH. However, the model was not able to simulate the behavior of P-HCl and P-residual fractions and the difference between experimental and calculated values were significant ($p<0.05$).

This study was supported by FONDECYT Project of Chilean Government

Keywords：*Andisol, phosphorus, organic phosphorus, Hedley fraction, cow dung*

P1-311

[C1.3-2] Volcanic Soils: Distinctive Properties and Management

Diminishing Grain-Size of Mt. Fuji-Derived Holocene Intermediate Tephras in Japan with Increasing Distance, and Different Directions, from Volcanic Source: Influences on Andic Soil Properties

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Pyroclastic fall materials from Mt. Fuji, typically andesite-basalt in composition, were deposited almost due east by the prevailing westerlies in south Kanto, central Japan. Tephra thicknesses and grain sizes thus decrease eastward. Because finer grains have a larger specific surface than coarser grains, then the rate of weathering of the fine grains is enhanced, as indicated by various secondary properties including Al/Si ratio, the formation of different clay minerals, and degree of humification. We studied six pedons formed by upbuilding pedogenesis derived from Holocene fall deposits at a range of distances (km) and azimuths (degrees) from their source volcano, Mt Fuji as follows: (1) Yamanakako (18 km, 27°); (2) Ohkura(40 km, 6°); (3) Nishi-Ohtake (48 km, 1°); (4) Fujisawa (67 km, 2°), (5) Sagamihara (64 km, 30°); and (6) Tachikawa (72 km, 33°). At each site, the Holocene deposits were divided pedostratigraphically into four horizons according to eruption age from youngest to oldest. Uppermost scoria material, Hoei tephra, was deposited in AD 1707. Material comprising the 2nd horizon was deposited around 1,200 calendar cal. yr BP, correponding to the Medieval Warm Period. The materials comprising the 3rd horizon were deposited c. 1,200-4,000 cal. yr BP. The 4th horizon is a composite of materials grouped into a horizon named “Fuji black horizon” that formed c. 4,000-10,000 cal. yr BP, corresponding to the Jomon transgression and the Holocene Climate Optimum, with relaively high clay and humus contents. In accord with increasing distance from Mt. Fuji, the textures of the soil horizons of each of the pedons become finer. The textures reflect the original (primary) particles and different amounts of secondary particles (clay-size minerals) that have formed to a greater or lesser extent according to the primary particle sizes that in turn relate to distance from source. The Yananakako soil is an Udvitrand with c. 1.8 m of coarse textured (sandy loam) materials, including scoria (>2 mm) formed from the Hoei tephra, to the base of the 3rd horizon. The texture of the 4th horizon (Fuji black) in this soil is LiC, finer than those of upper horizons but coarser than the equivalent horizons at the other pedons. The soil at Ohkura is an Udvitrand and the texture of the 1st horizon (Hoei tephra) is LS to S. This soil has the coarsest textures overall because the thickness of the Hoei tephra exceeds that at any of the other pedons. The Nishi-Ohtake soil is a Melanudand and has finer textures (SCL to HC) compared with those of the Ohkura soil. The Fujisawa soil is a Melanudand and the textures of the horizons range from LiC (1st horizon, Hoei tephra) to HC (4th horizon, Fuji black). This soil has a thick humic horizon (2 m) and the highest content of humus compared with those of the other pedons. The Sagamihara soil is a Melanudand and the textures range from SiL (1st horizon, Hoei tephra) to HC (4th horizon, Fuji black). The Tachikawa soil does not fit these trends, however it has a lower clay content (despite being farthest from Mt Fuji) because it is located on a low terrace with the lowest horizons formed on well drained alluvium, so the horizons get mixed with alluvial materials and not developed humic horizon such as the Fuji black. SiO2, CaO, MgO, K2O,Na2O are decreased by eluviation, whereas Al2O3, Fe2O3, TiO2, and MnO2 are increased because they are residual. Therefore, weathering indexes such as SiO2/Al2O3 decrease in the Yamanakako to the Tachikawa soil with increasing distance from Mt Fuji. The values of the (Alo-Alp)/Sio ratio increase from Yamanakako (1.3) to Fujisawa (2.0), reflecting the concomitant formation of Si-rich to Al-rich allophane. The Yamanakako and Ohkura soils have 20 and 60 cm of the Hoei tephra, respectively. Both are little weathered and hence these horizons have high Si/Al ratios and small amounts of Si-rich allophane, halloysite, and opaline silica, indicating a Si-rich weathering environment. Beyond the Fujisawa area, about 27 km southeast from Ohkura, the soils have Al-rich allophane and gibbsite, indicating an Al-rich weahering environment. In contrast, the Nishi-Ohtake soil, 8.2 km southeast from Ohkura, contains only allophane but no gibbsite nor halloysite, indicating that it lies in a transitional zone rich in both Si and Al.

Keywords：*tephra size, weathering, clay formation, humification*

P1-312

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Cultivation of Populus Euphratica* Populus Alba Hybrid in Garmsar Saline Soil Plain in Iran

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One of the specificities warm and dry climates is this that evaporation is more than precipitation of land salinity that is. 20 million hectares of Iran's soil is alkaline and saline soils constitute that day is added to the surface. Increasing demand for wood and wood products And loss of forest area in the country has led to the cultivation of wood. Poplar due to extensive ecological adaptability of plant species suitable for this purpose are and the Poplar Populus euphratica and hybrides most species are resistant to salt. Poplar species react differently to salinity is chosen based on the hybrid nature of the resist should be chosen.

The response of hybrids to salinity transfer characteristic 'salt tolerance' of the Euphrates poplar hybrids are other considerations. This project led to further plans to use the land for wood production is saline soil. The Populus euphratica and hybrides roots of seedlings grown in a randomized complete block design and variables such as height growth, diameter and survival rate were measured during the growing season.Data using SAS software and statistical analysis was performed by Duncan's test. Analysis of variance showed that the diameter and the height difference between hybrids and species, there is a significant level of 5%.

Keywords：*salinity, poplar, Iran, wood, plain*

P1-313

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Utilization of Salt Tolerant Species for Rehabilitation Coastal Saline Soil at Petchaburi Province of Thailand

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Salt-affected soils in Thailand cover an area of 2.302 million hectares. It can be classified to inland geologic origin in northeastern part and coastal salt-affected soils originated from seawater. Coastal salt-affected soils are scattered along the coast of the Southern and Eastern regions, covering an area of 0.425 million hectares. The management of coastal salt-affected soils needs to cope with the specific characteristics of local soil and water regimes. Biological method is one of the methods that recognized. The study on utilization of salt tolerant species for rehabilitation coastal saline soil at Petchaburi province of Thailand was carried out at Sirindhon International Environmental Park, Cha-um district, Petchaburi province during 2010-2011. The objectives are to compare growth of salt tolerant species on coastal saline soil and to study the effect of salt tolerant species plantation on change of soil chemical properties and rehabilitation of coastal saline soil. The experimental design was randomized complete block design with 4 replications. Salt tolerant species namely 1) Dixie grass (Sporobolus virginicus coarse type) 2) Smyrna grass (Sporobolus virginicus smooth type) 3) Seabrook grass (Distichlis spicata) 4) Georgia grass (Spartina patens) and 5) natural grass were studied. It found that Dixie grass showed highest survival percentage of 99.31 % at age of 4 months after planting, higher than Smyrna grass, Georgia grass and Seabrook grass, respectively. Seabrook grass gave highest fresh weight and dry weight of 19.79 and 12.18 t ha-1 during 14 months of experiment, higher than Georgia grass, Smyrna grass and Dixie grass, respectively. However, biomass varied with type of plants and age. And it found that Seabrook grass showed higher Na accumulation in stem of 36.94 kg ha-1, elements accumulation varied with dry weight and element concentration in plant. After the experiment, soil organic matter and available phosphorus were increased, especially at Seabrook grass plot increased from 0.52 to 1.32 % and 40.25 to 225.75 mg kg-1, respectively while available potassium was decreased from 228.75 t0 170 mg kg-1. Generally soil electrical conductivity was decreased; at Seabrook grass plot, ECe was decreased from 12.46 to 6.02 dS m-1. From these results, it can transfer to farmers, group of farmers or organization for rehabilitation coastal saline soils.

Keywords：*Coastal saline soil, Dixie grass, Smyrna grass, Seabrook grass, Georgia grass*

P1-314

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Characterization and Classification of Some Selected Wtland Soils for Rice and Vegetable Production in Ekiti State, Nigeria

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Field experiments and Land Evaluation and Degradation Studies were carried out on three wetland soils for rice and Vegetable production in Ekiti state, Nigeria. Results obtained from the study showed that the wetland soils were found to be moderately suitable (S2) to non-suitable for wetland rice production.They were also found to be moderately to highly suitable for Drip irrigation but not suitable for gravity irrigation.Ten soil properties(pH,sand,silt,CEC, Mg, Zn, Avail. P. Cu, Na and Ca)were found to correlate with rice yield on these wetland soils.The best Crop and soil Management practices(spacing-25cm by 25 cm,fertilizer rate of 100kgN/ha or rate based on soil test, birds control using nets or explosives) were evolved for rice production on farmers fields.N15 studies showed that recovery of rice of N15 was much higher at sites 1 and 3 when compared withsite 2.Management practices(Local and improved) on wetland rice field have significant($P<0.05$) effects on Soil organic matter,N,Mg,Ni, Cu and Pb.With twenty two soil properties in regression, the soil properties that contributed most to rice yield were Zn,Mg,Pb, Mn,Cu, Clay and Silt.Significant($P<0.05$) higher leaf yields were obtained for A.Cruentus(28.9ton/ha) and C.argentea(35.8t/ha) under cultivated wetland(L2) using the Fertilizer Factor(Ff) when compared to other Landuse types and fertilizer Regimes. Least leaf yields were recorded for the two vegetables under control(no fertilizer) regime. Statistical analysis($P<0.05$) showed that total Carotenoids, crude protein and calcium contents of A. cruentus(V1) were significantly higher than that of C. argentea(V2) under all Landuse types.The plants under Ff had significantly higher contents of carotenoids, calcium, ascorbic acid, and Crude protein and crude fibre compared to plants under blanket and control treatments.The result of the study showed that higher leaf yields and optimum nutrient composition of A. cruentus and C. argentea can be realized by proper combination of Landuse types and Fertilizer rates.

Keywords：*characterization, classification, wetland soils,Rice, Vegetable, Ekiti, Nigeria*

P1-315

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Soil Resource Potential of Buraka Micro-Watershed in Mewat District of Haryana, India for Integrated Development

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Land and water are the basic natural resources and form essential inputs to growth and prosperity. These resources have to be used carefully and conserved for sustainable development. Keeping this view in mind, the Buraka micro watershed in Mewat district of Haryana in India was taken up for detailed soil survey and its characterization for integrated development. The area is situated between 28^{o} $10'00''$ to 28^{o} $11'58''$ N latitudes and 76^{o} $57'12''$ to 76^{o} $59'34''$ E longitudes occupying agro-ecological subregion No. 4.1. The area of micro watershed is 635 ha comprising Buraka, Panchgaon and parts of Chila and Gwarka villages. The elevation ranges from 266 to 335 meter above mean sea level and slope varies from nearly level to moderately steep slopes. The geology is sandstone and quartzite. Major crops grown are bajra, wheat, jowar, mustard, pigeon pea and barley.

The geocoded IRS P6 LISS IV data on 1:12,500 scale was integrated to prepare the physiography map of the study area. The detailed soil survey had been conducted by studying minipits and master pedons. On the basis of remote sensing data and field observations seven physiographic units viz Hill tops, side slopes, inter hill basin, upper piedmont plain, middle piedmont plain, lower piedmont plain and stream terraces. Ten soils have been identified and mapped into 22 soil mapping units as phases of soil series. Soils of hill tops are shallow, gravelly sandy loam, brown in colour and classified as Loamy skeletal Lithic Ustorthents. Soils of side slopes are shallow, gravelly sandy loam, brown in colour and classified as Loamy skeletal Lithic Ustorthents. Soils of inter hill basin are deep, calcareous, loamy sand, yellowish brown in colour and classified as calcareous, Typic Ustipsamments. Soils of Upper piedmont plain are deep to very deep, loamy sand to sandy loam in texture, brown to dark yellowish brown in colour and classified as Typic Ustipsamments and coarse loamy Typic Haplustepts. Soils of middle piedmont plain are very deep, loamy sand to sandy loam in texture, both calcareous and non calcareous, dark yellowish brown in colour and classified as Typic Ustipsamments, coarse loamy (calc) Typic Haplustepts and coarse loamy Typic Haplustepts. Soils of lower piedmont plain are very deep, loamy sand to sandy loam in texture, calcareous, brown to dark yellowish brown in colour and classified as calcareous Typic Ustipsamments and coarse loamy (calc) Typic Haplustepts. Soils of stream terraces are very deep, loamy sand in texture, calcareous, yellowish brown in colour and classified as calcareous Typic Ustipsamments,

Various thematic maps viz land capability, land irrigability, drainage, erosion, slope, soil depth and texture have been generated. The study reveals that the soils of the watershed are mostly neutral (pH 6.5 to 7.5), low in organic carbon (< 0.4‰), low in cation exchange capacity (1.0 to 9.0 Cmol〈p^{+}〉 kg^{-1}) with base saturation 70 to 85 percent. The soils are in general low in fertility status. However, it varies with land use, soil characteristics and landform. Sandy soils (Typic Ustipsamments) are low in available nutrients (macro and micro) where as sandy loam soils are variable in fertility status (low to high) due to variation in management practices. Available P content in general is medium to high (12 to 24 kg ha^{-1}) due to its regular application except soils of hills and sandy soils of plains whereas available K content is low to medium because of its rare application. Most of the soils are deficient (< 0.6 ppm) or medium (0.6-1.2 ppm) in available Zn because of depletions due to continuous cultivation. Sulfur content is mostly deficient in most of the soils due to low organic carbon and coarse texture except uncultivated soils and some cultivated soils where S containing fertilizers are applied for oilseed crops and its content is more than 10.0 ppm. The soils have adequate reserves for Fe and Mn content except in sandy soils where it is low to medium. This information of soils is highly useful for integrated development of the micro-watershed.

Keywords：*Micro-watershed, Physiography, Detailed Soil Survey*

P1-316

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

The Subaqueous Soils of the Danube Delta Biosphere Reserve

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Danube Delta is situated in Eastern Europe in the northwestern part of the Black Sea at the intersection of the 45°N parallel of latitude with 29°E longitude. The most part of these delta belongs to Romania's territory and is a Biosphere Reserve, that has about 580,000 ha. Its mean elevation is 0.52 m above Mean Black Sea Level.

Special soil surveys were carried out between 1975 and 1992 (Munteanu, 1984; Munteanu et al, 1989) and published few years later (Munteanu, 1996). These area of the Danube Delta comprises a big part with submersed soils, named Limnosols by Ioan Munteanu and floating Histosols; these soils occupy more than a quarter of total delta's area.

Extending the Kubiena classification (1953), Munteanu distinguished the Limnosols as specific soil category for the bottom of the lakes or lagoons, many years before the subaqueous soils to be introduced in the international soil taxonomies, namely in World Reference Base for Soil Resources (WRB) in 2006 and in Soil Taxonomy (ST) in 2010.

The subaqueous soils (or submersed soils) are formed as consequence of some peculiary processes that justifies their consideration as distinct soils different from other kind of soils:

- accumulation of organic matter due to activity of the subaquatic vegetation and fauna;
- lime deposition as a consequence of the photosynthetic activity of the subaquatic vegetation;
- formation in the subaquatic milieu of the reducted compounds, in certain cases pyrite, and volatile compounds of anaerobic transformation of organic matter (mainly CH4).

On this basis, the limnic horizon was defined as main diagnostic character for Limnosols (Munteanu, 1984; 1996).

This soil taxon was introduced also in the Romanian System of the Soil Taxonomy (RSST) in 2003 and 2012 (second edition). According to RSST (2012) the subaqueous soils from Danube Delta belong to two taxa, Limnosols and Submersed Histosols; also these soils are found in two taxa in WRB, as Subaquatic Fluvisols and Subaquatic Histosols, and in Soil Taxonomy (ST) in two suborders Wassents and Wassists. Only in the RSST taxon Limnosols is considered as apart taxon and not as a subdivision of Fluvisols (or Entisols). This perception seems to be justified because the Limnosols are soils that acquire specific features formed in long time and in specific conditions and processes.

Concerning the subdivisions of these soils there is a very good correlation between RSST and WRB and a little good with ST because in this system the contents of carbonates and of soluble salts are taken into account only at lower level of classification

(family, series) and in exchange the “n value” (fluidity - deformation degree) is considered. It is considered useful to introduce the limnic subgroup for the Psammowassists and Hydrowassents (already used at some great group of Histosols).

A special kind of Histosols, encountered in Danube Delta is the “plaur” (Romanian word) that is organic soils floating on water, forming wandering islands.

The different taxa of Limnosols and Histosols from Danube Delta are characterized by analytical data.

Area occupied by subaqueous soil is of 106,900 ha, representing 26.3% from total area; about 9% correspond to Floating Histosols, 3.7% to different subaquatic Histosols and 13.6% to Limnosols (out which 9.4% are saline). The Limnosols are associated in territory with Histosols and Gleysols, and Histosols with Limnosols, Gleysols and Psammosols (in the marine part of Danube Delta).

Being a natural reserve, the soils of the Danube Delta are used more or less in natural conditions (small areas were diked and cultivated). The Limnosols and Histosols are used for wildlife and reed harvesting and also for pisciculture. The tourisme is an activity in course of developing. But this delta remains an interesting territory of various researches on soils in relation with their natural conditions and with different kinds of land use and human activities.

It is suggested that soil unit of Limnosols to be introduced in any soil taxonomy at a high level, these soils reflecting indeed conditions of landscape (of energy fluxes and pedogenic processes and factors) altogether different from those specific to other soil units.

Keywords：*subaqueous soil, Danube Delta, Limnosol, Histosol*

P1-317

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Elite and Prime Land: Similar Messages and Continued Trade-Offs Over Half a Century Later in New Zealand's Largest City

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A formidable global challenge is securing soil and water resources to support an ever-increasing population and sustainable land management options are essential to achieve these requirements. In Auckland, New Zealand's largest city, population growth is forecast to increase from 1.5 to 2.5 million by 2040 putting immense pressures on the region's soil resources to accommodate future growth. The objective of this study is to robustly quantify the amount of elite and prime land (Land Use Capability Classes 1-3) that has been converted, and what is likely to occur, to urban development in Auckland using both long-term trend and future growth records.

Spatial analysis indicated that 10,399 hectares (or 8.3%) of elite and prime land has been converted to urban development through incremental urban extension, operative/approved greenfields and building consents. Furthermore, the majority of land allocated to urban extension since 1996 is elite and prime land. Looking into the near future, lodged/future greenfield developments equate to an additional potential conversion of 6,010 hectares (or 4.8%) of elite and prime land. Conversion of highly productive agricultural and horticultural land in and around Auckland caused by the continuous extension of the urban frontier can be traced back to the early-mid 1900s and future growth pressures indicate that this trade-off will continue.

There is a real need to analyse the economic benefits and long-term sustainability of future development and the protection of elite and prime land for current and future production needs to provide prolonged benefits to the wider and future communities. Further research should account for the true cost of lost provisioning, regulating and cultural services soil natural capital supports to ensure that these values are recognised and considered by not only urban planners but by both policy and, more importantly, decision-makers in Auckland. It has never been timelier to assess the consequences of continued elite and prime land trade-offs to development in Auckland, particularly its implications on current and future food security requirements.

Keywords：*Versatile land, soil natural capital, urbanisation, population increase, Auckland*

P1-318

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

The Amount and Distribution of Peatlands Carbon Stock in Selected Areas of Papua, Indonesia

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Peatlands has significant roles in the ecosystem, among them are well known for high Carbon (C) storage. Peatlands are mostly covered by peat swamp forest and mangrove forest and characterized by large diversity of species which are mostly dominated by small size of trees. However, it is surprisingly invented that the available data on carbon storage for Papua regions are insufficient. Soil carbon stock inventory is important to rectify determination of peatlands. This land type has long been considered as carbon sink ecosystems. However, with the onset of climate change, peatlands may become carbon source ecosystems with the potential to lose carbon (Koehler et al., 2010). Pristine peatlands can function as a persistent sink for atmospheric CO2 (Tolonen and Turunen, 1996) and source for CH4 (Huttunen et al., 2003).

In order to achieve an effective peatland conservation strategy, it is necessary to have an adequate information on the actual extent and the current status of peatland. Therefore, objective of the research was to measure the amount and distribution of C stocks of peatlands in selected areas of Papua, Indonesia.

There were three selected study sites for C-stock sampling in Papua, Indonesia (Figure 1a, i.e. Sorong Selatan (Teminabuan District), Bintuni (Bintuni District and Aranday District), Timika (Mimika District). The study was conducted in September 2011. Detail of C-stocks sampling in the field referred to the Field Sampling Protocol for C-Stocks Assessments in Tropical Wetland Ecosystems (Kauffman and Donato, 2011; Kauffman et al., 2011). The total carbon stock or pool (carbon density) was estimated by adding all of the component pools, as follows : a) Each component pool was averaged across all plots (e.g., trees, soil, etc); b) These average values were then summed together to obtain the total. Total C stock (Mg/ha) of the sampled stand = CtreeAG + CtreeBG + Cdead-tree + Csap/seed + Csap/seedBG + Cdeadsap/seed + Cnontreeveg + Cwoodydebris + Csoil. (CtreeAG = aboveground carbon pools of trees, CtreeBG = belowground tree carbon pool, Cdead-tree = the dead tree pool, Csap/seed = saplings and seedling carbon pools, Cnontreeveg = non-tree vegetation carbon pools, Cwoodydebris = downed wood carbon pool, Csoil = the soil carbon pool). Total C stock of project area (Mg) = Total C (Mg/ha) x Area (ha).

The data presented in this study show that peatland ecosystems stored exceptional high Carbon comparing to other ecosystem in the tropics. There was a spatial variation between the selected sites in soil carbon estimation. The quantities of carbon were hold two fold in the soil pools comparing to that holding in the biomass of vegetation. However according to biplot analysis, it is clear that the life trees were also contributed importantly to the C stock of the ecosystems. A small stature of vegetations but in large

number of individuals could not be ignored in their roles to the C stock of the ecosystem such as shown by saplings of Nypa fructicans and Metroxylon sagu that frequently occurred in dense population. It was observed that the variation of C stock in peatland ecosystem of the studied area was in the range of 1484.34 to 1833.12 Mg ha-1. The highest value was recorded in the peatland of Teminabuan. Below ground pools of roots and soils had significant contribution to the majority of C storage in this ecosystem. These total carbon stock were exceptionally higher compared to the other forest types, and even to the same peatland located around the world.

The result implies that peatlands are unique ecosystems that need to be well managed so that it contribute to the benefits for local, regional, and global communities, and therefore evaluation of soil organic carbon is important for protecting peatlands function.

Keywords：*Carbon stock, peatlands, swamp forest, mangrove, species diversity, Wetland Papua*

P1-319

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Agronomy Development of Mustard Plants (brassica Juncea) Grown on Mining Soils

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Introduction

Mining and metallurgical activities are known to be an historical and actual source of heavy metals environmental contamination. Since mining is a very important sector of the Mexican economy, the environmental problems these practices cause through the generation of mine tailings (jales) calls for effective remediation strategies. Phytoremediation uses plants to remove-accumulate, or chemically reduce, transform, mineralize, volatilize or stabilize these contaminants. Among these techniques, phytoextraction (ability to mobilize and accumulate heavy metals in the aerial plant part) offers a feasible solution for removing contaminants that cannot be otherwise degraded, such as heavy metals. Metal bioaccumulation capacities of some specialized plant species may provide an effective and in situ way of removing heavy metals from contaminated soils. Two important factors to be considered for a plant to be a good phytoextractor rely on the biomass and efficiency bio-concentration processes.

Experimental

In this work, the pytoextraction capacity of mustard plants (Brassica juncea) grown on mine soils contaminated by Cu, Cd, Pb and Zn was evaluated. The first part of this study was focused on correlating metal concentration and uptake with the various plant growth parameters (agronomic parameters), mainly to evaluate the plant development of a metal tolerant plant.

Mustard plants were grown on three mine tailings from Zimapan, Hidalgo State, Mexico, differing in oxidation-aging degrees and correspondingly in pH values (acid, moderately acid and neutral). Different mixtures of jal:soil (neutral pH from the mining area) were prepared in order to grow and evaluate plant development. During the experiment leaves number, leaf width, plant height and chlorophyll index (SPAD-502 (Konica Minolta)) were monitored.

Xylem sap was also extracted introducing the fresh plant part (without root) in a 5 ml syringe. The syringe was frozen until the time of analysis. This technique allows the plant extraction of sap with a minimal sample manipulation. Concentration of inorganic anions and cations was determined by ion chromatography in the cell extract obtained.

Results and discussion

Plant growth was severely limited when plants were grown in the highly acidic mixtures. Plant photosynthetic activity was also reduced, probably because the metal bioavailability in acidic mixtures is always higher than in moderately or neutral media.

The xylem sap analysis showed low concentration of nitrates, N-NO3-, especially in plants grown on high jal proportions. Low nitrates levels affect plant development and the chlorophyll production. However, the high phosphate contents found helped the plant growth. The lower the levels of jal in the mixtures, the higher the Ca2+, K+ and PO42- concentration in xylem sap, especially in the first days of plant development. The phosphate presence was directly correlated with N and S metabolism. Plants grown on high levels of jal in the mixtures showed higher Na+ concentrations in the xylem sap.
Most probably, the presence of bioavailable metal in the acidic mixtures, exacerbated by the low pH values, had a severe influence on plant growth, and therefore on the phytoextraction efficiency. Therefore, from these preliminary it could be considered that B. juncea could efficiently operate only in the case of slightly acidic media. The technique used to extract the xylem sap was successfully applied, as long as enough biomass was obtained from the plant.

In view of these results, it must be considered the potential role of agricultural practices in the future of phytoremediation. Liming and fertilization practice will facilitate the potential growth and phytoextraction of metals by the plant selected.

Keywords：*Brassica juncea, jal, phytoremediation*

P1-320

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Subsidence Rate in Peatland Planted to Acacia Crassicarpa at Bukit Batu, Riau over a Two-Year Measurement

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Measurement of peatland subsidence has been conducted for two years in two adjacent blocks of Acacia crassicarpa plantation in deep peat at Bukit Batu, Riau. The subsidence was monitored using a pole anchored up to the underlying mineral sediment in 4 points within a block that have been opened and developed for plantation for past 9 years, and 2 monitoring points located in another block that have been opened for plantation for the past 6 years.

Additional measurement of microrelief surrounding each pole based on two crossed-horizontal lines with each pole as the centre was conducted during the second year. The additional microrelief measurement is to check if the subsidence process is evenly distributed over a finite area surrounding a pole, and if the subsidence is consistent with the data recorded right at the pole.

The results show that the peat subsidence rate of deep peat during two years consecutive measurement after 6-9 years elapsed after forest conversion into A. crassicarpa plantation was found to vary within narrow space with an average of 3,5 ? 4 cm per year, a figure that is lower than most published data. Interesting results were observed in that the subsidence rate fluctuated over two years, and that the land surface was found to alternately go down and up following the water table. Therefore, it is hard to say that the land surface will go down further if the measurement is continued. The two crossed lines measurement show surprising data in that the rate of subsidence was found to be about 1 cm which is completely inconsistent with the data from the pole point. This observation shows that the accuracy of a single point measurement is therefore considered weak. Measurement of peatland subsidence using a technique of a pole based measurement combined with measurement of change in the surrounding microrelief is more powerful to get reliable data. Using this combination technique will in turn reduce the amount of poles to be anchored.

Keywords：*Acacia crassicarpa, microrelief, peatland, subsidence*

P1-321

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Exactly Soil Science Study of South-West Iran Region

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Soil survey studies are one of the necessary preliminary studies for the further future development in each region. Therefore, in the present study, the soils of Mirza Kochak Khan Agro-Industrial company has been studied as representative soils of south-west Iran in terms of macro and micro morphological, physico-chemical, mineralogical characteristics and finally classified according to USDA soil classification system. Twenty pedons were digged and studied based on air photo, topographic and geological maps with appropriate scale, using the grid method. The samples from each horizon were characterized by physico-chemical, mineralogical and micromorphological methods. The results showed that Typic Torrifluent and Typic Haplocalcids are the most dominant soils in this area with more or less developed profiles. The Ochric epipedon occur on top of these soils and calcic or cambic horizons have been recognized at the subsurface layers. Accumulations of secondary carbonates are not clearly visible throughout some of soil profiles, but carbonate accumulation showed with lab and micromorphological results. A negative correlation between steepness of the soil surface with soil development and depth of maximum carbonate accumulation have also been observed in this soils i.e. the more steep soil surface the less developed soil profile and the more close calcic horizon to the soil surface. The soils on the low laying lands don't show calcic subsurface horizon, in contrary they have a good properties of fluvial materials. So, they have been classified as Typic Torrifluent. The soils that occur on the upper slope of small hills, and they have neither a calcic horizon nor fluventic properties, therefore they have been classified as Typic Haplocambids. These soils have an Ochric epipedon on top and a Bw horizon, which is not qualified for a cambic horizon at dept. However, the main reason for occurring different soils in different parts of this region is most probably slop gradient and aspect, which can control the soil erosion and deposition through the degree of stability of the land surfaces. The results of micromorphological studies showed that the main rocks in these soils are transported and basic igneous rocks and also calcareous rocks. Also the main micromorphological pedofeatures are crystallitic pedofeatures in the form of nodules, cutans and pendants. These findings have also confirmed the degree of soil development, depth and thickness of pedogenic horizons determined by other methods.

Keywords：*Micromorphology, Classification, Mineralogy, Carbonates accumulation, Fluventic soils, Sou*

P1-322

[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Characterization and Classification of Salt Affected Soils for Reclamation and Management - A Case Study Of Haryana, India

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Haryana is one of the most agriculturally important state in India but about 2.33 lac hectares area of the state is affected by salinity/sodicity which is declining the crop productivity. Delineation and chracterisation of salt affected soils is thus very essential to improve the soil quality and crop productivity. The information on the degree and extent of salt-affected soils and depth of its occurrence is prerequisite for managing such degraded soils. Keeping this in view, a case study was carried out to identify, characterize and classify the salt affected soils in the Lakhan Majra Block, Rohtak district, Haryana state. The study area lies 28° 55' 26″ to 29° 05’ 56″ N latitude and 76° 28’ 25″ to 76° 35’ 35″ E longitude, occupies an area of 7409 hectares and is tract of Indo-Gangetic alluvial plain with nearly level to level old alluvial plain (concave relief) physiography under sub-tropical, semi-arid climatic condition. The interpretation of IRS-P6, LISS-IV Geocoded remote sensing imageries coupled with ground truth was carried out to demarcate the extent of soil salinity/sodicity. The representative soil profiles were studied in the field and soil samples were collected for their characterization and classification. The major soils identified were Inceptisols and taxonomically classified as Typic Haplustepts, Typic Calciustepts, Natric Haplustepts, Typic Halaquepts and Aquic Halaquepts. Soils in general are very deep, moderately to imperfectly and poorly drained, yellowish brown to olive brown/light olive brown, loam to clay loam/silty loam in texture. The clay content ranges from 20 to 38 per cent. The soils were moderately to strongly alkaline and pH ranged from 8.4 to 10.2. EC ranged from 0.8 to 5.2 dS m ?1, CEC from 10 to 20 cmol (p+)Kg ?1 . The CaCO3 content ranged from 5 to 19 per cent and it increased with depth. The ESP values ranged from 8 to 28. The study area suffers from salinity/sodicity in varying degrees due to improper use of canal water and poor quality of ground water. In some area it is due to concave (saucer shape) topographic setting, which result rise of water table and consequent accumulation of salts. Soil were categorized in different classes of salinity/sodicity as per there severity of occurrence. Nearly 48.2 % soils were slightly saline, 10.2 % as slightly saline/ slightly sodic, 5.4 % as moderately saline/moderately sodic and 14.4 % area belonged to strongly saline soils. Saline ground water in the semi-arid region could be responsible for the development of salinity/sodicity due to accumulation of salts within root zone through capillary rise during dry season which further aggravated by fluctuating ground water table. These salt affected soils can be amended by adopting suitable reclamation measures like application of low doses (4 t ha ?1) of Gypsum and Pyrites coupled with improved management practices. Provision of sub-surface drainage system such as small drains can be dug to remove excess water and salts. Farm Yard Manure (FYM) and green manure may be applied to improve physical condition and fertility status of these soils. Beside growing salt tolerant crops like rice, barley, oat, berseem and safflower with optimum land management practices may be adopted to enhance the productivity of these salt affected soils.

Keywords：*Soil classification; salt affected soils; Rohtak district, Haryana; reclamation; management*

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[C1.4-1] Marginal Soils: The Classification of Technogenic, Subaqueous, and Extraterrestrial Soil-like Bodies

Nutrient Cycle in Acacia Crassicarpa Plantation on Deep Tropical Peatland

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Utilization of peatland in Indonesia as agricultural land in the past was mainly aimed for cultivation of annual crops, especially rice. Governmental projects has been made to utilize Indonesian peatland for rice cultivation in large scales following success stories of local inhabitants living in peatland neighborhood in using peatland for paddy field as well as for perennial crops in small scales. However some of the projects eventually ended up in failure and have resulted in serious environmental deterioration, including the latest project of Mega Rice Project in Central Kalimantan. The failure was mainly caused by difficulties in overcoming the curb related to land and soil characteristics, among others are drainage, peat subsidence, and nutrient poorness. During the last decade some peatland areas were converted into forest plantation planted with Acacia crassicarpa. This plantation is regarded successful so far in that it shows good growth and high productivity of the plant even with low nutrient inputs but of course with application of appropriate water management. This paper shows a beneficial aspect of A. crassicarpa plantation on deep tropical peat with respect to nutrient cycle, a case study in Riau Province.

A series of chemical analyses shows that peat soil of the case study area across a landscape has very low pH ranged from 3.2 to 3.5 and contains low macro- and micro-nutrients, the characteristics that are common for peat soil. Bulk density of the soil ranges from 0.15-0.17 g/cm3 at depth above the water level and 0.08-0.10 g/cm3 at depth below the water level. However A. crassicarpa is found to grow well on this poor soil condition as shown by growth data in that it reach 6 m height at 1 year growth with 5.5 cm in diameter and reach a height of 30.0 m and a diameter of 25.0 cm after 5 years. Based on litter fall measurement followed by decomposition experiment it was found that the highest nutrient released from litter fall is nitrogen that is counting to 271 kg N/ha/year equivalent to 602 kg urea/ha/year and. This fact is attributable to characteristics of A. crassicarpa as a leguminous plant having dense lateral roots rich in nodules that enrich the soil nitrogen. The other nutrients (P, K, Ca, Mg, and S) are cycling from soil to the plant via litter fall and decomposition without significant increase.

Keywords：*Acacia crassicarpa, nutrient cycle, tropical peatland*

P1-324

[C1.5-1] Validation of Soil Carbon Sequestration

Changes in Soil Carbon and Nitrogen Contents, and their Anaerobic Decomposition Potentials after Rice Paddy Abandoned to Wetland

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Land use changes have been occurred in many areas in the world during the past several decades through natural or anthropogenic change from one ecosystem to another. According to IPCC WGI AR5 (2013), from 1750 to 2011, CO2 emissions from fossil fuel combustion and cement production have released 365 [335 to 395] GtC to the atmosphere, while deforestation and other land use change are estimated to have released 180 [100 to 260] GtC. It means the land use changes had a profound impact on global warming. In the world, most land use changes were for expanding agricultural production area. For example, the world rice harvest area was increased at 38% from 115 Mha in 1961 to 159 Mha in 2010 during past 50 years by changing various lands to rice paddy. However, in Japan due to decreased rice consumption, the rice harvest area also decreased from 3.3 Mha in 1970s to 1.6 Mha in 2010. As the result, part of rice paddies was abandoned and changed to wetlands in many places where the fields can receive and keep flooding water.

For understanding how changes in the soil carbon and nitrogen dynamics by the land use change from rice paddy to wetland, we collected the soils from continuous and abandoned rice paddy (wetland) in Shounai Plain, north of Japan. The rice paddy and wetland are located same place and belonged to one farmer original. The continuous rice paddy is for cultivating rice more than 50 years according the local conventional management and practices, while the wetland was abandoned from rice paddy before 12 years ago. In the wetland, the vegetations were changed year by year after abandoned from rice paddy, and changed to Phragmites australis (shosi) in 6th year and keep it as dominant plant until now. Soil samples were taken from both rice paddy and wetland, and divided to 5 layers of 0-5, 5-10, 10-15, 15-20 and 20-25cm depths. All soil samples were air-dried, then analyzed pH, EC, Soil organic carbon (SOC), Total nitrogen (TN). For investigating the C decomposition and N mineralization potentials between both rice paddy and wetland, an anaerobic incubation experiment was conducted in lab under 30 oC 4 weeks.

The results showed that the SOC in the bulk soils of rice paddy and wetland decreased with soil depth, from 31.02 to 19.66 g kg-1 and from30.26 to 18.86 g kg-1, respectively. There was no significant difference of SOC between wetland from abandoned rice paddy and continuous rice paddy at all depths. TN in the bulk soils of wetland (2.61~1.49 g kg-1) and rice paddy (2.91~1.78 g kg-1) also had a decreasing tendency with depth, but the difference between them was significant with the exception of that at 20?25cm depth. The C/N, ratio of SOC and TN increased with soil depth from 5-10cm to 20-25cm layers in wetland, but maintained stably in rice paddy. There were significant differences of C/N between wetland and rice paddy at all depths. The amount of decomposed C (CO2 and CH4 productions after 4 weeks anaerobic incubation) of rice paddy soil was larger than wetland with a significant difference. Also the amount of mineralized N (calculated as the amount of NH4+-N in soil after 4 weeks anaerobic incubation minus the amount of NH4+-N in the bulk soil) of rice paddy was larger than wetland with a significant difference too. The dC/N, ratio of decomposed C and mineralized N was significantly larger in wetland (8.1-8.6) than that of rice paddy (6.9~7.3) for 5 layers. Results also showed that, when rice paddy was abandoned and changed to wetland, though the amount of SOC hadn't been changed evidently, the ability of C decomposition decreased at 32%. Additionally, the TN decreased at 14% only, but the N mineralization rate was reduced more at 42% by this conversion. It indicated that the soil organic matter was much easier to be decomposed in the continuous rice paddy than in the wetland abandoned from rice paddy.

Keywords：*Abandoned; Carbon decomposition; Nitrogen mineralization; Rice paddy; Wetland; Land-use change*

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[C1.5-1] Validation of Soil Carbon Sequestration

Spatial Evident of Soil Organic Carbon Inference in Tropical Reserve Forest Using Geospatial Domain

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The soil organic carbon is one of the most significant issues in the research of the worldwide carbon cycle as it is the biggest terrestrial carbon pool. This study focuses the estimation of soil organic carbon in Palamau Tiger Reserve. Geospatial approaches and various forest inventories were used for arithmetical correlation between estimated and predicted value. Geospatial Strategy plays a crucial role in geospatial data acquisition of the ecosystem carbon dynamics at local, regional, and global scale. The advantage of remote sensing is that it helps in getting wide area surveillance, periodical and uninterrupted measurement, and accessibility of digital data for processing standardization. The data of IRS P6 LISS III (September, 2012) is used for precise estimation of the percentage of the soil organic carbon associated with organic matter in soil. The main objective of the study is to analyze the precise estimation of the percentage of the soil organic carbon associated with organic matter in soil using arithmetical analysis and to find the regression curve between the predicted and estimated value of soil organic carbon using statistical analysis. The extraordinary positive correlation between the estimated SOC directly from field parameters and predicted SOC from spectral band information demonstrates the fact that NDVI can be considered to be an effective spectral vegetation index to estimate SOC. Linear models also showing comparable results and can be considered as standard.

Keywords：*Bare Soil Index, NDVI, Soil organic carbon, Regression analysis*

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[C1.5-1] Validation of Soil Carbon Sequestration

Evaluation of Soil and Plant Carbon, Nitrogen and Water Use Efficiency under Different Tillage Systems and Manure Application Using Stable Isotope Technique

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This study was conducted to assess the impact of tillage and manure application on soil and plant carbon and nitrogen contents and intrinsic water use efficiency (iWUE). The experiment was a split-split-plot factorial design with three replications. The main plot consisted of three tillage treatments: zero tillage (ZT), minimum tillage (MT) and conventional tillage (CT). The sub-plot were four NPK fertilizer treatments (0, 90, 120 and 150 kg N ha^{-1}), while the sub-sub-plot comprised three poultry manure (PM) treatments (0, 10 and 20 Mg ha^{-1}). Soil carbon and nitrogen sequestration were evaluated using stable isotope of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$). The $\delta^{13}C$ in maize plant was used to obtain iWUE. It was observed that soil $\delta^{13}C$ and $\delta^{15}N$ were more depleted under ZT than CT and in plot treated with 20 Mg ha^{-1} PM (PM20) implying carbon and nitrogen sequestration under ZT and by PM20. Application of PM20 raised soil ^{15}N enrichment by 45% and 49% under CT and ZT, respectively. Highest iWUE of 25.7% was obtained under CT and was significantly higher than the iWUE values under ZT and MT in the second year of the study while the iWUE was significantly lower with PM20 application than other manure treatments. The significant $\delta^{13}C$ depletion and hence lower iWUE with combination of NPK fertilizer and PM under CT and MT than the control suggested that soil disturbance under tilled soil would have been mediated by combined nutrient management thereby limiting soil C available for fractionation resulting in lower iWUE.

Keywords: *Fractionation; intrinsic water use efficiency; tillage; sequestration; stable isotope*

P1-327

[C1.5-1] Validation of Soil Carbon Sequestration

Carbon Stocks and Soil Fertility in Physically Degraded Lands - Are We Over Estimating?

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In recent years, the degraded lands are in focus for both food production and CO2 mitigation. New plantations on these degraded lands help in fixing atmospheric CO2. Thus, the overall fertility, productivity and soil carbon stocks of these soils are enhanced with such interventions. The present soil fertility assessment methods may be unsuitable for physically degraded lands. The general protocol is to quantify nutrients and soil organic carbon (SOC) for a few grams of fine soil (< 2mm) and estimate it later for the soil mass of 2.0 m kg in a hectare furrow layer.

In a field study, the surface soil samples (0-15 cm) were analysed for bulk density (BD), gravel % (v/v), SOC and available nutrients. The SOC and available nutrient concentrations were found higher in agricultural soils compared to physically degraded soils and they declined with increase in gravel content. Their estimations for the soil mass of haFS under 3 different situations namely, a. 2.0 m kgs (conventional method); b. based on field BD values; c. for the fine earth fraction in the bulk soil. Theoretical estimations were made for SOC stocks for the similar situations. Both hypothetical and field observations indicate that the existing method (2.0 m. kg / ha basis) or field BD values would overestimate SOC stocks and nutrients for the physically degraded lands. Hence, the proportional volume of fine earth in the bulk should be given importance in soil fertility and carbon stock assessments under such situations.

Keywords：*Degraded soils, soil carbon stocks, soil fertility, methodology, fine soil volume, estimations*

P1-328

[C1.5-1] Validation of Soil Carbon Sequestration

Effect of Soil, Fertilizer and Cropping System Management on Soil Carbon Storage under Maize and Cassava Production

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Thailand locates in tropical monsoon climatic zone which intensify decomposition of soil organic carbon and consequently ineffective for soil carbon storage. However, the soil carbon storage is also affected by soil and fertilizer management including cropping system. Therefore, effect of cropping systems and fertilizer management on soil carbon storage under maize and cassava production of four long-term plots had been investigated. The first plot of maize cropping systems had been conducted on Samo thod alkali clayey soil (very fine, smectitic, isohyperthermic, Chromic Haplusterts) since 1981. The results of the 32nd experimental year showed that organic carbon incorporation into the soil by maize stover and root were about 4,019 and 1,113 kg C ha-1y-1, however, the soil organic carbon at 0.15 m depth from the plots without fertilizer application, with recommended chemical fertilizer application, chicken manure application and both applications of recommended chemical fertilizer and chicken manure depleted about 458, 397, 16 and 158 kg C ha-1 y-1, respectively. Assimilation of carbon dioxide of maize varied from 12.5 to 27.1 t CO2 ha-1 y-1 which principally depending on fertilizer management.

The second plot of cassava cropping systems had been conducted on Yasothon sandy loam soil (fine-loamy, siliceous, semiactive, isohyperthermic, Typic Paleustults) since 1980. The results at the 33rd experimental year showed that soil organic carbon at 0.2 m depth of all treatments i.e. without fertilizer application, recommended chemical fertilizer application, compost application and both applications of recommended chemical fertilizer and compost, depleted about 168-180 kg C ha-1 y-1, respectively. Cropping systems of cassava mono-cropping system, cassava-groundnut crop rotation system and cassava-groundnut intercropping system caused depletion of soil organic carbon about 171, 179, and 176 kg C ha-1 y-1, respectively. Carbon dioxide assimilation to cassava root, stem, stalk, and leave was about 13.3, 2.6, 1.1 and 0.8 t CO2 ha-1 y-1, respectively.

The third and the fourth plots determined the effect of fertilizer and crop residues incorporation on soil carbon sequestration under cassava mono-cropping system on Yasothon sandy loam soil and Huai Pong sandy loam soil (fine, kaolinitic, isohyperthermic, Typic Kandiudults) at Khon Kaen and Rayong provinces, respectively, since 1976. The resulted of the 36th experimental year show that application of chemical fertilizer and compost in Yasothon soil increased the soil organic carbon at 0.2 m depth about 91 kg C ha-1 y-1. On the contrary, other treatments such as without fertilizer application, crop residues incorporation, recommended chemical fertilizer application, recommended chemical fertilizer application and crop residues incorporation, caused a reduction of soil organic carbon about 142-529 kg C ha-1 y-1. Similarly to Yasothon soil, the application of chemical fertilizer and compost on the cassava plot in Huai Pong soil increased the soil carbon storage about 160 kg C ha-1 y-1 whereas other fertilizer application reduced the soil carbon storage about 48-424 kg C ha-1 y-1.

Keywords：*Soil carbon sequestration, maize, cassava*

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[C1.5-1] Validation of Soil Carbon Sequestration

Soil Organic Carbon Dynamics under Soil Managements after Deforestation in Eastern Thailand

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Deforestation is an important contributor to increasing concentrations of atmospheric greenhouse gases. The transformation in land cover also leads to reduced organic carbon storage in soil due to rapid decomposition of soil organic carbon (SOC) exposed to agricultural practices. However, soil managements can potentially sequester organic carbon in the soil. This study aims to investigate (1) the loss of SOC when tropical forest is converted to conventional corn plantation and (2) the enhancement of SOC when the land is developed under intensive soil managements after deforestation. The study was conducted during 2005-2009 at Tha Ta Kieb district (TTK) and Khao Hin Sorn (KHS) King's project, Phanom Sara Kham district in Chachoengsao province, eastern Thailand. The impact of land-use change and soil managements on SOC dynamics was studied using the stable carbon isotope technique and chronosequence study. The amounts of soil carbon and its components (comprising C from forest and C from corn), were estimated using the isotope technique. The relationship between soil C and its components was examined by studying soil under corn cultivation after deforestation at periods of 0 year of forest soil plot as reference (NFT plot), 3 years (AG3 plot) and continuous study of 4 and 5 years, 7(AG7 plot), 8 and 9 years, 10 (AG10 plot), 11 and 12 years after deforestation, respectively. The results revealed that only small C inputs to the soil under conventional corn cultivation were found over this time span, and thus soil carbon is still dominated by the forest-derived fraction. When the values of soil carbon content were plotted against number of years after deforestation showed in the exponential decay model, it was found that turnover rate of soil carbon was reduced at the rate of 6.97 ton C ha-1 yr-1. Reduction was most pronounced in the top 10 cm soil layer, which after 12 years of cultivation, reduced by 47%. Stable carbon isotope data revealed that the main fraction lost was forest-derived carbon. Generally low input rates of corn-derived carbon were not sufficient to maintain SOC at the level prior to forest conversion. After 12 years of continuous corn cultivation, the corn-derived carbon fraction made up about 10% of total SOC (1.96 ton C ha-1 of the total 24.22 ton C ha-1). When we applied the exponential decay model from TTK site to study in KHS site after deforestation in 1967 (Land was developed under intensive soil management program for 30 years: 1979-2009). This research found that the amount of SOC was raised up more than the original forest soil in 2 times (10.28 ton C ha-1 to 16.51ton C ha-1). From these results, it can be concluded that in tropical climates, deforestation followed by conventional corn cultivation causes a rapid reduction of soil organic carbon and only small inputs of C under conventional corn cultivation into the soil after deforestation. However, it found that the amount of SOC carbon was raised up to the prior level or more of the original forest soil under long term intensive soil managements.

Keywords : : Soil organic carbon, deforestation, corn cultivation, stable isotope, turnover rate

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[C1.5-1] Validation of Soil Carbon Sequestration

Comparison of Methods to Estimate and Map the Carbon Content of Scottish Soils

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The Scottish Government wish to preserve the carbon stocks already stored or sequestered in both organic and mineral soils and see land use change as one of the key drivers affecting storage of soil C. A key component to developing any strategy to maintain the existing carbon stocks is the quantification of these stocks both in terms of the carbon content and its spatial distribution. To date, three contrasting methods that use the same existing legacy data have been used: a traditional approach, an approach based on neural networks and a hybrid GAM-geostatistical 3D model.

The traditional approach was based on calculating average organic carbon values from around 40,000 observations stored within the Scottish soil Database. The average C concentration was calculated for individual horizons typical of individual soil types (semi-natural or cultivated phenotypes of each Soil Series). The stock for each horizon (calculated from horizon thickness, average C concentration and predicted bulk density) was summed to give an estimate for a modal soil profile typical of each Soil Series to a depth of 1m and spatially extrapolated using the 1:250,000 scale national soil map of Scotland combined with land use data. The total C stock was then determined by multiplying the areal extent of each Soil Series/land use combination by the calculated profile stock. This gave a total estimated C stock of 3000 Mt.

A neural network model was developed to predict bulk density, organic matter content and profile depth. It was trained using attribute data from the National Soil Inventory of Scotland datasets and spatially explicit topography, climate, geology, soil type and land cover. These Inventory data were collected from 2007 to 2009 from 183 sites on a 20 km grid. The trained network was tested and found to explain 79.8% of the variance in organic matter content, 77.9% of the variance in bulk density and 57.3% of the variance in profile depth. The neural network model was used to make predictions for profile depth, organic matter content and bulk density at depths from the surface to 1 m depth in 1 cm intervals, at 100 m spatial resolution. This allowed us to make a prediction of the total C stocks and the stocks in different soil/vegetation combinations. The total C stock estimate by this method was 2954 Mt. Soils under peatland vegetation had the greatest carbon stocks followed by heathland and grassland. The greatest C stocks were predicted in peat soils, as expected, although gley soils are also predicted to contain a large carbon stock.

A hybrid GAM-geostatistical 3D model combined the fitting of a GAM using a 3D smoother with related covariates and the kriging or Gaussian simulations of GAM residuals to spatially account for local details. The aim was to model the continuous vertical and lateral distributions of SOC stocks making explicit the uncertainty in the results. The model was used to estimate the carbon content for each node of a 1 km grid. A subset of the 40,000 horizons (26,000 horizons and 7,800 profiles) was used with 25% randomly selected and used for validation. The use of GAM is flexible, and can deal with linear and non-linear relationships between soil properties and the covariates. The covariates are freely and globally available and were selected to describe the most important SCORPAN factors; topography, vegetation, climate, time and position. The features and indices used were derived from the Shuttle Radar Topography Mission and the Moderate Resolution Imaging Spectro-radiometer. The results showed good agreement with the data in the validation set with a global R2 of 0.60. This method gave a median value for the total C stock estimate of 3410 Mt C. The uncertainty was large indicating a wide range of credible values for each pixel. The deviation from the median ranges was between 5 and 75% for the interpolated values depending on location.

As well as giving slightly different estimates of the total stock, each of the three methods revealed differences in the spatial patterns of C stocks. Understanding these differences will enable the development of more robust and accurate models that can be used to assess changes in stocks due to changing land use.

Keywords：*Carbon Stocks, Legacy data, Neural Networks, GAM-geostatistical model*

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[C1.5-1] Validation of Soil Carbon Sequestration

Soil Organic Carbon (soc) Prediction in Cocoa (theobroma Cacao L.) Landscapes in South-West Ivory Coast Using Infrared Spectroscopy

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Ivory Coast is the world's largest cocoa producer and is likely to remain a major actor on the cocoa market in the long term. The country produces approx. 1.5 million metric tons of cocoa beans annually, accounting for 40% of the worldwide production. Cocoa represents 10% of Cote d'Ivoire GDP and 40% of its exports. Cocoa is generally grown by smallholder farmers after slash and burn of the primary forests or woodlands, and the crop can remain on the land for more than forty years. In most cases, no fertilizer is added to the soil during that period resulting in soil mining and soil fertility depletion. Furthermore, when the orchards get old and unproductive, farmers shift to more productive land to create new farms leading to a dramatic expansion of cocoa production areas at the costs of the environment i.e. deforestation of the humid forest and its adverse effects on climate change. Currently, such new land are very rare in most cocoa production areas, suggesting that most cocoa growers in the country would remain on the existing farms. These call for the need to design sustainable cocoa production systems including, among others, the use of integrated soil fertility management (ISFM) approaches to rehabilitate degraded soils under existing cocoa orchards. Soil organic carbon (SOC) is key in defining the best ISFM approach for a given soil while the level of SOC is a major indicator of soil quality in the tropics . The objective of the work was to predict the SOC content in cocoa landscapes in South-West Ivory Coast (where most Ivorian cocoa beans are produced) and ultimately model the spatial distribution of SOC in order to design ISFM at large scale for the cocoa farmers in the region. The land degradation surveillance framework (LDSF) for systematic and unbiased field surveys which is an approach to mapping of soil properties and land degradation prevalence were used to collect soil data over five blocks of 10 x 10 km each located in different catchments. Land use in these catchments is dominated by cocoa cultivation, while other land uses such as food crops cultivation, rubber farms as well as fallow were also present. SOC was analyzed using infrared spectroscopy, while a sub-sample analyzed with conventional wet chemistry was used as reference data for calibration. The RMSE values show good prediction of SOC using infrared spectroscopy. When soil sand content was used as covariate in selecting the l-PLS predicting neighbours, the prediction varied between land use. It was more accurate in cocoa orchards than in land cultivated with food crops and in land under fallow. The promising results obtained in this study allow us to explore the use of predicted SOC data to model the spatial distribution of SOC in the study area, and further develop adapted ISFM recommendations for cocoa landscapes in South-West Ivory Coast.

Keywords：*Cocoa orchards, Infrared Spectroscopy, Integrated Soil Fertility Management, Ivory Coast, Soil organ*

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[C1.5-1] Validation of Soil Carbon Sequestration

Soil Organic Carbon Mapping of a Forest Beech in Southern Italy Using Laboratory-Based Vis-Nir Spectroscopy

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The project LIFE09 ENV/IT/078 Managing forests for multiple purposes: carbon, biodiversity and socio-economic wellbeing (ManFor C.BD.), among other objectives, is aimed to evaluate carbon sequestration taking into account forest management for conserving and enhancing carbon stocks, and increase carbon sequestration. The first step to do that is modelling and mapping spatial variability of soil organic carbon to assess the ability of soil to sequestrate biologic carbon. Conventional methods for soil organic carbon (SOC) determination are based on laboratory analyses and are costly and time consuming. Soil spectral reflectance is an alternative approach for SOC determination and has the advantage to be rapid, non-destructive and cost effective.

The paper was aimed at: 1) quantifying SOC using laboratory-based soil visible, near infrared (Vis-NIR) reflectance spectroscopy and 2) mapping SOC using a geostatistical approach.

The study area was a forest beech (332.000 m2) located in southern Italy at a mean elevation of about 1,180 m a.s.l. Soils mainly are coarse-textured, relatively young (Entisol and Inceptisol) and from poorly to moderately differentiated. They are strongly dependent on the nature of the parent rock (Paleozoic granitoid rocks) and their depth range from shallow to moderately deep and soil profiles are characterized by A-Bw-Cr and/or A-Cr horizons. The upper A horizon has an high accumulation of organic matter (umbric epipedon) and a very dark brown colour.

Soil samples were collected at 235 locations within the study area using a metallic core cylinder with a diameter of 7.5 cm and a height of 20 cm.

Each sample was oven dried at 45° for 48 hours and sieved at 2 mm and was used before for spectroscopic measurements and then analysed to determine organic carbon content. The Vis-NIR reflectance of soil samples was measured in laboratory, under artificial light, using an ASD FieldSpec IV 350 - 2500 nm spectroradiometer (Analytical Spectral Devices Inc., Boulder, Colorado, USA), while SOC was determined using a TOC-L analyzer (Shimadzu Corporation, Kyoto, Japan).

The partial least squared regression (PLSR) analysis was used to establish the relationships between spectral reflectance and OM content. PLSR was performed on 2/3 of the soil samples. The optimum number of factors to retain in the calibration models were determined by cross validation. The models were independently validated using data from the remaining soil samples. Results revealed a high level of agreement between measured and predicted values with coefficients of determination. Finally, ordinary kriging was used to map SOC in the study area.

Keywords：*soil carbon sequestration, Vis-NIR spectroscopy, Partial least square regression, kriging*

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[C1.5-1] Validation of Soil Carbon Sequestration

Impact of Land Use Change in the Soil Carbon Stock in Brazilian Semiarid

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Climate change is natural processes, considering the time geological scale. However, the speed and intensity of the changes that are occurring in the Earth's climate system, since the Industrial Revolution, conferred the emission of greenhouse gases (GHGs), mainly carbon dioxide (CO2), nitrous oxide (N2O) and methane (CH4) has been a main concern of scientists and world leaders in last three decades. The GHG has its dynamics emission to the atmosphere related to agricultural production processes, land use change, the burning of fossil fuels and industrial activities. In current global levels, land use change, with agricultural production processes, contributing with 22% of CO2 emissions, 43% of CH4 emissions and 85% of N2O emissions. In Brazil, however, historically this sector contributes with 75% of CO2 emissions, 91% of CH4 emissions and 94% of N2O emissions, representing significantly higher proportions relative to global averages. Thus, in Brazil the imposition of measures to contain the increasing concentration GHG in the atmosphere involves measures relating the change in land use and productive agricultural sector, The semi-arid region of Brazil, whose main biome is the Caatinga, needs a special attention due to studies disability and predictions of climate change pointing that this environment will evidence climate markers more impactful. On the other hand, over 44% of the area under forest in this region has changed, and is currently occupied by extensive ranching, agriculture dependent of rain and on proportions for irrigated agriculture. The removal of wood energy also has degraded this ecosystem. The conversion of native vegetation areas, Caatinga, for other agricultural uses and exploratory are associated with the emission of large amounts of carbon in the form of CO2 into the atmosphere, which need to be quantified. For this, it is important to quantify the carbon stocks of terrestrial component of remnant vegetation and major anthropogenic systems. In this context, this paper is an initiative that tackles studies in order to generate consistent information on land use change in carbon stocks in the soil system, under remnant vegetation and anthropogenic systems in the Brazilian semiarid. In the same geoenvironmental unit were evaluated ten different systems of land use. Were selected an preserved native vegetation, degraded native vegetation, called Caatinga, two production system of irrigated agriculture, cultivation of mango tree (Mangifera indica L.) and grapevine (Vitis vinifera L.), two systems of t dependen rain agriculture, corn (Zea mayz L.) and cowpea (Vigna unguiculata L), and related systems livestock containing monocultures of buffelgrass (Cenchurs ciliairis L), palm (Opuntia ficus indica Mill), gliricidia (Gliricidia sepium (Jacq.) Walp.) and leucaena (Leucaena leucocephala (Lam.) de Wit.). In each system, four trenches were opened of ± 1.20 m depth, to collect undisturbed samples on two walls at depths 0-5, 5-10, 10-20, 20-30, 30-45, 45-60 , 60-80, 80-100 cm for analysis of soil density. Also, in the same layers were obtained samples collected by auger, at 120 points, constituting 40 composed by depth to determine the contents of total organic carbon. The native vegetation had a stock of carbon in the soil of 80.75 Mg.ha-1 to 100 cm deep, not differing significantly from systems containing Gliricidia (81.34 Mg ha-1) and leucaena (80.68 Mg.ha-1). The degraded native vegetation has a carbon stock of 72.14 Mg.ha-1, not differing farming systems of buffel grass (74.77 Mg.ha-1) and grapevine (69.52 Mg.ha-1). The cultivation of palm, maize and beans respectively show a stock of carbon in the soil of 66.39, 63.27 and 61.50 Mg.ha-1. The mango tree was the cultivation system with the lowest carbon stock in the soil up to 100 cm deep, with 23.96 Mg.ha-1. In the Brazilian semiarid region, the conversion of native vegetation to anthropogenic uses promotes the loss of carbon stored in the soil.

Keywords：*Caatinga Biome, livestock, agruculture systems*

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[C1.5-1] Validation of Soil Carbon Sequestration

Carbon Stock of Dead Wood, Litter and Mineral Soil in the Forest of Japan

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Introduction: Japanese government is required to account carbon stock change for five carbon pools: aboveground biomass, belowground biomass, dead wood, litter, and soil organic carbon in forest sector for the Kyoto Protocol and the United Nations Framework Convention on Climate Change. The carbon stock change for dead wood, litter and soil organic carbon per unit area are estimated by using CENTURY-jfos model and are multiplied by land area of each forest management type. A national forest soil carbon inventory project started in 2006 in order to support these reports to the UNFCCC. The first phase of the project was carried out from FS 2006 to FS 2010. In this presentation we will show the results of the first phase of the project.

Materials and methods: Survey plots are systematically selected from the plots of the Forest Resources Monitoring Survey (FRMS) which has conducted by the Japanese forestry agency over forest sector at 4km × 4km grid. For dead wood (>5cm), the volume is estimated by line-intersected method (IPCC Good Practice Guidance 2006), and the carbon stock of dead wood was calculated by density (visual judgment), carbon concentration (500mg g-1), and volume. For litter, fine woody debris (< 5cm in diameter), L, F, and H layers are taken from 50 cm square in four points at each survey plot. Mineral soil samples for chemical analysis and volumetric analysis were taken at 0-5, 5-15 and 15-30cm depth. The gravel percentage was visually judged for each layer. The carbon concentration of litter sample and soil samples are measured by dry-combustion method (NC analyzer). The carbon stock of litter is calculated by the weight and the carbon concentration. The carbon stock of mineral soil for 0-30cm depth is calculated by gravel content, carbon concentration, and bulk density.

Results and discussion: Firstly, we examined the carbon stock for unit area. The mean±S.D. of carbon stock was 0.42±0.67, 0.49±0.32 and 6.94±3.25 kg m-2 for dead wood, litter and mineral surface soil, respectively. The mean carbon stock of dead wood was slightly lower than that in Asian countries in Global Forest Resources Assessment 2005 (FAO 2006). The mean carbon stock of litter was lower than those reported in cool temperate forests in European countries and was similar to other studies in Japan. The mean carbon stock of surface mineral soil was somewhat lower than that of the previous national report for Japanese forest soils (Morisada et. al. 2004), and was almost same to that in Asian countries (FAO 2006). Next, we estimated nationwide carbon stock by multiplying the mean carbon stock for unit area and total forest area. The nationwide carbon stock was 0.11, 0.12 and 1.74 Tg for dead wood, litter, and mineral soil (0-30cm), respectively. The carbon stock of these three pools was 1.3 times as much as that of nationwide forest living biomass reported in Global Forest Resources Assessment 2010 (FAO 2010). Furthermore, we compared the carbon stock for unite area among regions. Carbon stock in dead wood and litter showed no unidirectional tendency among regions. On the other hand, the mineral soil carbon stock was generally high in the northern regions and was low in southern regions. However, high carbon stock was observed in mineral surface soil in the southernmost region where active volcanoes were distributed, and the soil carbon stock was extremely low in Kinki region in central Japan where the former capital was situated. These results suggest that carbon stock in mineral soil was mainly regulated by climate conditions and human impact also to some extent influence on carbon stock in Japanese forest.

Keywords：*dead wood, litter layer, forest soil, climate change, carbon stock, forest soil carbon inventory*

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[C1.5-1] Validation of Soil Carbon Sequestration

Organic Matter Content in the Lower Horizons of Taiga Soils in Russia

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Upper humus soil horizons are studied in the vast majority of papers; the lower horizons with their low organic matter content (OMC) are left without attention in majority of cases. However, knowledge of humus formation in the lower part of the soil profile is relevant in solving the problems of the modern organic carbon cycle. Also, organic matter stocks in the lower part of humus profile due to its high depth are comparable to the stocks of the soil top, and sometimes exceed them. In this study the OMC in the lower horizons is discussed on the example of the Boreal database, where the information about 900 soil profiles of Russian boreal soils developed in drained conditions on loamy soil forming rocks was gathered from scientific sources published over the last 60 years. The “lower horizons of humus profile” (father “lower horizons”) are considered in this study as the soil layer, which lies under the organic accumulative horizons and contains minor OMC, where changes with depth are not observed. The following characteristics of the lower horizons are discussed: 1) depth of the top border; 2) OMC content; 3) types of OMC vertical distribution; 4) OMC features of the lower horizons in the frame of classification units, geographic areas and functioning of the landscape. The upper border of the lower horizons is the bend of the curve of vertical OMC distribution, below which the OMC still almost the same. The lower boundary of the “lower horizons” remains uncertain and depends of the idea about the soil profile depth. Sod-podzolic soil (Albeluvisoils Umbric) in the Southern taiga of the European territory of Russia differ by a sharp (3 - 10 times) fall of OMC, which occurs in eluvial horizon El, sometimes only in its lower part, or in the horizon ElB. The OMC is 0.5-0.6% near the upper border of the layer in 40% of cases. It gradually decreases to 0.1-0.2% with the depth or rarely it did not change up to 1.5-2 m. The lower horizons of podzolic soils (Albeluvisoils Haplic) in the middle taiga of the European territory of Russia are close to sod-podzolic soils; they differ from them by the less sharp fall of OMC from the surface to the lower horizons and the increase of the lower horizons upper border up to 10-30 cm (60% of cases). The upper border goes in the horizon El or ElB. Gley-podzolic soils (Gleyic Albeluvisoils) of the Northern taiga differ significantly by the following features: the upper border of the lower horizons is lack expressed, relatively high OMC (0.5-0.6 % at a depth of 40-50 cm) and wide OMC range (0.1-0.7%). The upper border is usually lower than the horizon El, where MOC equals 1.5-3%, and goes in the top or even middle part the horizon B. Sod-podzolic soil of West and Central Siberia differ from ones of the European part of Russia. The upper border of the lower horizons goes down to 40-60 cm and coincides with the upper border of the horizon ElB. OMC is 0.7-0.8% in average; it ranges from 0.4 to 1.0%. The lower horizons of podbels (Albeluvisols Umbric) of the Far Eastern region have expressed their specificity. The top border is unusually situated very high (5-10 cm). The bend of the curve of the vertical OMC distribution is clearly expressed, but the OMC near the top border is significantly high (0.8-1.2%). The OMC profile has usually a deviation of 0.4-0.5% corresponding to a buried humus horizon. Mountain soils includes different types of brownzems (Cambisols Distric, Haplic, Eutric) and sod-podzolic soil, which are formed on the rubble-loam soils. All of them have the same features of the lower horizons: a small depth of the layer, high OMC (3-5%), unstable penetration deepness. Thus, the study has revealed the diversity of the lower horizons of the OMC profile of taiga mezomorphic soils of Russia. The variety of its types and the expressed localization in geography and environmental space testifies to the different genesis of the lower horizons of the OMC profile. The study was supported by the RFBR grant N 11-04-02089 and partially supported by the Russian Federation Government grant N 11.G34.31.0079.

Keywords：*organic matter content, organic matter profile, boreal soils*

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[C1.5-1] Validation of Soil Carbon Sequestration

Soil Organic Carbon Storage Potential under the Impact of Post-Settlement Deposition in Depressional Landscapes of Minnesota

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Agriculture-induced erosion and deposition affect soil organic carbon (SOC) dynamics and storage on the hillslope. Because soil is the largest terrestrial carbon (C) inventory, such SOC change can have significant impacts on global C cycling. The downslope deposition and burial of C-rich topsoils in the depressional landscape is likely to sequester SOC, but the understanding of their spatial patterns and mechanisms behind it is still limited. In this study, we aim to identify spatial distribution of post-settlement deposition (PSD) and SOC and to understand physical impact of PSD to soil C storage in the Kasma Marsh in the depressional landscape of Minnesota. The objectives for this study are to

1) Understand PSD presence and thickness by building spatial soil-landscape models using local and upslope dependence area terrain attributes;

2) Identify spatial distribution of SOC by developing soil C models in various profile depths;

3) Comprehend the spatial relation between PSD and SOC to estimate SOC storage potential.

We apply upslope dependence and local (3-by-3 cell window) terrain attributes in spatial modeling because topographic features are key factors controlling landscape-scale soil processes. Upslope dependence terrain drives the waterflow-relevant soil processes such as soil erosion production, and local terrain controls redeposition. We predict spatial-explicit probability of PSD presence using logistic regression, and employ multiple linear regressions for the prediction of the deposition thickness. Because SOC is affected by various levels of biological activities and topographic controls in different depths, the spatial distribution of SOC (kg/m2) is interpolated and mapped in five fixed-depth layers (0-10cm, 10-30cm, 30-60cm, 60-90cm, and 90-120cm) that are close to field sample horizonation. SOC will be reported compositely after individual layer modeling. The resulting SOC map will be overlapped with spatial distribution of PSD to identify the linkage of their spatial patterns in this landscape. I will estimate potential storage of SOC based on the amounts of SOC in PSD and undisturbed SOC data. PSD and SOC models will be validated using ten-folds cross-validation as well as by regional samples for upscaling to a regional application.

Keywords：*erosion and deposition, soil carbon sequestration, digital soil mapping*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Cu(ii) Removal from Aqueous Solution Using Iron Oxide Coated Sand

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Increased concern about the environment and tighter regulations on water pollution and the discharge of heavy metals from industries make it necessary to develop new technologies for their removal. In this paper, the copper removal efficiency of iron oxide coated sand was studied. In addition, the adsorbent's Micro-structure was discussed using scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR). It was found that for initial concentration of 46.07 mg/L of Cu(II) when iron oxide coated sand was used as an adsorbent in fixed bed column (bed depth of 35 cm & pH of 10) and completely mixed batch reactor (adsorbent concentration of 10 g/L & contact time of 60 min), the removal percentage of copper was 100%. The results indicated that iron oxide coated sand may be applied successfully in water purification technologies in order to remove copper from aqueous solutions.

Keywords: *Water treatment, Copper removal, Iron oxide coating, Sand*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Nitrogen Balance and C:n Ratio Influence in Agro-Ecosystems on Soil Carbon Sequestration

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Nitrogen (N) is biogenic nutrient essential for mineralization and synthesis of stable soil organic matter (SOM), the soil quality index most commonly accepted for sustainability assessment. Therefore the following hypothesis was postulated: N balance of an agro-ecosystem can be used to predict the future of the SOM or Carbon (C) sequestration and therefore the sustainability of a system. To contrast this hypothesis the long term effect of different rotation systems on total N, N balance, C:N ratio and SOM of the arable layer (20 cm) of a silty-clay-loam Argiudoll was studied using information from a rotation experiment established in 1963 at “La Estanzuela”, Uruguay (34° 29' S; 57°; 44' W, 81 m). Two periods were considered, one from 1963 to 1983; and other after redesigning the experiment in 1984. Regression and correlations were performed for soil N and C stocks and for C:N ratios in four rotation systems, two including forage legumes differing in pasture type and length, and two of continuous agriculture with sequences of summer and winter crops, with and without fertilizers. Nitrogen balances were estimated considering N inputs and outputs based on previous studies (erosion losses and productivity), biological nitrogen fixation (BNF) and crop management records. The rotation system consisting in 4-y pasture-4-y crops had very high N input via BNF but SOM was maintained almost constant through years, and N losses were very high with a high pollution risk. The system including a biannual legume showed a slightly negative trend of N stock until 1983 according o a negative N balance. Continuous agriculture showed an annual drop of N stock of 51 Kg N/Ha until 1983 in the fertilized system, altogether with an almost linear drop in SOM; while the annual N losses in the unfertilized system were 69 Kg/Ha. In 1984 the pasture length was duplicated in the system with bi-annual legume, crop sequence was modified and N balance change from -7 to +7 Kg/Ha/y, SOC started to stabilize and afterwards to accumulate. A better adequacy between the amount of N released by mineralization of the pasture residues and the amount of N recovered by the crops than with the multi-annual pasture resulted in fewer N losses. Changes such as land use intensification (1 crop/y to 1.3 crops/y) with consequent reduction of tillage and fallow duration (less erosion), as well as technological improvement that gradually took place (glyphsate usage, higher yielding crops, improved N-fertilization practices) tended to equilibrate N balance, N stock was stabilized during the last decade and so did SOC. These equilibrium however, was accomplished with N stocks of 77% and 65 % of the one in the system rotating with multi- o bi-annual pasture, respectively. The soil under continuous agriculture without fertilization continued losing N (11 Kg /Ha/y) and SOM even after 1984. Typical value for C:N ratio in the soil range between 10 and 12, and since is determined by the chemistry of microbial cells, the evolution of these parameters has a parallelism when the system is in equilibrium. Considering both periods this parallelism was only observed in the rotation with multi-annual pasture in which C:N ratio was kept close to 11 (R2= 0.05). In the others systems C:N ratio increased until 1983 because a higher losses of N than that of C, but without an increase in SOM. A turning point was evident in 1984 when the trend was reverted, a fact particularly outstanding in the system rotation with the bi-annual legume. The soil with continuous agriculture and fertilizer is presently trending towards a C:N similar to that of the multi-annual pasture system but with much lower C and N stocks and a relative stabilized SOM. The C:N in the unfertilized system is much lower (approximately 10) and still dropping, this system is not sequestrating C. In such poor environment microbiological changes may have reduce mineralization and synthesis of SOM. It was concluded that to preserve SOM it is a “must” for the balance of N in the system to be at least neutral and to preserve an adequate C:N ratio or microbial equilibrium.

Keywords：*N-balance, C:N, SOM, agroecosystem sustaniability*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Soil ^{15}n Natural Abundance Reflects the Nitrogen Dynamics in the Riparian Zone Soils of Subtropical Australia

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As an important part of the ecosystem, riparian zones are considered to be the dynamic boundaries between terrestrial and aquatic systems. In order to quantify the spatial and temporal carbon (C) and nitrogen (N) dynamics, soil and sediment samples (0-10 cm) were collected from the riparian zone of Wyaralong Dam in southeast Queensland, Australia (27°54'28.77'S, 152°52'53.59'E) in February (summer), May (autumn) and August (winter) 2013, respectively. This area has a subtropical climate with the mean minimum temperature of 13 °C, mean maximum temperature of 27 °C, and mean rainfall of 900 mm. This site was dominated by the grassland. The soil type is Dermosols, with clayey texture. Three transects spaced about 5 meters apart, with 6 sampling points along each transect were selected. The distance among the 6 sampling points decreased from the upland soil (1.6 meters) to the sediment (0.8 meters). The spatial and temporal variations in soil moisture, soil total C (TC), soil total N (TN), stable C isotope composition ($\delta^{13}C$), and stable N isotope composition ($\delta^{15}N$) were analyzed.

It was found that soil moisture was significantly different along the transects; while no significant difference was found for TC, TN, δ^{13} C and $\delta^{15}N$ along the transects. However, those sampling points could be classified into three groups by the group contrast analysis as follows: the upland soil, the riparian zone soil, and the sediment. Soil $\delta^{15}N$ varied with soil moisture both spatially and temporally. In the summer, soil $\delta^{15}N$ decreased with soil moisture from 6.1 ‰ in the upland soil to 2.7 ‰ in the riparian soil, but then increased with soil moisture to 4.7 ‰ in the sediment ($R^2 = 0.466$, $P < 0.01$). By contrast, soil $\delta^{15}N$ showed the completely opposite way with soil moisture in the winter ($R^2 = 0.465$, $P < 0.01$). In the autumn, soil $\delta^{15}N$ stayed quite stable with the average of 4.8 ‰, but had no relationship with soil moisture. The lowest soil $\delta^{15}N$ in the summer (wet season) and the highest soil $\delta^{15}N$ in the winter (dry season) along the transects were detected with the soil moisture ranging from 30% to 50%, which was corresponding to the riparian zone. Although no relationship between soil moisture and TC or TN was detected in either the summer or autumn, both soil TC and TN displayed pronounced dependency on soil moisture in the winter (TC: $R^2 = 0.289$, $P < 0.01$; TN: $R^2 = 0.511$, $P < 0.01$), which reached the lowest value with the soil moisture ranging from 30% to 50% corresponding to the variation of soil $\delta^{15}N$. Soil $\delta^{15}N$ in the ecosystem was related to the soil N dynamics. In the summer, the C and N availability were high due to the residual inputs from the upland topsoil. More labile N pools were moved and accumulated in the riparian zone with lower $\delta^{15}N$ in these N pools. Hence, $\delta^{15}N$ was relatively low in the riparian zone than the adjacent area in the summer. The explanation for the high $\delta^{15}N$ in the riparian zone soil in the winter is that soil microbial processes such as N mineralization, nitrification and denitrification would discriminate against heavier stable isotope of N (^{15}N). This may lead to losses of ^{15}N-depleted N forms from soils via nitrate (NO_3^-) leaching and nitrous oxide (N_2O) or N_2 emission, and the remaining soil N enriched in ^{15}N. Overall, soil microbial activity for N transformations may be much higher in the riparian zone driven by soil moisture and plant residues / labile N pools, which is both seasonal and spatial dependence when compared with the upland soil and sediment sections along the transects. Soil $\delta^{15}N$ has been shown to be a sensitive indicator for providing insights into the N transformation processes occurring in the riparian zones.

Keywords：*$\delta^{15}N$, riparian zone, N transformation*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Modelling Flow and Sediment Transport Through Vegetative Buffer Strips

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Vegetative buffer strips are widely employed as a conservation measure to reduce fluxes of sediments and associated pollutants from overland flow in catchments. Buffers generally reduce sediment and pollutant loads through a combination of deposition and infiltration processes. This paper will briefly describe some existing models used to predict sediment deposition in vegetative buffers and will outline the development of the new Vegetative Buffer Strip component of the Griffith University Soil Erosion & Deposition model. Unlike other models, this model simulates the evolution of the deposited layer by dynamically adjusting the bed elevation, the water profile and the velocity as a result of sediment accumulation. Results from a series of flume-scale buffer experiments using vetiver grass are presented. These experiments quantified the reduction in sediment and particulate-sorbed plant nutrients from overland flow and data were used to test the model.

The model successfully predicted water and sediment profiles as well as the masses of deposited sediment and sorbed nutrients (P, N). Current model development is incorporating infiltration to provide a coupled overland/vadose approach to simulating flow through vegetative buffers.

Keywords：*Buffer strip, sediment transport modelling, vegetation strip, runoff, erosion*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Effact of Q/i Parameter on Limiting Soil Potassium Critical Levels of Some Soil Order at Kurdistan Region-Iraq

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This Study was conducted during 2007-2009 to determine Potassium critical level for calcareous soil in Kurdistan region for this purpose 16 soil sample were taken from different soil Orders (Mullisols, Vertisoils, Aridisols, Inceptisols and Entisols). The Potassium critical were determined depending on extracted K+ with NH4AOc, Potassium activity ratio (ARk) and Potential Buffering Capacity (PBCk), using Graphic and statistical methods. the result indicated that the best parameter for determining Potassium critical level is Potential Buffering Capacity. the critical level of potassium depending on PBC was 71.9 cmole/Kg (mol/L)0.5

Keywords：*Potassium activity ratio, Critical level, Potential Buffering Capacity.*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Distribution of Bromine and Iodine in Volcanic Ash Soil Profiles in Relation to Soil Properties

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Bromine (Br) and iodine (I) belong to the halogen group and have similar chemical properties. Although excess intake of Br is harmful for human health, considerable amounts of Br (as methyl bromide and ethylene dibromide) have been used in agriculture as pesticides. Soil fumigation with methyl bromide is a significant source of Br in the atmosphere, which is involved in stratospheric ozone loss. Iodine is an essential micronutrient for the synthesis of thyroid hormones in humans and its deficiency causes goiter. The need for I by higher plants has not been confirmed, although excess I has a known toxic effect. The natural abundance and distribution of these elements in soil is quite important in a biogeochemical study. Although Br and I are generally not abundant in parent rock materials, higher concentrations of these elements are often found in soils, particularly in volcanic ash soils in Japan. This exogenic Br and I in soils is considered to be transported from the ocean, from where they are volatilized to the atmosphere and supplied to the land surface by aerial deposition. However, the processes of Br and I accumulation in soils during soil formation remains unclear. In this study, the distribution of Br and I in selected soil profiles of a region affected by volcanic ash were investigated to characterize the processes of Br and I accumulation in volcanic ash soils.

Soils were collected from three pedons in a broad-leaved forest (Silandic Andosol), coniferous forest (Aluandic Andosol), and undisturbed lowland (Gleyic Fluvisol) in the southern part of Shimokita Peninsula, Japan. Sixteen soil samples including eight A horizons (including three buried horizons), two B horizons, three C horizons, one AB horizon, one AC horizon, and one B/C horizon were used in this study. Br and I concentrations in the soil samples were determined by polarizing energy-dispersive X-ray fluorescence spectrometry after preparing pressed pellets of the soil powder samples.

The concentrations of Br and I in the soil samples were 1.4?233 mg $kg^{?1}$ and 1.2?83 mg $kg^{?1}$, respectively, and were significantly correlated (r = 0.869). The concentration ratio of Br to I in the soils varied from 1.1 to 7.4 mg $kg^{?1}$. Total carbon content in the soil, varied from 1.7 to 149 g $kg^{?1}$, which significantly correlated with Br (r = 0.676) but not with I concentration in the soils. Oxalate-extractable Al and Fe, pyrophosphate-extractable Al and Fe, phosphate absorption coefficient, and soil pH (NaF) had significant correlations both with Br and I concentrations in the soils (P > 0.01). In particular, the Br and I concentrations in soils exhibited the highest correlation coefficient with pyrophosphate-extractable Al (r = 0.931) and oxalate-extractable Al (r = 0.938), respectively. These results suggest that Br and I are enriched in the soils with the formation of non-crystalline aluminosilicate minerals. Speciation of these elements in the soils will also be discussed.

Keywords：*bromine, halogens, iodine, speciation*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Phosphorus Speciation of Clay Fractions from Long-Term Fertility Experiments in Sweden

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The increased use of fertilizers on Swedish arable land has resulted in increased eutrophication in inland lakes and the Baltic Sea. Phosphorus (P) has been pointed out as one of the main elements promoting this process, where losses from agricultural fields are of major concern. Substantial efforts have been put into minimizing P losses from these fields. However, more information about soil P and its reactions are needed to understand and identify ways to minimize the P losses. The aim with this study is to investigate how the P speciation in soils has changed as a result of P fertilization.

Six sites were included in this study. Two soil samples were collected from each site where; (1) no P was added; and (2) P fertilizer amendments replaced of crop removal plus 30 kg ha-1 yr-1. Ranges of soil pH, clay content, and organic C were 5.9 to 7.8, 12 to 56% (w/w), and 1.2 to 2.3% (w/w), respectively. Oxalate extractions were made on the soil samples, and extracted aluminum and iron were analyzed by ICP-AES.

Clay fractions of soil samples were analysed by phosphorus K-edge XANES spectroscopy. Clay fractions were used was to increase the P concentration in the samples. Linear combination fitting (LCF) was used to analyse P speciation from these spectra. Standards included were different phosphorus minerals, phosphate adsorbed to aluminium and iron (hydr)oxides, and organic P species. Principal component analysis and target transformation was used to select standards to be included in the LCF analysis. The fit from the unfertilized sample was included as a standard for the fit of the fertilized sample from the same site, which assumes that the native P species were unchanged by fertilizer additions. Additional standards needed to get to fit the fertilized sample were assumed to be the P species formed after fertilization.

Based on the combinations of selected standards giving the best fit to the soil P data, P speciation in unfertilized samples was variable. Calcium phosphates were fit in all samples, except for the soil with the lowest pH (Ekebo). By contrast, a calcareous sample with a relatively high pH (Fors) had the major part of its P fitted as calcium phosphates. However, no clear relationships were found between the proportions of P as calcium phosphates and pH. All samples were also fit with phosphate adsorbed onto aluminium and/or iron (hydr)oxides. Phosphate adsorbed to iron (hydr)oxides was found in samples from soils with greater amounts of oxalate-extractable iron (> 4 g kg-1). However, in soils with lower amounts of oxalate-extractable iron (< 2 g kg-1) phosphate adsorbed to aluminium (hydr)oxides gave a better fit. In one sample with intermediate levels of oxalate-extractable iron (Ekebo), phosphate was fit with both types of adsorbed species. Organic P was distinguished in two samples that also had the highest content of organic carbon among the soils.

Standards selected to fit the fertilized samples were the fit of the unfertilized samples and P adsorbed primarily to aluminium (hydr)oxides. However, in the sample from the soil with the largest amount of oxalate-extractable iron (Kungsängen) the added P was partly bound as iron phosphates. In one sample from a soil with moderately high pH (Fjärdingslöv) the added P had been bound partly as calcium phosphates.

Our results indicate that the P speciation in unfertilized soils is dependent on a range of soil characteristics, e.g. content of organic matter, oxalate extractable iron and pH. Phosphorus added through fertilization is commonly adsorbed to aluminium (hydr)oxide-type phases, sometimes with a minor contribution from other P phases such as e.g. iron or calcium phosphates.

Keywords：*phosphorus, phosphorus speciation, XANES, clay soils, fertility experiments*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Evaluation of Nutrient Release from the Matrixes Produced Based on the Shotcrete Vegetation Mulching Technique

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By mixing cement and greening additives (GA) with hydraulic mulching materials in an appropriate proportion, the novel Shotcrete Vegetation Mulching Technique (SVMT) was proven to be able to make soil surfaces resistant to erosion within a short time and suitable for germination of grass seeds. However, the release of nutrients from the matrixes into environments has not been investigated while the SVMT is used on a dike or a steep slope in an ecosystem. Therefore, a continuous extraction procedure was conducted to evaluate the nutrient release of the matrixes used in the SVMT.

The sediments from a reservoir were mixed with bagasse compost to reach a organic matter content of 20% as an initial material. This material was then mixed with cement (10%) and a commercial GA (3.3%) as the GA treatment. Another portion of initial material was mixed with cement (10%), expanded vermiculite (EV) (2.8%), and ferrous sulfate (FS) (5.6%) as the Adjusted treatment. We used EV as a water retention agent and FS to lower pH of the matrix. A mixture of initial material and EV (2.8%) was also used as the Control treatment. A series of three replicates of each matrix were first incubated for 2 weeks and then followed by 40 continuous extractions using 50 g matrix with 100 mL distilled water. The pH and the concentrations of total N, inorganic N, total P, K, Ca, Mg and dissolved organic carbon (DOC) in the extracted solutions were analyzed.

The results show that under GA and Adjusted treatments, the available water content of the matrixes was significantly higher than Control. In addition, the pH of the matrixes was reduced to be lower than 9 after 28 days' incubation. The results of extraction experiment showed that the pH of extracted solutions under GA and Adjusted treatment were 0- 0.5 unit higher than Control throughout the experiment. Compared to Control and GA treatments, the Adjusted treatment showed higher rate and accumulative amounts of release of organic N and Inorganic N. Both GA and Adjusted treatment had higher rate and accumulative amounts of Ca and K release than Control. Conversely, compared to Control, the accumulative amounts of P and Mg release were lower under the GA and Adjusted treatments while that of DOC was lower only under Adjusted treatment. Ca content in cement is very high which resulted in 6.1 and 4.3 folds of accumulative release amount in Adjusted and GA matrixes compared to Control. The N and P release should be more concerned for their environmental implications. The increases in accumulative release amounts of organic N and inorganic N were up to 67% and 50% under Adjusted treatment, respectively. This implicates that decomposition of organic matter was accelerated. The precipitation/adsorption of P with Ca and Fe might occur which resulted in lowering accumulative release amounts of P to 8.7% and 42% under Adjusted and GA treatment, respectively. The seed germination experiment showed that the number of seed germination was not different among treatments while the growth of seedlings were retarded in both Adjusted and GA treatments.

The results of this study indicate that the matrix produced and used in the SVMT was able to produce a more stable environment for re-vegetation on steep slope with high water retention capacity and Ca and K supply. However, the matrix had different release potential of various nutrients. The nutrient release potential of the matrix needs to be taken into consideration when they are used in the SVMT in order to avoid to causing environmental side effects such as eutrophication.

Keywords：*Shotcrete Vegetation Mulching Technique (SVMT), nutrient release, cement, continuous extraction*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Molecular Characterization of Enterobacter Diazotrophic Bacterium for Improving Crop Yield in Pakistan

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A Gram-negative, anaerobic diazotrophic bacterium, designated NCCP-231, was isolated from root nodule of chickpea (Cicer arietinum) collected from the farmer field of District Attock, Pakistan and subjected to a polyphasic taxonomic study. The cell of strains NCCP-231 was catalase negative and weakly positive for oxidase, non spore forming and rod shaped. Strain NCCP-231 can grew at 10-45○C (optimum at 37○C), pH 6.5-9.0 (optimum at pH 7.5) and in 0-6% NaCl (w/v) in tryptic soya agar medium. The dominant fatty acid was C16:0, C16: 0 N alcohol, C17:0 cyclo, C18:0, C19:0 cyclo w8c. The phospholipid profile was found to comprise phosphatidylethanolamine, diphosphatidylglycerol, phosphatidylglycerol, Aminophospholoipids and unidentified polar lipids. The G + C content of the genomic DNA were 54.99%. Phylogenetic analysis of the 16S rRNA gene sequence showed that strain NCCP-231 is a member of genus Enterobactor and exhibited sequence similarity of 99.67% to Entereobactor Oryzae and 99.46% to Enterobactor Arichidis. In vitro growth promoting assay indicated that the strain NCCP-231 positive for nifH gene (+), Phosphorus solubilization in broth culture was associated with significant drop in pH by 7±2 to 4.97 and amount is 161.72 µg ml-1 and produce IAA in the presence of tryptophan is 15.40 µg ml-1. The strain NCCP-231 proved the best PGPR by increasing crops biomass and grains (Soybeant 40-45%) over un-inoculated control. The DDBJ/EMBL/GenBank accession number of the 16S rRNA gene sequence of strain NCCP-231 is AB610883.

Keywords：*Enterobactor Oryzae, 16S rRNA gene sequence, Phospholipid profile, phylogenetic analysis, diazotroph*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Effect of Soil Ph on Decontamination of Chlorate in Longan Plantation Soil

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Potassium chlorate is widely used as an active substance for flower induction in longan plantation for off season production of fruits in Thailand. Three soil series collected from logan plantation field soil, and decontamination of residual chlorate and ammonium-N in soil were examined by conducting a laboratory soil incubation study. At soil pH 7 under upland soil conditions, chlorate applied to soil at the concentration of 34 mg kg-1 soil , chlorate were faster decomposed than soil pH 5 in Num Pong soil series. Soil pH 7, nitrate-N accumulation in all soils were increased higher than at soil pH 5 under upland conditions. Flooded soil conditions, all Soil pH 7 were completely decomposed within 1 week of incubation; Soil pH 5, chlorate decomposition rate were slower than soil pH 7 . These results may lead to practical method to stimulate chlorate decomposition in longan plantation field.

Keywords：*chlorate, decontamination, longan plantation soil, pH*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Soil Grinding Treatment Causes not only Release but also Accumulation of Fixed Ammonium Depending on the Content of Exchangeable Ammonium

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Introduction

It is well known that ammonium ions held at exchangeable and interlayer sites in soil maintains a dynamic equilibrium. McDonnell et al. (1959) reported that the ball milling of several subsoils suspected of containing naturally occurring fixed ammonium led to a progressive increase in exchangeable ammonium with time of ball milling and that the increase of exchangeable ammonium by ball milling was ascribed to release of fixed ammonium or breakdown of organic matter. The ball milling was considered to destroy the crystal lattices of clay minerals and release fixed ammonium. When we analyze fixed ammonium in soil by the most conventional method (Silva and Bremner, 1967), the sample is also finely ground to pass a 0.15 mm-mesh sieve for a complete recovery of fixed ammonium by HF-HCl extraction. This suggests that a part of fixed ammonium in soil can be released by the grinding treatment, apart from the finding by Paramasivam and Breitenbeck (2000) that removal of organic matter by alkaline KOBr oxidation used in the conventional method causes a release of weakly-fixed ammonium in soil. Based on the concept of dynamic equilibrium of soil ammonium, however, it is also hypothesized that the ball milling of soils containing exchangeable ammonium at a high level may lead to a decrease of exchangeable ammonium by its fixation by soil minerals. We test this hypothesis in this study.

Materials and Methods

Five soil samples collected from the surface layer of paddy fields in Japan were treated with ammonium sulfate at the rate of 0, 100, 500, 1000 mg N kg^{-1} followed by an aerobic incubation at 30°C for 7 days and air-drying at 40°C. The samples thus prepared were ground with a ball mill for 10 minutes, which has been used by us for the analysis of fixed ammonium in soil. The particle size distribution and the contents of exchangeable and total fixed ammonium were determined before and after the grinding treatment. A sequential extraction method described in a previous paper (Matsuoka and Moritsuka, 2011) was applied for the analysis of ammonium in soil.

Results and Conclusions

The average content of the clay fraction in the soils increased from 22% to 41% by the grinding treatment. In the case of the soils without application of ammonium, the grinding treatment led to a decrease of total fixed ammonium with a range from 23 to 48 mg kg^{-1}, which was accompanied with an increase of exchangeable ammonium for two of the five soils. In the case of the soils applied ammonium at the rates of 1000 mg kg^{-1}, on the other hand, the grinding treatment led to a decrease of exchangeable ammonium and an increase of total fixed ammonium for all soils. On the average, the increase of total fixed ammonium by the grinding

treatment amounted to 58% of the decrease of exchangeable ammonium on the average. The decrease of exchangeable ammonium unaccounted by the fixation process suggested a presence of other reactions during the grinding treatment.

These results support the hypothesis that soil grinding treatment causes not only release but also accumulation of fixed ammonium depending on the content of exchangeable ammonium. The content of exchangeable ammonium when total fixed ammonium starts to increase by the grinding treatment was less than 500 mg kg^{-1} for four of the five soils.

In conclusion, the grinding treatment performed for the analysis of fixed ammonium by the conventional method will affect the content of fixed ammonium in soil in both positive and negative directions. So a revised method for fixed ammonium needs to be established in the future. A possible way to eliminate the artifact by grinding is to apply a sequential extraction by which exchangeable ammonium in soil can be removed before the grinding treatment (Matsuoka and Moritsuka, 2011). Use of a 2-mm sieved soil sample is also a promising alternative, provided that fixed ammonium can be fully recovered by chemical extraction without additional grinding treatment.

Keywords：*Dynamic equilibrium, Fixed ammonium, Grinding treatment, Paddy soil, Sequential determination*

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[C2.2-1] Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales

Rate of Farm Manure Decomposition Applied alone and in Combination with Dap and Release of P in Different Soils

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Organic phosphorus (Po) of manures transforms into plant available inorganic P (Pi) through a series of biochemical reactions of mineralization. Therefore, P kinetic study of a manured soil not only determines the fate of applied P to that soil but it also helps to quantify the appropriate P requirement for a target crop. The present pot experiment was designed to study kinetics of P release/desorption in three calcareous soils of Northern Punjab. For incubation purpose diammonium phosphate (DAP) was added to soils separately and in integrated form with farm manure (FM); an organic amendment. Phosphorus from DAP was added to supply 35 mg P kg-1 soil while FM was applied at 10 g kg-1 soil. After equilibrium, soil samples were collected to study the rate of FM decomposition and rate of P release. Results depicted faster release of P at initial stage of incubation and afterward slow reaction was observed. Rate of FM decomposition and P release kinetics were best described by Elovich and Zero Order equations. Higher R2 values up to 1.0 and lower values of standard error up to 0.001 of the equations were observed. Integrated organic and inorganic sources of P showed maximum R2 values which depicted beneficial effects of integration of organic and inorganic sources of P over their separate use for P release.

Keywords：*Farm manure, DAP, decomposition, Phosphorus release and soils*

P1-349

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Microbial Assimilation of Atmospheric Co_2 In Soil: An Important Process in Terrestrial C Cycling

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Like higher plants, microbial autotrophs possess photosynthetic systems that enable them to fix CO_2. Whilst present in large numbers in soils, their capacity to fix CO_2 and importance in terrestrial C cycling have not been quantified. To measure the activities of microbial autotrophs in assimilating atmospheric CO_2, seven soils were incubated with ^{14}C-labelled CO2 for 80 d, and the ^{14}C-labelled organic C synthesized was determined. The results indicate that the synthesis rates of ^{14}C-lablled organic C ranged from 0.0134 to 0.103 g C m^{-2} d^{-1}, which represent an annual, global rate of about 0.6-4.9 Gt C, and were closely related to RubisCO activities and the abundance of cbbL-genes in the soils, indicating that the synthesis could be attributed to soil microbial autotrophs. This finding suggests that microbial assimilation of atmospheric CO_2 is an important process in the sequestration and cycling of terrestrial C that, until now, has been ignored.

Keywords：*C assmilating; Agricultural soil; Bacteria; cbbL gene; ribulose-1, 5-bisphosphatecarboxylase/oxyg*

P1-350

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Methane Oxidation Needs Less Stressed Plants

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Methane (CH_4) is an important greenhouse gas and responsible for approximately 25% of global warming. Upland soils of forest and grassland ecosystems function as sinks for atmospheric CH_4. Under stressful conditions, plant responses often produce accelerated ethylene biosynthesis, subsequently exuding ethylene into the soils, while ethylene can exert remarkable inhibition on CH_4 oxidation. With increasing global temperature and extreme climate events, more frequencies of inhibition on CH_4 uptake are predicted to occur in these ecosystems. Recent work shows that bacterial 1-aminocyclopropane-1-carboxylate (ACC) deaminase can decrease ethylene levels in soils by metabolizing its precursor ACC, leading to alleviate or eliminate the magnitude of inhibition of ethylene on CH_4 oxidation. Here, we provide perspectives of inoculation of bacteria containing ACC deaminase or transgenic plants with genes encoding ACC deaminase for enhancing capacity of CH_4 uptake in upland soils. Given 25 times global potential warming per molecular CH_4 relative to carbon dioxide, upland soils harbor more capacity for CH_4 uptake, which can lead to an increase in carbon sinks, even without increasing carbon stocks in these ecosystems.

Zhou, X.Q., Smaill, S.J., Clinton, P.W. Methane oxidation needs less stressed plants. Trends in Plant Science, in press. (IF 11.81)

Keywords：*Methane uptake, ACC, ACC deaminase, ethylene, bacteria, upland soils*

P1-351

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Testing the Origin of Agricultural Nitrogen Sources in Soil, Plant, and Water

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In agriculture, several nitrogen (N) sources, such as soil organic matter, chemical N, and manure N are used for crop production. When these N sources are mineralized, they can be converted into nitrate-N. Nitrate-N in the soil can be used by plant, stayed in soil, and lost through soil profile into ground water. It is not easy to differentiate where the nitrate-Ns come from because the nitrate-Ns from these N sources have similar chemical structures. One way to look at it is to use natural stable isotope. Therefore, the objectives of this study are to test the feasibility whether natural stable isotope method (N15) can be used as an indicator of N sources in soil, plant, and drained water and to investigate whether mineralized N (nitrate-N) through soil profile in the drained water is from N fertilizer or from soil N. Corn was planted on a sandy soil, Becker, MN in 2012 and 2013. Experimental design was randomized complete block design with 4 replications. 224 kg N/ha of 8 nitrogen sources was used for N leaching trial. N sources were control (no N fertilizer), urea, ESN, Super U, UAN, dairy, turkey, and chicken. Additional water was supplied with an irrigation system. Soil, plant and drained water samples during the growing season were collected and prepared for total N and N15 analysis. Water samples were collected every week using lysimeter, which was installed 0.9 meter deep. Initial soil pH, nitrate-N concentration, Bray-P, and K concentration were 5.2, 7.4, 12, and 51, respectively. Average corn grain yield was 3.7, 7.1, 10.5, 8.9, 4.3, 7.4, 5.6, and 7.8 Mg/ha for control, urea, ESN, super U, UAN, chicken, dairy, and turkey manures, respectively. Nitrate-N leaching in drained water was observed during the growing season of 2012 and 2013.

Keywords：*Nitrogen, isotope, N15, water quality*

P1-352

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Near Infrared Spectroscopy (nirs) to Estimate Earthworm Macroaggregate Age

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As ecosystem engineers, earthworms are major actors of soil aggregation, a process that drives the delivery of ecosystem services by soils. However, persistence of soil aggregates produced by earthworms, their degradation rates, and their role in the dynamics of soil organic matter (SOM) and nutrients remain poorly known. In this experiment, near infrared (NIR) spectral signatures were measured in subterranean casts of the endogeic earthworm Aporrectodea caliginosa, incubated in controlled laboratory conditions for different periods of time. In parallel, dynamics of total amounts of C and N were assessed in ageing casts. As casts aged, NIR spectral signatures went through three main stages in the maturation process: (1) rapid changes in the NIR signal during the first 48 hours, (2) a maturation period from days 3 to 30 with much slower change in NIR spectral signatures and (3) a further stage of maturation (days 45 to 90), where cast signals converged towards those of control soil. The first two axes of the PCA corresponded closely to the C and N content, respectively, of the casts. C and N contents in casts remained higher than those in control soil during the whole incubation time. Drying of casts halted the mineralization of organic matter, resulting in lack of change in the NIR spectral signal as long as casts were kept dry.

Keywords：*Laboratory experiment; Cast ageing; Near Infrared Spectroscopy; C and N kinetics*

P1-353

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Removal of Nitrate in Subsoil by Denitrification in Wheat - Maize Rotation System in North China Plain

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Excessive application of fertilizer nitrogen (N) in crop production systems in North China Plain has resulted in the accumulation of nitrate (NO_3^-) in subsoil and groundwater. Denitrification is a possible pathway for removal of accumulated nitrate in subsoil, but is often neglected and/or regarded as unimportant because of (i) the difficulty of measuring denitrification in the subsoil, and (ii) the low amounts of metabolizable carbon in most subsoil.

The aim of the study reported here is to quantify the seasonal variations in denitrification activity in a 190cm deep soil profiled under a winter wheat - maize double cropping system as a function of N fertilizer application. The study was conducted at the Luancheng agro-ecosystem experimental station, in 2009-2010. The N fertilizer treatments included 0 (CK), 450 (N1) and 750 (N2) kg N ha^{-1} $year^{-1}$, in triplicate. Soil cores were taken by the Geoprobe machine about every other. A total of 8 intact cores (5 cm diameter) were taken per plot and subjected to the acetylene inhibition technique.

Denitrification rates in the 1.9 m deep soil profile were on average rather low and showed the commonly observed responses to N fertilizer application, irrigation and rainfall, leading to strong a temporal variability. Nitrogen losses through denitrification were significantly higher (a factor of 2.0 to 2.7) in the maize growing season than in the wheat season, likely because of the more wet and warm weather conditions in the maize growing season. On average, only 33% of total denitrification activity in the 190 cm deep soil profiled occurred in the top soil (0-15 cm); 26% occurred in the 15 to 90 cm soil layer and 41% in the 90 to 190 cm soil layer. The contribution of the top soil (0-15 cm) increased to ~ 45% and that of the subsoil (90-190 cm) decreased to ~ 30%, when the N fertilizer application increased to 750 kg per ha per year. The total amount of N lost via denitrification was 6, 15 and 28 kg N $ha^{-1}yr^{-1}$ in the CK, N1 and N2 treatments, respectively.

In conclusion, the subsoil (15-190 cm) was a large contributor to N losses via denitrification, although the total N losses via denitrification were only in the range of 1 to 6% of total N fertilizer application. Further studies should try to understand the mechanism and controlling factors of denitrification in the low-carbon subsoil.

Keywords：*Denitrification; Removal of nitrate; Subsoil; Wheat-maize rotation system*

P1-354

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Enrichment of Acid-Tolerant Gamma-Proteobacterial Ammonia-Oxidizing Bacterium from Strongly Acidic Soils

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The aim of this study was to determine whether ammonia oxidation in acid soils resulted from the existence of acid-tolerant ammonia-oxidizing bacteria (AOB) by attempting their enrichment in low-pH medium. The acid-tolerant ammonia-oxidizing bacterium (TAO) was enriched from strongly acidic soil from an agricultural field. The TAO was identified as belonging to the genus Nitrosococcus on the basis of morphological characterization and analysis of 16S rDNA and amoA sequences. The cells were non-motile and shaped spherical-to-ellipsoidal. Electron microscopy showed that the cells had a centrally located organelle composed of a stack of parallel, flattened membrane vesicles. This ultrastructure was typical of AOB belonging to genus Nitrosococcus. The 16S rDNA and amoA sequences of TAO had 94% and 70% identity, respectively, with those of N. oceani. Although the optimum growth pH was around 7, growth was still observed below pH 5. Growth ceased above pH 8 - 9. The pH of a vigorously growing, aggregated TAO culture finally decreased to pH 2. However, when pH was readjusted to around 7, the cells oxidized ammonia again and continued to grow. Using amoA-targeted quantitative PCR, we estimated abundances of TAO, beta-AOB, and ammonia-oxidizing Archaea (AOA) in the soils used for isolation. The abundance of TAO was 50–100 times higher than those of beta-AOB and AOA. These results indicated that TAO played an important role in nitrification of acidic soils.

Keywords：*ammonia-oxidizing bacteria, acid soil, nitrification*

P1-355

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

The Use of Biomarkers to Trace Carbon Transformations and Input in Soils

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Tracing the origin of soil organic matter is an important tool to unravel mechanisms that lead to (de)stabilization of organic carbon in soil systems. To this end biomarkers, i.e. (groups of) specific molecules that can be linked to (groups of) specific plant species or plant parts are often used. A good example is the use of suberin and cutin as biomarkers to distinguish organic matter with a root origin from organic matter with a leaf origin. However, the use of biomarkers to trace the origin of soil organic matter is also subject of fierce scientific debate. On the one extreme end there are those colleagues who see biomarkers as a cure-all solution to all organic matter tracing problems. On the other end of the spectrum there are experts who claim that the concept of biomarkers is so intrinsically flawed that it can never yield meaningful information about carbon transformations except in the most specific cases.

We believe that neither vision is correct. In our presentation we discuss the merits and drawbacks of using biomarkers to trace root versus leaf derived organic matter in soils. For this we use a 1-year incubation experiment with fine root and leaf material of six temperate tree species as a case study. We discuss the abundance, or lack thereof, of root and leaf derived biomarkers and the development of their concentration over time. Specifically, we found that the specificity of root and leaf specific biomarkers depended strongly on the amount and diversity of studied species. For instance, four molecules were identified to be leaf biomarkers for some species, while serving as root biomarkers for others. This could result in serious misjudgment of root and leaf specific biomarkers if the boundary conditions, including species of interest, are not well known. On the other hand, our results show that cutin and suberin derived biomarkers can indeed be successfully used to distinguish root from leaf input in certain situations, such as an ecosystem dominated by the six forest species tested.

We will link the incubation study to our experience with the application of biomarkers in podzols and plaggic anthrosols, and place it in the context of similar attempts by other groups . Thus we hope to stimulate a broader discussion about the merits and drawbacks of the use of biomarkers to trace the origin of soil organic matter.

Keywords：*biomarkers, SOM, lipids, carbon transformation*

P1-356

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Effect of Agricultural Land Use Change on Community Composition of Bacteria and Ammonia Oxidizers

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Soil microbial communities can be strongly influenced by agricultural practices, but little is known of about bacterial community successions as land use changes. The objective of this study was to determine microbial community shifts following major land use changes in order to improve our understanding of land use impacts on microbial community composition and functions.

Four agricultural land use patterns were selected for the study, including old rice paddy fields (ORP), Magnolia nursery planting (MNP), short-term vegetable (STV) and long-term vegetable (LTV) cultivation. All four systems are located in the same region with the same soil parent material (alluvium) and the MNP, STV and LTV systems had been converted from ORP for 10, 3 and 30 years, respectively. Soil bacteria and ammonia oxidizer community compositions were analyzed by 454 pyrosequencing and Terminal Restriction Fragment Length Polymorphism (T-RFLP), respectively. Quantitative PCR (qPCR) was used to determine 16S rRNA and amoA gene copy numbers.

The results showed that when land use was changed from rice paddy to upland systems, the relative abundance of Chloroflexi increased whereas Acidobacteria decreased significantly. Whilst LTV induced significant shifts of bacterial composition, MNP had the highest relative abundance of genera GP1, GP2 and GP3, which were mainly related to the development of soil acidity. The community composition of ammonia oxidizing bacteria (AOB) but not ammonia oxidizing archaea (AOA) was strongly impacted by the agricultural land use patterns, with LTV inducing the growth of a single super predominant AOB group. The land use changes also induced significant shifts in the abundance of 16S rRNA and bacterial amoA genes, but no significant differences in the abundance of archaea amoA genes was detected among the four land use patterns. Soil TP, AP, NO3-, SOC contents and pH were the main determinants in shaping driving the composition of both bacteria and AOB communities.

In conclusion, these results clearly show the significant impact of land use change on soil microbial community composition and abundance and this will have major implications on the microbial ecology and nutrient cycling in these systems, some of which is unknown. Further research should be directed to studying the impacts of these microbial community shifts on nutrient dynamics in these agroecosystems so that improved nutrient management systems can be developed.

Keywords：*Ammonia oxidizer ? Bacteria ? Community composition ? Land use ? Nitrification*

P1-357

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Microbial Nitrogen Transformation in the Legume Rhizosphere

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The term “rhizosphere” was first coined in 1904 by Lorenz Hiltner in Germany, who had a special interest in complicated N transformations around leguminous nodules with higher N contents in fields. Nitrous oxide (N2O) is a greenhouse gas and a destructive substance of ozone layer. Agricultural soil is the biggest source of N2O. Soybean (Glycine max [L.] Merr.) is one of the most important crops in the world. Bradyrhizobia, symbiotic nitrogen-fixing soil bacteria, can also denitrify and produce N2O. Marked N2O emission were detected from soybean root systems with degraded nodules during late growth stage in field-grown soybeans.

A model system developed to produce N2O emissions from soybean fields. Soybean plants inoculated with nosZ mutant of Bradyrhizobium japonicum USDA110 (lacking N2O reductase) were grown in aseptic jars (1). After 30 days, shoot decapitation (D, to promote nodule degradation), soil addition (S, to supply soil microbes), or both (DS) were applied. N2O was emitted only in the DS treatment. Thus, both soil microbes and nodule degradation are required for the emission of N2O from the soybean rhizosphere. The N2O flux peaked at 15 days after DS treatment. A 15N tracer experiment indicated that the N2O was derived from N fixed in the nodules. As for nitrification, the addition of nitrification inhibitors significantly reduced N2O flux. Both AOA and AOB were detected by PCR analysis with N2O emission profile in soybean rhizosphere (Unpublished). N2O emission was compared between a nirK mutant and ΔnosZ. The N2O flux from the ΔnirKΔnosZ rhizosphere was significantly lower than that from ΔnosZ, but was still 30% to 60% of that of ΔnosZ, suggesting that N2O emission is due to both B. japonicum and other soil microorganisms. Only B. japonicum nosZ+ strains could take up N2O (1).

From these results, the organic-N inside of the nodules was mineralized to NH4+, and N2O producing processes simultaneously occur in the soybean rhizopsphere (1). In a sense, the present study advances a historical work for rhizosphere that was coined in 1904 by Lorenz Hiltner.

N2O is then emitted to the atmosphere, or is further reduced to N2 by N2O reductase (N2OR), encoded by a nosZ gene. B. japonicum USDA110 mutants with higher N2OR (N2O reductase) activity were selected under N2O respiration by a mutator strategy, which were designated as nosZ++ strain. Pure culture and vermiculite pot experiments showed that N2O emissions from nosZ+ and nosZ++ (mutants with increased N2OR activity) strains of Bradyrhzobium japonicum were less than those from nosZ− strains. A pot experiment using soil also confirmed these results (2). Although the use of N2OR has been suggested as a N2O mitigation option, this has never been tested in a field scale. It was demonstrated that N2O emissions from soybean ecosystems can be mitigated by the inoculation of nosZ+ and nosZ++ strains of B. japonicum at field scale based on careful characterization of the nosZ++ strains (2).

I would like to introduce our research efforts to address how nosZ++ strains of B. japonicum induce higher N2OR activity than wild-type B. japonicum USDA110. Comparative genome analysis between nosZ+ and nosZ++ strains revealed the presence of a novel gene encoding a sensor protein of two component regulatory system (Unpublished), which co-regulated nap (encoding

periplasmic nitrate redutase) and nos (encoding N2OR). The knowledge would improve our mitigation options of global N2O emission from soils. This study was supported by BRAIN and JSPS.

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Keywords：*Nitrogen, Rhizosphere, Soil*

P1-358

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Effect of Manure Applications on Denitrification Enzyme Activity of Grassland Soil

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Introduction

In Japan, a substantial proportion of manure is derived from livestock management using imported feed. Therefore, farmers must utilize manure proactively to improve the production of forage crops. In our country, approximately 660 Gg of nitrogen (N) is excreted from livestock annually, of which approximately 430 Gg is composted before application to agricultural soils. The combination of composted manure application in late autumn and a reduction in the synthetic N fertilizer during summer growing season is considered to be a possible option for mitigating N2O emission from grassland (Mori and Hojito 2012). However, the precise mechanism to reduce N2O emission is less well understood. The objective of the present study was to investigate effects of composted farmyard manure (FYM) applications to permanent grassland on denitrifying enzyme activity (DEA) of soils.

Materials and Methods

Site description

For measurements of DEA (denitrification enzyme activity), top 5cm grassland soils were sampled from FYM plots and fertilizer plots in grassland at the NARO Institute of Livestock and Grassland Science in Nasu, Japan (36?55N, 139?55E, 320 m a.s.l.). The site is located at a border where cropland transitions into forest. The dominant plant species were orchardgrass (Dactylis glomerata L.) and Italian ryegrass (Lolium multiflorum Lam.). For FYM plots, composted dairy FYM (30 Mg ha?1 year?1) was applied in November, and ammonium sulfate was supplemented, however, the application rates of ammonium sulfate (200-95kg N ha?1 year?1) were reduced year by year by using the Uchida's model (Shiga et al. 1985). For fertilizer plots, almost constant rates of ammonium sulfate (190-210 kg N ha?1 year?1) was applied every year. In both the plots, the timings of synthetic fertilizer applications (e.g. March, May, July and September) and harvestings (e.g. May, July, September and October) were exactly same.

DEA measurement

Fresh soils were collected 4 times a year (e.g. March, May, July and September) within 2 weeks after synthetic fertilizer applications. The soils were sieved through 4 mm mesh, and then temporarily stored at 4°C. The soils were pre-incubated at 25°C for 24 hours just before measurements of DEA. In 125-mL serum vials, 15g of fresh soils were mixed with 15mL of the assay solution containing 0.1g chloramphenicol, 50 mg NO3-N and 300 mg glucose-C per L. Next, the serum vials containing soil slurries were evacuated and flushed 4 times with O2-free N2 gas. To determine the rates of N2+N2O and N2O productions from soils, the soil slurries were incubated at 25°C with N2 gas containing C2H2 (0.1 L L?1) or N2 gas containing no C2H2, respectively. Gas samples (1mL) were taken from headspaces of serum vials after 0, 1, 2, 3, and 4 hours after initiations of incubation. Concentrations of N2O were determined by an ECD-GC, then the N2+N2O and N2O productions rates from soils were determined by using linear interpolations.

Results and Discussion

The DEA values of soils which was collected in July and September were greater than that of soils collected in March. The DEA values of soils from FYM plots were greater than those of soils from fertilizer plots ($P < 0.001$). However, the ratios of $N_2O/(N_2O+N_2)$ production of soils from FYM plots were smaller than those of soils from fertilizer plots ($P = 0.051$). The pH (H_2O) values of soils from FYM plots was greater than those of soils from fertilizer plots ($P < 0.001$). The greater pH (H_2O) values of soils from FYM plots is considered to be due to the annual FYM applications and the reduction in ammonium sulfate applications. Against this background, FYM applications to permanent grassland have promoted DEA of soils, however, reduced the soil pH (H_2O) values, and then reduced the ratio of $N_2O/(N_2+N_2O)$ productions in soils.

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Keywords：*denitrification enzyme activity, farmyard manure, nitrous oxide, volcanic soil*

P1-359

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Effects of Alternate Wetting and Drying (awd) Practice on the Microbial Processes of the N-Cycle in Rice Paddy Soils of the Mekong Delta, Vietnam

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Traditional rice production with continuous flooding (CF) irrigation practice has been predominantly used by the farmers in the Mekong delta (MD) area of Vietnam. However, river water is forecasted to become a limited resource in coming years due to climate change and up-stream human exploitation of the Mekong River water resources (MRC, 2010), and the farmers, therefore, have starting applying the AWD practice for rice production to achieve the dual goal of maintaining rice yield and saving water. The question is if the AWD practice should be recommended as an appropriate strategy for sustainable rice production in the MD. We conducted a greenhouse and dry season field experiment to investigate the impact of a CF-to-AWD transition on both N transformation (the microbial N-cycle processes, fertilizer-N losses) and the associated agronomic parameters from rice paddy soils of the MD. The greenhouse experiment was carried out with two dominant soil types of the MD, alluvial and slight acid sulfate soil, and 15N-labelled NH4Cl was applied as N fertilizer in the rice pots. The field experiment was conducted in MD alluvial soil and 15N-labelled urea was applied in microplots managed within a controlled field experiment to follow the fate of fertilizer N. For the greenhouse experiment, as expected, potential nitrification in the alluvial soil was higher in the AWD treatment than in the CF treatment (6.7 times higher, 0.20 μg N g-1.h-1 in AWD versus 0.03 μg N g-1 h-1 in CF). However, in the acid sulfate soil potential nitrification was not different between the two water management schemes (average = 0.02 μg N g-1.h-1). Accordingly, AWD stimulated coupled nitrification-denitrification significantly in the alluvial soil, but not in the acid sulfate soil. Plant fertilizer-N uptake was found slightly higher in AWD alluvial soil, but the difference was not significant and the final plant N uptake in acid sulfate soil was also not affected by AWD. These results indicate that, irrespective of soil type, gaseous fertilizer-N loss due to coupled nitrification-denitrification and the nitrogen use efficiency were not significantly affected by irrigation practice in the greenhouse experiment. For the field experiment, in comparison with CF, AWD enhanced gross N-mineralization activity, but only increased net N-mineralization activity after harvest. Also potential nitrification was significantly higher in the AWD practice. Fertilizer N loss as dinitrogen (N2) produced from coupled nitrification-denitrification was significantly higher in the AWD treatment, but this was counter balanced by lower rates of ammonia volatilization. Hence, rice plant N uptake, N use efficiency, and rice yield were not significantly affected by irrigation practice. A mass balance for fertilizer N successfully accounted for 96% of the added 15N and showed that 13% and 2.5% of the fertilizer N in AWD microplots was lost by ammonia volatilization and denitrification, respectively. The data reported here are the first to target the effects of AWD on N-cycle related microbial processes and on the in situ gaseous loss of fertilizer nitrogen. Data do not indicate that adoption of the AWD practice will lead to increased losses of fertilizer N in alluvial MD soils. Hence, AWD practice can be recommended as an appropriate strategy for sustainable rice production in the MD to meet with water shortage in the future. These results are most important, since AWD is an emerging, water-saving practice in the MD rice production. However, the AWD may create soil health problem due to further acidification of acidic sulfate soils and increased bioavailability of toxic metals. Therefore, the validation of AWD practice for rice production in acidic sulfate soils, which occupy a large area in the MD (more than 1.8 million hectares), needs more investigation before it may be generally recommended.

Keywords：*Rice paddy, 15N-urea, Ammonia volatilization, Nitrification-Denitrification, Mekong delta, Vietnam*

P1-360

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Microbial Community Structure and Proteolytic Activity in the Rhizosphere of Maize Plants Differing in Nitrogen Use Efficiency

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The rhizosphere, the thin soil layer influenced by the presence of plant roots has different physico-chemical properties from the bulk soil because of the active or passive rhizodepositions, which sustain larger and more active microbial populations in the rhizosphere than in bulk soil, and this plays a key role in soil organic matter decomposition and nutrient solubilization. The rhizosphere is chemically complex and dynamic microenvironment and this makes it difficult to study. Progresses in the study of the rhizosphere can be achieved by using rhizoboxes allowing the plant growth and precise sampling of rhizosphere. Plants select microbial bacterial and fungal populations in the rhizosphere during the plant growth, and while plant mechanisms involved in increased N uptake efficiency have been clarified, the importance of the rhizosphere microbial communities in nutrient availability to plants are still poorly understood.

Nitrogen is the main nutrient limiting the plant growth and the crop yields and today, the nitrogen use efficiency (NUE) of crops at field scale is still relatively low, with detrimental effects on groundwater quality and atmosphere due to NO3- leaching and NH3 and nitrous oxide emissions caused be excessive fertilization, and large efforts have been carried out to increase the NUE to enhance the crop production and reduce the environmental impact of agriculture, especially through plant breeding and preparation of fertilizers with slow N release.

We evaluated the changes in the biochemical activity and microbial community structure induced by the inbred maize (Zea mais L.) lines Lo5 and T250 characterized by high and low NUE using rhizobox experiments. The adopted experimental approach allowed to describe the relative plant induced changes on the different rhizosphere chemical and microbiological components and provide information to improve the crop NUE. In this work we studied the changes in the biochemical activity and microbial community structure in the rhizosphere of the inbred maize (Zea mais L.) lines Lo5 and T250 characterized by high and low NUE, repectively, using rhizobox experiments. Because of the importance of the proteolytic activity in soil N mineralization, the proteolytic activity in the rhizosphere of the two maize lines was also studied by the assessment of the diversity and abundance of the apr and npr genes coding for coding for alkaline protease and neutral metalloprotease, respectively, and determination of the protease activity.

The results showed that the Lo5 plant, having the higher NUE, induced the greater modification in the rhizosphere chemical properties, induced significantly faster depletion of inorganic N, higher bacteria diversity, proteolytic populations and protease activity. The importance of the plant activity in modifying microbial community structure, protease functions and rhizosphere biochemical activity will be presented.

Keywords：*NUE, rhizobox, maize, proteolytic activity, microbial diversity, proteolytic populations*

P1-361

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Productivity and Biological Nitrogen Fixation as Influenced by Groundnut Genotypes and Nitrogen Fertilizer in the Northern Guinea and Sudan Savannas of Nigeria

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Reliable estimates on the amount of atmospheric nitrogen (N2) fixed by groundnuts (Arachis hypogaea L.) in the Nigerian savannas are limited and smallholder farmers in the region rarely apply nitrogen (N) fertilizer despite recommendation for modest application due to low inherent soil N. Field trials were conducted in 2013 to assess the productivity and symbiotic nitrogen fixation of ten groundnut (Arachis hypogaea L.) genotypes in the northern Guinea (NGS) and Sudan savannas (SS) of Nigeria. A non-nodulating genotype (ICGL 5) was used as reference to estimate the amount of N2 fixed using the N-difference method. Highest pod and haulm yields were observed in the SS than in the NGS and application of 30 kg N ha-1 gave significantly higher yield than 0 kg N ha-1 at both locations. The highest yielding genotypes in the SS were ARRORSICGX-SM 00017/5/P15/P2 and SAMNUT 24 while ARRORSICGX 000201/5/P4P10, SAMNUT 22 and SAMNUT 23 were the highest yielding in the NGS. The highest yielding genotypes also responded better to N application while the remaining genotypes showed little or no response. Similar to the pod yield, the highest amount of N2 fixed (77.5 kg N ha-1) was obtained in the SS while 54.5 kg N ha-1 was recorded in the NGS. Despite this, the proportion of N derived from the atmosphere (%Ndfa) by most of the groundnut genotypes was higher in the NGS than in the SS. Notable high fixing genotypes with high %Ndfa were ARRORSICGX-SM 00017/5/P15/P2, ARRORSICGX 000201/5/P4P10 and SAMNUT 22. When only the pods were removed, all the genotypes contributed positively to the soil N with the highest value of 48 kg ha-1 by ARRORSICGX 000201/5/P4P10 and the lowest of by 8 kg N ha-1 by SAMNUT 24. In contrast, removal of pods and haulms as practiced by the farmers resulted in net negative soil N balance by all the genotypes in both locations. The study reveals that great variability exists in the productivity and symbiotic N fixation of groundnut genotypes at different mineral N levels and also in the adaptation of the genotypes to different agro-ecologies. Improvement of the symbiotic effectiveness of groundnuts to improve soil N balance within the context of the current farmers practice will remain a daunting challenge.

Keywords：*Arachis hypogaea L., Groundnut, N-difference method, N2 fixation, N balance, Savanna*

P1-362

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

How Do Environmental and Land-Use Drivers of Soil Microbial Diversity Affect Soil Organic Matter Dynamics?

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Many of the ecosystem services provided by soil depend on soil microbial communities. A better understanding of factors (environmental and agricultural) driving soil microbial diversity, together with the link between microbial diversity and activity, appears crucial to preserve soil ability to provide ecosystem services. Numerous datasets evidencing the effects of agricultural practices on microbial communities and activity correspond to agronomical field trials, testing simplified and sometimes theoretical combination of practices. However, since the soil physicochemical characteristics (texture, pH, carbon content) have been identified as the main drivers of microbial community variation, it is impossible to compare such studies and to robustly rank the influence of agricultural practices.

To fill this gap, one of the main strategies is to perform a more integrated approach by considering the taxonomic and functional variation of microbial communities in multiple situations of land-use with a reduced environmental heterogeneity. In this context, the aim of our study was (i) to examine the variation of microbial communities abundance and diversity in an agricultural landscape to better analyse the effects of land-use drivers, and (ii) to determine the consequences of microbial diversity variation on microbes-mediated SOM dynamics.

The studied landscape is representative of intensive mixed agricultural area of Western Europe. 85% of the catchment area (12 km^2) is dedicated to agriculture. This landscape is heterogeneous in terms of agricultural practices (with different organic matter input management and crop rotation). Typologies of environmental factors and cropping systems over the landscape were precisely referenced. Two hundreds soils covering the different combinations of environmental conditions and cropping systems were sampled. Soil molecular microbial biomass was determined by quantification of the soil DNA yield. Bacterial and fungal community composition was determined by pyrosequencing of the 16S and 18S rRNA gene sequences, respectively. Variance partitioning was applied to identify and rank the contribution of environmental characteristics and cropping systems in determining microbial taxonomic composition and diversity. One hundred of the sampled soils were thereafter incubated under controlled laboratory conditions with or without a ^{13}C labelled wheat residue. Microbial respiration was measured on several dates during a 80-days incubation and we determined the respective decomposition of soil and wheat residue carbon.

Altogether our study integrated the heterogeneity and complexity of cropping systems and enabled us to discuss the effects of the interactions between agricultural and environmental landscape characteristics on soil microbial diversity and activity. Cropping systems range from permanent grasslands to maize monoculture and intensive vegetable productions with different organic matter management (quantity and frequency of pig slurry and cattle manure input). The soils exhibit little differences in soil texture across the landscape but are overall silty loam (Cambisols and Luvisols). Soils vary in their water regime characteristics from well-drained soils to temporarily or permanently saturated soils. Soil microbial biomass varied according to both soil cropping systems and environmental conditions with hot spots in grasslands and temporarily or permanently saturated soils. Soil microbial diversity also varied according to cropping systems and environmental conditions with differential effects on bacterial and fungal communities. Variance partitioning demonstrated that both environmental characteristics and land management by modulating microbial diversity are important in determining soil carbon mineralisation. The relative importance of microbial diversity depends on the carbon pool mineralised (fresh plant residue versus stabilised soil carbon). In a context of sustainable agriculture our results can contribute to design landscape management strategies able to provide environmental services along with their production function.

Keywords：*land management, microbial diversity, microbial activity, carbon dynamics*

P1-363

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Microbial Properties and Biomass Carbon and Nitrogen of Soil under Different Soil Management Practices

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Microorganisms are responsible for the biogeochemical transformation occurring in the soil. These microorganisms constitute the soil microbial biomass and can be used as an index to assess sustainable land use. Few scientists have studied the soil microbial biomass carbon and nitrogen using Philippine soils. Hence, this study was done mainly to examine the use of methods other than the chloroform technique for the determination of the biomass carbon and nitrogen.

This study aimed to: (1) determine the microbial population and some soil enzymatic activity of different soils; (2) compare the different methods of determining biomass C and N of soils under different soil management practices and (3) relate some chemical and physical properties of soils with either microbial population or some soil activity.

The physical, chemical and microbiological properties of one forest, five upland and 6 lowland soils were studied. The microbial population were counted using the agar plate method. The nitrifiers were enumerated using the Most Probable Number method. The soil enzymatic activities measured were urease, phosphomonoesterases and dehydrogenase activity. Performance of two liquid fumigants, chloroform and 1-hexanol in the fumigation incubation technique(FIT) of determining biomass C was also done. Microbial biomass C was calculated as: B=F/k (0.45; Flush C (F) refers to the CO2-C evolved by fumigated soils less that of non-fumigated soils.

Population of bacteria, molds , yeast and actinomycetes varied among soils. Highest bacterial count, fungal count and actinomycetes count were observed in cultivated soil adjacent to forest soil, paddy soil with composted rice straw for 2 years and upland soil under alley cropping with mulching and with hedgerows, respectively. Some of the genera, identified were Aspergillus, Penicilium and Fusarium.

Forest soil had the highest soil urease activity(SUA). SUA was significantly correlated with soil organic matter (SM) (r=0.69*), cation exchange capacity (r=0.66*) and total N (r=0.84*). Acid and alkaline phosphatase activities showed a high value except SOIL 11,paPddy soil with azolla. The dehydrogenase activity was highest in forest soil and lowest in upland soil under farmers' practice.

Preliminary experiments showed that the amounts of biomass C of 1-hexanol fumigated soil were comparable with those of chloroform fumigated soils. Population counts after fumigation showed that the organisms were not completely killed. The k value was determined using the two organisms namely: Aspergillus niger and Bacillus thuringiensis The C, N, and C/N ratios of the mentioned organisms were: (1) Aspergillums Niger ? 53.6 percent 4.4 percent N and C/N of 11.0; (2) Bacillus thuringiensis - 59.13 percent C, 5.2 percent N and C/N ratio of 12.0. The C and N content of the microorganisms facilitated the computation of the amounts of organisms C and N added to the soil. Determination of k factor, the paddy soil with inorganic fertilizers (SOIL 7) and the FIT were used. The k factor determined and computed in this experiment was 0.36 and this was comparable with the k used by Sparling (1990) which was kEC and kEN were 0.30 and 0.38, respectively.

The paddy soil applied with composted rice straw has the highest biomass C of 1660.8 μg g soil -1 and 451.3 μg g soil -1 using 1-hexanol and chloroform as fumigant, respectively. The upland soil under farmers' practice has the lowest biomass C of 7.4 μg g soil -1using 1-hexanol. The paddy soil grown to azolla and wetland rice for 10 years has the highest biomass N of 248.3 μg g soil -1 and 86.8 μg g soil -1 using 1-hexanol and chloroform, respectively.

The flush carbon(C) of chloroform fumigated upland soils (SOIL 1 and 4) was comparable with the flush C of 1-hexanol fumigated upland soils. The amounts of biomass C of 1-hexanol fumigated soils were higher compared with the amounts of biomass C of chloroform fumigated soils. The amounts of biomass C of chloroform fumigated soils (SOIL 1,3 and 4) were comparable with those of 1-hexanol fumigated upland soils.

The results showed that 1-hexanol could be used as a fumigant, instead of chloroform. McLaughlin and Alton (1986) preferred 1-hexanol to chloroform (both effective biocides), because it is less harmful.

Keywords：*bi0mass carbon, biomass nitrogen, k constant,*

P1-364

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Microbial Gene Abundance and Community Structure of Particle Size Fractions and the Change with Rice Cultivation Length

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Particle size fractions (PSFs) had been concerned as basic soil components mediating biogenic processes and the ecological functioning of field soil. However, changes in distribution of microbial community abundance and diversity within PSFs and with soil development had not yet been well addressed. Coarse sand, fine sand, silt and clay fractions of topsoil samples were physically fractionated from a chronosequence of rice soils under rice cultivation in a time span of 0-700 years shifted from salt marsh soil in a coastal area of East China. Microbial community abundance and structure were fingerprinted of the PSFs using a combination of real-time PCR and terminal restriction fragment length polymorphism (T-RFLP) methods. Both microbial community abundance and structure differed between the PSFs. Higher biomass and diversity of bacterial community was found in coarse sand and clay fractions while those of fungal in coarse sand fraction only. Low microbial biomass and diversity in the original salt marsh soil in all particle fractions, but gene copies both of bacterial 16S and fungal ITS in different particle fractions was significantly increased shortly after conversion to rice cultivation for 50 years. However, microbial gene abundance was stable with prolonged cultivation of rice for more than 300 years.

Keywords：*Soil organic carbon, Rice soil, Particle size fractions, Microbial community, Microbial gene abundance, Soil chronosequence*

P1-365

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

How Do Soil Properties and Environmental Conditions Affect Nitrous Oxide Emission from Nitrification and Distribution of Ammonia Oxidizers?

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Nitrification is an important nitrogen (N) transformation process in soils, which converts relatively immobile ammonium (NH4+) and ammonia (NH3) into more mobile nitrate (NO3-). The NO3- can then be subjected to losses by leaching and as gaseous emissions (N2O or N2) from subsequent denitrification. Nitrous oxide (N2O) is a potent greenhouse gas with a global warming potential 300 times that of carbon dioxide (CO2). It is primarily produced by the microbially-mediated nitrification and denitrification processes in soils. It is commonly accepted that nitrous oxide is primarily produced in soil by the anaerobic activities of microorganisms during denitrification. There is very limited information about how much N2O derived from nitrification. It has been suggested that up to 70% N2O in Australian soils are derived from nitrification. Due to lack of experimental data most of processed based models use the fixed proportion nitrification rate to estimate nitrification induced N2O emissions, for example 0.24% by DNDC and 2% by DayCent Model. However, it is evident that N2O emission from nitrification in soil is not a fixed factor of nitrification and it is highly variable both in time and space. It is influenced by soil physical, chemical and microbial properties as well as soil moisture and temperature. It is necessary to quantify the effects of soil and environmental variables on N2O production from nitrification.

Some studies have verified that ammonia oxidizers can directly regulate N2O production. Ammonia-oxidizing bacteria (AOB) are generally believed to be the most important contributors to nitrification in agricultural soils, but ammonia-oxidizing archaea (AOA) can also be present in large numbers. Inhibition of nitrification after application of fertilizers treated with nitrification inhibitors has been observed for soil AOB populations but not for AOA populations. Differences in soil properties seems to be a key parameter responsible for the variation in their distributions, however there is no clearly identified soil chemical or physical or environmental parameter that is most important, and limited data exists regarding the importance of the soil microbial community. Therefore, we undertook two laboratory incubation experiments aimed at measuring N2O production from nitrification from three soils of different physical and chemical properties and from one soil but under different temperature and moisture, and examine how do soil properties, temperature and moisture affect the dynamics of AOB and AOA abundance. This information will help to more accurately evaluate and predict N2O emission from the field following the addition of NH3 based fertilizers and will help to understand well the mechanism of N2O production from nitrification.

In a laboratory incubation study, we examined N2O production under different temperatures (15?C, 25?C and 35?C) and moistures (50%, 70% and 85% water-filled pore space (WFPS)) using 15N labeled ammonium and nitrate, acetylene (1% vol/vol) was used as nitrification inhibitor to block nitrification process. In another incubation study, we measure N2O production from three soils

(neutral clay loam soil, acid loam soil and alkaline clay loam soil) under 25?C and 60%WFPS using ammonium chloride and acetylene (1% vol/vol).

The results showed that different soils have different nitrification rate, followed the order neutral clay loam? acid loam ? alkaline clay loam. Acid loam soil can produce more N2O than other two soils. At 50%WFPS, the contribution of nitrification to N2O production from nitrification increased as temperature increased from 7.2%-28.2%, however, at 85%WFPS it decreased as moisture increased from 28.1%- 6.4%. The ratio of NO3- and N2O increased as temperature and moisture increased, except 35?C, 85% WFPS. At 35?C, 85%WFPS, denitrification dominated over nitrification for N2O production due to presumably low O2 availability.

Further studies are currently being undertaken to quantify the amoA gene from bacteria and archaea in our soils to test if there is a direct relationship between these nitrifiers and soil properties, temperature and moisture that can influence N2O production from nitrification.

Keywords：*nitrous oxide, nitrification, soil properties, soil temperature, soil moisture, ammonia oxidizers*

P1-366

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

The Potential Use of Burkholderia Cenocepacia as Bio-Ameliorant for Oil Palm Seedlings at Sandy Soil

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Water is an important constituent of a sandy soil and has direct impact on growth particularly to a water-sensitive crop such as oil palm. Therefore, many efforts have been carried out to overcome water stress problem in those planting areas with sandy soil texture with very unstable soil aggregate. The use of exo-polysaccharide producing-bacteria to mediate sandy soil micro-aggregate formation by bio-augmentation technique has opened the opportunity to be an accepted practice. This study was conducted to determine the impacts of exo-polysaccharide-producing bacteria as an active substance of soil bio-ameliorant on the growth performance of the oil palm seedlings in a Typic Udipsamments. A high potential exo-polysaccharides-producing bacterium capable of fixing N2 and producing growth-promoting hormone was isolated from a sandy textured soil located at Kotawaringin Barat-Central Kalimantan, Indonesia. The bacterium was identified as Burkholderia cenocepacia KTG strain. The bacterium was formulated in a granular-form bio-ameliorant by using zeolite and peat mixture as carrier. Application of the bio-ameliorant in combination with reduced dosages of conventional NPK-Mg fertilizers was made to a three-months old seedlings in polybag and observation was carried out for three months. The result indicates that the bacterium is capable of improving water retention of the soil used in this experiment (11.2 ? 61.6%) and improved the fertilizer use efficiency. Plant biomass of a-six-months old oil palm seedlings at main nursery stage was higher 1.9% (leaf), 10.5% (frond), 17.2% (stem), and 23.2% (root) by application of 75% standard dosage NPK-Mg and 100 gram bio-ameliorant seed-1 than those applied by 100% standard dosage of conventional NPK-Mg fertilizer.

Keywords：*sandy soil, Typic Udipsamments, main nursery, bio-ameliorant, water retention*

P1-367

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Evaluation of Soil Carbon and Nitrogen Transformation by Microbial Metabolism and New Microbial Legacy

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Abstract: We know that the transformation of soil organic carbon (C) and nitrogen (N) is driven by microorganisms, but we know little about how and to what extent the microbial processes of exogenous substrate transformation mediate carbon (C) and nitrogen (N) cycling in soil ecosystem. The mediation of exogenous substrates on soil microbial processes cannot be well deduced from microbial biomass measurements or microbial community information alone due to its vulnerability to environmental regime change, but microbial metabolism feature and legacy (residue) such as amino acids and amino sugars can provide an integrated view of microbial roles and functions linked to soil C and N transformation and dynamics. However, a big challenge or a pivotal knowledge gap for the understanding of the underlying mechanisms is how to interpret the microbial metabolisms of both added substrate and soil native C and N, and moreover, a crucial technical limitation is how to differentiate the newly microbial-derived legacy (residue) from the soil native portions with the same components. In this context, we established a set of isotope-based gas/liquid chromatograph-mass spectrometry techniques, and applied the novel techniques to investigate the biochemical processes of C and N transformation and dynamics in soil systems as affected by substrate input. The key approach is differentiating between the newly microbial-derived amino sugar and amino acid legacies (residues) and the same soil intrinsic components (molecules). Our hypothesis is that microbial metabolism and new microbial legacy would mediate soil C and N cycling. Our results showed that extraneous organic C (13C labeled) and inorganic N (15N labeled) were rapidly immobilized by microorganisms and a large portion was incorporated into soil amino acids and amino sugars fractions as metabolic constituents. The both 13C and 15N enrichments in the target compounds increased significantly with increasing C:N ratios from 5:1 to 30:1 of substrates, although significant decomposition of the endogenous microbial-derived components was found along with the synthesis processes. The finding indicates that higher C availability stimulated microbial proliferation and in turn enhanced the microbial assimilation of exogenous C and N. However, a significant net decomposition of both the new microbial legacy and soil native organic C occurred at the C:N ratio of 5:1 and interestingly the decomposition rate and magnitude of the latter was found in a much larger extent as priming effect suggesting that soil native organic C is apt to be decomposed for compensating C and N supply when available C is in deficiency. On the contrary, the higher availability of C (C/N=30) resulted in more rapid renewal of both microbial derived components and soil intrinsic organic C and consequently, the net accumulation of soil organic matter (SOM) was possible. Given the important transitional function of microbial-derived legacy we suggest that the endogenous microbial components can be further stabilized in the soil organic matter as recalcitrant components and this processes were controlled by available C, i.e. the substrate availability controls the transformation and dynamics of microbial legacy and soil native organic components. Therefore, we conclude that the cycling of soil organic C and N is dominantly mediated by microbial metabolism and new microbial legacy, which may play an important transitional role in adjusting and balancing the processes of microbial synthesis and decomposition of C and N, but the strategies of microbial proliferation and the contribution of microbial metabolisms to C and N accumulation is dependent on the stoichiometry of labile C and N.

Keywords：*Keywords: microbial process, microbial legacy (residue), metabolism, soil organic carbon and nitroge*

P1-368

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

Investigating the Impact of Plant Composting on Soil Organic Matter and Microbial Community Dynamics Using 13c and 15n Labelling

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Loss of soil organic matter (SOM) may lead to reduced soil fertility and increased soil erosion. A small but consistent increase in SOM could mitigate climate change effects by storing atmospheric CO2-C. Annual application of exogenous organic matter (EOM) to cultivated land may lead to long continued accumulation of SOC. Composts are often applied on arable soils to sustain the content in SOM but the mechanisms leading to an increase of SOM content are still poorly understood. Our objectives were to better understand the effect of composting on the dynamics of C and N in soils and to investigate the potential relationships with the chemical composition, the structure of the soil microbial degrader communities and the aggregate stability.

In this study, we used 13C and 15N labelled plant materials composted (12 weeks) or not. Chemical changes due to composting were monitored using 13C-NMR spectra and molecular analysis of lipid, sugar and lignin fractions. Composted (COM) and non-composted (NCOM) plant materials were then incubated with an arable soil during 3 years under controlled condition. Throughout the experiment, 13C and 15N concentrations were analysed in the mineralised fraction (CO2 or nitrates) and the microbial biomass (fumigation extraction technique) using GC- or EA-IRMS. The evolution of chemical composition of plant residues, CO2 evolved and the dynamics of the microbial degraders throughout the experiment were determined by 13C-NMR and PLFA-SIP method, respectively. The aggregate stability of samples was determined using the slow wetting test of Le Bissonnais.

The composting processes reduce the C/N ratio from 11 to 7 (loss of 69% of C and 21% of N). Molecular analysis showed that COM was depleted in lipids and carbohydrates but enriched in lignin compared to NCOM. The C mineralisation of NCOM, and the priming effect on SOM were higher than those observed on COM treatment. Thus, 3 years after the amendments in soil, the loss of C due to composting process was compensated. The N mineralisation of NCOM was lower than COM during the first year, due to higher amount of N assimilated to the microbial biomass. The structure of the whole soil microbial community was only slightly affected by the addition of OM, whatever their nature, compared to non-amended soil. During the first 3 months of incubation, the structure of the microbial degrader communities differed between COM and NCOM treatments added but converged thereafter. The addition of both amendments increased soil aggregate stability up to 45 days. However, this aggregating effect did not last, and by the end of the incubation, the aggregate stability of the amended soils was not different from that of control soil.

This study shows that composting plant material had an impact both on C and N dynamics in soil. Composting plant material had an significant but transient impact on the microbial degrader community structure when applied to a soil. This result could explain the dynamics of aggregate stability. The amount and the relative specificity of the microbial degraders' communities were higher NCOM only during the first month of incubation, which can be related to the initial differences in chemical composition of the plant residues.

Keywords：*13C, 15N, Compost, Dynamics, SOM, Microbial Structure, NMR, PLFA-SIP*

P1-369

[C2.2-1] Modern Soil Biology for N and C Transformation: From Genes to Ecosystems

How to Improve Chloroform-Fumigation Efficiency of Microbial Biomass Measurement for Water-Saturated Soils?

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Introduction

Chloroform-fumigation extraction (CFE) method is widely used to measure soil microbial biomass. However, it was found that CFE method for water-saturated soils such as paddy and wetland soil is not as successful as for water-unsaturated soils due to hindrance of chloroform diffusion through soil pores by water filled in pore (Inubushi et al., 1994). This study was conducted to explore how to improve the efficiency of CFE method for the determination of microbial biomass of water-saturated soils. We tested the effects of sand mixing and decreasing soil stacking depth on the CFE efficiency funder the hypotheses that 1) sand mixing may increase chloroform diffusion by creating water-unfilled macro-pores and 2) decreasing soil packing height will facilitate chloroform fumigation by shortening gas diffusion path.

Materials and Methods

Four independent experiments were conducted with two paddy soils with low (S_L, 11.6 g C kg^{-1}) and high (S_H, 34.8 g C kg^{-1}) organic C content and thus expected to have different microbial population. The two soils were incubated at 25°C for 7 days under water-saturated conditions before chloroform fumigation. The four experiments were; Exp. 1) mixing sand (0, 2, 4, 5, 6, 7, 8, and 9 g) with a constant amount (10 g) of soils in 100-mL beakers, Exp. 2) mixing sand (0, 2, 4, 5, 6, 7, 8, and 9 g) with a varying amount (10, 8, 6, 5, 4, 3, 2, and 1 g) of soils in 100-mL beakers to keep a constant soil packing height, Exp. 3) decreasing soil packing height by decreasing soil amount (10, 8, 6, 5, 4, 3, 2, and 1 g) in 100-mL beakers, and Exp. 4) decreasing soil packing depth with a constant soil amount (10 g) by varying soil container diameter. All the soil samples were fumigated following the conventional CFE method (Vance et al., 1987). Extractable organic C (EOC) was determined with a TOC analyzer. All the treatments effects were statistically evaluated with the analysis of variance (ANOVA) using the general linear model procedure of the AASW statistics (IBM Corp. Amonk, NY, USA).

Results and Discussion

The two soils showed similar EOC pattern with sand mixing and soil packing height treatment, but the soil with a greater organic matter had a higher EOC values, reflecting greater microbial population. In the Exp. 1, EOC decreased from 132.7 to 49.3 mg C kg^{-1} for S_L and from 733.0 to 701.3 mg C kg^{-1} for S_H with increasing sand mixing rate, suggesting that sand mixing with a constant amount of soil does not improve chloroform diffusion probably due to increased gas travelling path. In the Exp. 2, sand mixing with a decreasing soil amount increased EOC from 128.5 to 433.9 mg C kg^{-1} for S_L and from 732.8 to 1136.2 mg C kg^{-1} for S_H and this implies that sand mixing can improve chloroform diffusion when soil packing height and thus gas travelling path is constant. In the Exp. 3, EOC increased from 131.4 to 482.5 mg C kg^{-1} for S_L and from 736.7 to 1172.1 mg C kg^{-1} for S_H with decreasing soil amount, and in the Exp. 4, decreasing soil packing height also increased EOC from 131.4 to 362.4 mg C kg^{-1} for S_L and from 737.1

to 908.9 mg C kg^{-1}. These results show that soil packing height is a critical factor affecting CFE efficiency. There are two ways to reduce soil packing height; reducing soil amount and using a wide container. Because using small amount of soil samples may undermine the reproducibility of the measurement, using a wide container can be a better option. In addition, using soil container with the same diameter is another critical point to obtain precise data.

Acknowledgment

This study was supported by the Center for Women in Science, Engineering, and Technology of the Ministry of Science, ICT, and Future Planning of Korea.

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Keywords：*Microbial biomass carbon, Chloroform fumigation, Extraction efficienct, Water saturated soil, Paddy soil*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Optimizing Oxidation by Methanotrophs to Mitigate Methane Emissions from Constructed Wetlands and Rice Paddy Soils

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Wetlands and flooded rice soils are a major source of methane (CH4) (25% of global emissions), a critical greenhouse gas. Biological oxidation of CH4 by methanotrophic bacteria offsets these losses. This offers the potential to manage flooded systems, by hydrologically controlling pulsing or wetting/drying cycles to stimulate methanotrophs and reduce net CH4 emissions. Therefore the objective of this study was to determine: potential rates of CH4 oxidation (POM), shifts in methanotrophic community structure, and fate of oxidized CH4-C along a hydrologic gradient over seasons in a constructed wetland (2 wetland replicates). This was done by measuring POM rates and phospholipid fatty acid (PLFA) biomarkers for Type I (high CH4 affinity) and Type II (low CH4 affinity) methanotrophs. In addition stable isotopic probing (SIP) was done using 13C-CH4 to track C uptake by methanotrophs and transfer to other microorganisms and soil. The environmental gradients of temperature, moisture content and redox potential were important controlling factors over seasons on CH4 oxidation and abundance and distribution of methanotrophs. The Type II methanotrophs dominated under the more favorable conditions of high CH4 concentration and oxygen availability. The high-affinity Type I methanotrophs dominated in the 0-8 cm depth and the Type II in the 8-16 cm depth. Type II PLFA biomarkers had the highest degree of 13C labeling in the permanently flooded site soils that was attributed to the high methanotrophic population promoted by high CH4 concedntrations. In contrast, intermittently flooded site both Type I and Type II methanotrophs equally abundant. Pulsing of wetlands, therefore, facilitate greater taxonomic diversity of methanotrophs and CH4 oxidizing activity. The results provided a potential basis to manage wetlands to promote CH4 oxidation to reduce CH4 emissions.

Keywords：*methanotrophs, methane oxidation, wetland soils, stable isotopic probing*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Timing and Form of Organic Fertiliser Application Affects Greenhouse Gas Emissions from an Arable Soil

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Manure and slurry are commonly used as fertilisers in arable agriculture due to their ability to provide large quantities of nitrogen (N) required for crop growth. However, a considerable amount of the N applied from organic substrates is inefficiently utilised by crops, and is vulnerable to loss to the environment in gaseous forms such as nitrous oxide (N2O) and ammonia (NH3), and through leaching as nitrate after undergoing transformations in the soil. The emission of N2O and NH3 result in damaging environmental impacts; N2O is a powerful greenhouse gas (GHG) with a global warming potential 298 times greater than that of CO2 and also acts to deplete the ozone layer. Ammonia and nitrate may be deposited in aquatic or terrestrial environments resulting in indirect environmental impacts such as eutrophication, indirect GHG emissions, and soil acidification. It is therefore imperative that organic fertiliser applications are carefully managed if significant environmental pollution is to be avoided. Timing of fertiliser application is critical when considering GHG emissions as these are significantly affected by soil conditions. It is thus vital to understand how manipulation of the timing of organic fertiliser applications may reduce potential environmental effects and impact on the tradeoffs in losses of different N forms. This research has quantified emissions of N2O and NH3 following application of a variety of organic fertilisers to an arable field trial in Eastern Scotland. Emissions from spring and autumn fertiliser applications were compared, to assess what effect the timing of application has on gaseous emissions and nutrient leaching. The impact of fertiliser type and method of application were also investigated.

A field experiment was established at an arable farm in Eastern Scotland in autumn 2012 on a sandy loam soil. The field was split into two areas, with one area receiving autumn applications of organic fertiliser, and the other spring applications in a randomised blocked design. Both areas were sown with winter wheat (a typical crop for the area). The organic fertiliser treatments included farmyard manure, poultry litter, layer manure and cattle slurry (all of which are livestock wastes commonly applied to Scottish farmland). All of the organic fertiliser treatments were applied at 180 kg available N/ha using methods which are usually practiced in the locality. NH3 emissions were measured using wind tunnels which enable measurement through absorption of NH3 in orthophosphoric acid. Emissions of N2O were measured using replicate static closed chambers on each plot. Soil characteristics including mineral N content, soil moisture and temperature were measured throughout the 18 month experimental period in addition to climatic conditions.

Losses of N2O and NH3 from autumn and spring applied manure treatments were compared in order to establish the effect of timing on gaseous losses and to reduce uncertainty in the UK GHG inventory. Data are also discussed in relation to differences in crop yield and effects of temperature and rainfall on overall N losses during the measurement periods. The data are used to highlight the importance of effective management of organic nutrient sources in contributing to improved environmental outcomes from the overall management system.

Keywords：*Nitrous oxide, ammonia, greenhouse gas, arable, organic fertiliser, nitrogen*

P1-372

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Soil Carbon Dioxide and Methane Fluxes Influenced by Nitrogen Rates and Landscape Positions from Switchgrass Land of South Dakota, USA

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The present study was conducted in South Dakota, USA with the specific objective was to assess the impact of nitrogen (N) and landscape positions on carbon dioxide (CO_2) and methane (CH_4) fluxes in land seeded to switchgrass (*Panicum virgatum* L.). The experimental layout was a randomized block experiment that contained three N levels (low, 0 kg N ha^{-1}; medium, 56 kg N ha^{-1}; and high, 112 kg N ha^{-1}). The experiment was repeated at shoulder and toeslope landscape positions. Soil surface CO_2 and CH_4 fluxes were monitored bi-weekly from May 2010 to October 2013 using the static chamber technique. The soil at the site was a Nutley-Sinai (silty clay, mixed, Chromic Hapluderts). Results showed that toe slope areas had higher soil organic carbon and moisture contents and lower bulk densities than eroded shoulder areas. These results were attributed to prior erosion that transported soil from the shoulder and summits areas to foot and toe slope areas. In addition, higher soil moisture contents of footslope areas most likely resulted in slower SOC mineralization. The N rates did not significantly influence soil properties. Soil CO_2 fluxes (but not CH_4 fluxes) were higher in footslope than shoulder areas. These results were attributed to higher soil moisture and SOC contents. Aeration enhances diffusion of oxygen and CO_2 while moisture facilitates microbial access to the substrate. Moisture was higher (not limiting) at toe compared to crest. However, temperature was the main driver for respiration (CO_2 emissions). Seasonal variations showed that the summer exhibited higher soil CO_2 fluxes than other seasons. Soil CH_4 fluxes showed two types of behaviors; net uptake in which CH_4 was consumed by soil and net release when CH_4 was released to the atmosphere. Nevertheless, the processes occur concurrently in soil because of the presence of oxygen that promotes CH_4 oxidation and moisture that promote partial anaerobic conditions required for CH_4 formation. The landscape position did not influence CH_4. Soil CO_2 and CH_4 fluxes were also not impacted by N rates. Moisture is more influential to CH_4 than temperature while temperature is more influential to CO_2 than moisture. However, moisture stress can prevent all microbial processes that control both CO_2 and CH_4 fluxes because they depend on dissolved substrate. Seasonal variations showed highest CO_2 releases and CH_4 uptake in summer and fall of 2011 and 2012, likely due to warmer and moist soil conditions. Higher CH_4 releases were observed in winter at crest, especially at high N rate, possibly due to increased anaerobic conditions. However, year to year (2010-2013) variations in soil CO_2 and CH_4 fluxes were more pronounced than variations due to the impact of landscape positions and N rates. Annual average air temperatures and low soil moisture indicated drought conditions at the study site in 2012. These drought conditions resulted in higher CO_2 fluxes in summer and fall (between 1.3 and 3 times) than in 2011 and 2010. Drought also promoted a net CH_4 uptake in 2012 in comparison to 2010 when there was a net CH_4 emission. Results from this study concluded that landscape positions, air temperature, and soil moisture content strongly influenced soil CO_2 fluxes, whereas, soil moisture primarily impacted the CH_4 fluxes (uptake or release). For future research, a comprehensive life cycle analysis that will include switchgrass production and its associated environmental and economic impacts is needed for this region.

Keywords：*GHG, swithcgrass*

P1-373

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Simulating Greenhouse Gas Emissions in Chinese Cropping Systems Using the Daycent Model

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Ecosystem models are important tools to predict greenhouse gas (GHG) emissions for different climatic regions and management practices. In this study we integrated a methanogenesis sub-model into the DAYCENT ecosystem model to estimate CH_4 emissions from rice production systems in China. The sub-model was parameterized using 25 sites, and then the DAYCENT model was evaluated with 350 sites in the croplands of China, including measurements of nitrous oxide emissions (N_2O), methane emissions (CH_4) and soil organic carbon (SOC) stock changes. In general, the model was reasonably accurate with R^2 values for model predictions versus measurements ranging from 0.71 to 0.85. Modeling efficiency varied from 0.65 for SOC stock changes to 0.83 for crop yields. Mitigation potentials were estimated on a yield basis (Mg CO_2-equivalent Mg^{-1}Yield). The results demonstrate that the largest decrease in GHG emissions in rainfed systems are associated with combined effect of reducing mineral N fertilization, organic matter amendments and reduced-till coupled with straw return, estimated at 0.31 to 0.83 Mg CO_2-equivalent Mg^{-1}Yield. A mitigation potential of 0.08 to 0.36 Mg CO_2-equivalent Mg^{-1}Yield is possible by reducing N chemical fertilizer rates, along with intermittent flooding in paddy rice cropping systems.

Keywords：*Ecosystem model; Cropland; Soil organic carbon; Greenhouse gas emissions; Nitrous oxide; Methane*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Efficacy of a Nitrification Inhibitor Mitigation Technology for Nitrate Leaching and Nitrous Oxide Emissions in Winter Forage Grazing Systems

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Introduction

In grazed grassland, most of the nitrate (NO3-) leaching and nitrous oxide (N2O) emissions is from nitrogen (N) excreted by the grazing animal, particularly in the animal urine. In many parts of New Zealand, dairy cattle graze high yielding forage crops during winter. The high stocking rate and wet soil conditions make winter grazing particularly prone for soil compaction, NO3- leaching and N2O emissions. A nitrification inhibitor mitigation technology involving the use of dicyandiamide (DCD) to treat grazed pasture soil has been developed to mitigate both NO3- leaching and N2O emissions. However, the efficacy of this technology under winter forage grazing conditions has not been well studied. This paper reports a series of laboratory, lysimeter and field studies to determine the efficacy of the DCD nitrification inhibitor in inhibiting ammonia oxidizers, reducing N2O emissions and reducing NO3- leaching under simulated winter forage grazing conditions.

Materials and methods

A laboratory incubation study was conducted to determine the effect of soil moisture status on the abundance of ammonia oxidizers and N2O emissions using a grassland soil (Horotiu soil: Typic Udivitrand). Two sets of incubations were established , one set for soil sampling to determine the ammonia oxidizer abundance and the other set for determining N2O emissions using a method similar to the static chamber methods by filling up glass jars to two thirds the height and leaving the top third as air space under the lid for N2O sampling. Three soil moisture conditions were compared: 60%, 100% and 130% field capacity.

A field experiment was conducted to determine the impact of animal treading on N2O emissions on a Wakanui sandy loam (Aquic Dystric Utrochrept). Field plots of 0.5 m diameter were established to simulate dairy cow urine patches. Dairy cow urine at the rate of 1000 kg N ha-1 was applied to the plots to simulate animal urine deposition. The nitrification inhibitor DCD was applied to some of the plots. Some plots were un-trampled, and some were trampled with a mechanical hoof delivering the same pressure as that of an adult cow hoof walking over the field. N2O emissions were determined using field static chamber methods.

A lysimeter study was conducted to determine the efficacy of DCD in reducing NO3- leaching under simulated winter grazing conditions. The lysimeters were 50 cm diameter and 70 cm deep, and the soil used was an Eyre stony silt loam (Dystrochrept) with annual ryegrass pasture. Urine was applied in mid-winter (June) at 1000 kg N ha-1 and DCD applied as a solution at 15 kg DCD ha-1. Nitrate concentration in the leachate was determined.

Results

The laboratory incubation study showed that soil moisture content was a major driver of ammonia oxidizing bacteria (AOB) growth and N2O emissions in the soil that received animal urine. Total N2O emissions from the soil at 130% field capacity were 400 times higher than those from the soil at 60% field capacity. Total N2O emissions were significantly related to the abundance of AOB amoA gene copy numbers. The field plot study showed that animal treading of a wet soil resulted in a reduction in air permeability and air-filled pore space. Trampling increased average cumulative N2O emissions over a three month period from 15.9 kg N2O-N/ha to 45.0 kg N2O-N/ha in the urine treatments. DCD was highly effective in reducing N2O emissions, with N2O emissions being decreased by 58-63%. Trampling did not significantly affect the effectiveness of DCD in reducing N2O emissions. The lysimeter study showed that NO3- leaching losses from the animal urine were significantly decreased by 66% with a single application of DCD following grazing.

Conclusions

These results suggest that the DCD nitrification inhibitor technology is a useful mitigation tool for nitrate leaching and nitrous oxide emissions in winter forage grazing systems.

Acknowledgments

We would like to thank the New Zealand Agricultural Greenhouse Gas Research Centre, Ministry of Business, Innovation and Employment, Ministry of Primary Industries, Fonterra, DairyNZ, and Beef and Lamb NZ for funding, and Steve Moore, Carole Barlow, Jie Lei, Neil Smith, Trevor Hendry and Manjula Premaratne of Lincoln University for technical support.

Keywords：*Nitrate leaching, nitrous oxide emissions, nitrogen cycing, nitrification inhibitor*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Assessing the Effects of Deforestation and Reforestation on Soil Carbon Dynamics and 14c Dating

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An important part of carbon cycling carries out in the soil and land use changes including changes in forestlands affects the SOC storage and CO2 flux into the atmosphere. The impacts of conversion of deciduous to coniferous forest and rangeland on the storage, dynamics, and isotopic changes in soil organic carbon in Kelardasht region (north of Iran) were investigated. Three land uses with minimum distances were delimited using landsat images. After description and sampling of three pedons (>100 cm), surface horizons (O, A and AB) at five points were sampled. Physicochemical properties, organic carbon storage, aggregate stability, physical fractionation (density and size fractions), functional groups of organic matter (FTIR spectrometry), and 14C dating were analyzed.

Soil pH and EC is not affected by land use change, but bulk densities have increased on deforestation and decreased at reforestation. The results showed that conversion of deciduous to coniferous forest and rangeland has caused on increase and decrease in soil organic carbon storage respectively. The highest SOC storages were determined in coniferous forest land uses (255.00 Mg C ha?1), followed by deciduous forest (216.74 Mg C ha?1) and abandoned rangeland (185.31 Mg C ha?1).

Land use changes showed significant impacts on soil CO2 efflux. The significant positive correlations, with exponential and linear relationships were observed between the monthly CO2 emissions; the minimum air temperature and the cumulative precipitation in the last week ended to CO2 measurement time. The highest recorded soil CO2 efflux in a wide range of land uses were obtained in August to October due to more suitable temperature and rainfall distribution. Based on lower CO2 emission in abandoned rangelands, lesser soil organic carbon is related to lower input to soil. The higher C: N ratios in litter and some of mineral horizons and lower CO2 emissions by the higher aromatic carbon proportion in coniferous forests compared to deciduous forests have probably caused increasing SOC storage.

Results of this study indicate that along with decreasing in aggregates size, stable aggregates and organic carbon percentage were increased; and also large macro aggregates (>2 mm) more susceptible than other aggregates to the deciduous forest-land change. Based on organic matter fractionation techniques free particulate organic matter (F-POM) and intra-aggregate particulate organic matter (IA-POM) among other fractions and even total organic carbon are critical and sensitive indicators to land uses change. The amounts of nitrogen and C: N of organic matter fractionation were determined degradation orders as F-LF> F-POM> IA-POM> IA-S+C, it was shown aggregate role in protecting them against microbial decomposing.

The FTIR spectra results showed that higher aromatic carbon proportion and their lower decay rate of organic matter in coniferous forest have caused more SOC content. Free and intra-aggregates particulate organic matters (POM) have been recognized as criterion indices for change of deciduous forest use. Compared to the other land uses, the higher aliphatic to aromatic carbon ratios were obtained in litter and intra-aggregates POM of deciduous forest. The highest14C age in both forest land uses was measured in the B horizon, while in the rangeland occurred at the A horizon. Aromatic functional groups as well as 14C age are suitable parameters for homification processes. In generally, the coniferous forests were more efficient in organic carbon storage compared to the other land use types. Therefore, the above mentioned considerations should be used in land use planning in order to reduce soil CO2 emission.

Keywords：*Deforestation, Reforestation, Soil Carbon Dynamics, Fractionation, FTIR, POM, 14C Dating.*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Urea- And Nitrapyrin-Affected N_2O Emission is Coupled Mainly with Ammonia Oxidizing Bacteria Growth in Microcosms of Three Typical Chinese Arable Soils

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Many nitrification inhibitors (NI), including dicyandiamide (DCD) and Nitrapyrin (NP), inhibit nitrification by interfering with the ammonia monooxygenase (AMO) enzyme which catalyzes ammonia oxidation, the first and rate-limiting step of soil nitrification. In soil, discrete groups of bacteria and archaea are both known to be involved in ammonia oxidation. It is unclear how inhibition of nitrous oxide (N_2O) emissions by nitrification inhibitor is regulated through the ammonia oxidizing bacteria (AOB) or archaea (AOA) in arable soils.

In this study, we investigated effects of 2-chloro-6-(trichloromethyl)-pyridine (Nitrapyrin, NP) on N_2O emissions, and characterized the ammonia oxidizing microbial community in three arable soils typical of northern China. Incubation experiments were carried out, AOA and AOB abundance and community structure were characterized using q-PCR and DGGE fingerprinting.

In alluvial, black, and paddy soils, average N2O emission rates were increased by addition of urea by 3.5, 0.7 and 2.1 pM N_2O g^{-1} soil h^{-1}, respectively, but were reduced by 2.9, 0.4 and 2.2 pM N_2O g^{-1} soil h^{-1} when urea was applied with NP. For the alluvial soil and paddy soil, AOB abundances were strongly increased by the urea addition, but this effect was inhibited when urea was added with NP ($P < 0.01$), while for the black soil, the effect of urea and NP was less obvious.The stimulation and suppression of N_2O emission by urea and NP was found significantly and positively correlated with AOB abundances for the alluvial soil and paddy soil ($P < 0.01$). Weak stimulation and suppression of N_2O emissions by urea and NP corresponded with weak effects on AOB abundances in the black soil. Changes in N_2O emissions were not significantly correlated with AOA abundances in any of the three soils. Meanwhile, treatment with urea or urea plus NP did not change the AOA community structure in the three soils tested during the whole incubation period, yet treatment of soil with urea changed the AOB community in the alluvial soil via reduction in the density of several bands.

In conclusion, to what degree the stimulation and inhibition of N_2O emissions could be triggered by urea and NP addition was widely divergent for the alluvial, black, and paddy soils. Both the increase and decrease in N_2O emission in the urea and urea plus NP treatment were consistent with variation in AOB but not AOA growth. The results showed that differential responses of N_2O emission to urea and NP application in arable soils can be mainly explained by differences in growth of ammonia oxidizing bacteria.

Keywords：*Nitrous oxide, Nitrification inhibitor, AOB, AOA, Real-time PCR, DGGE*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Importance of Soil Water Repellency in Controlling CO_2 and Ch_4 Fluxes from Soil

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Moisture is known to be an important factor affecting the carbon (C) dynamics in soils including decomposition of organic matter and exchange of gases like CO_2 and CH_4 between the soil and the atmosphere. Most studies and process models looking at the soil C dynamics assume, however, that soils are easily wettable and water is relatively uniformly distributed within the soil pores. Most soils, however, do not wet spontaneously when dry or moderately moist, but instead exhibit some degree of soil water repellency (i.e. hydrophobicity), which can restrict infiltration and conductivity of water for weeks or months [1]. This is world-wide occurring phenomenon which affects all soil textural types but is particularly common under permanent vegetation e.g. forest, grass and shrub vegetation [2, 3]. Soil water repellency is most profound during drier seasons, when the soil moisture content is relatively low [1]. Although prolonged contact with water can gradually decrease water repellency, some soils do not recover to being completely wettable even after very wet winter months or substantial rainfall events [2] [4]. It has been recognized that with the predicted climatic changes the phenomenon of soil water repellency will become even more pronounced and severe, additionally it may occur in the areas and climatic zones where the effect have not been currently recognized.

One of the main implications of soil water repellency is restricted water infiltration and reduced conductivity, which results in reduced soil water availability for plants and soil biota, even after prolonged periods of rainfall [3]. As the process of C mineralization and consequently CO_2 efflux from soil is driven by the accessibility of organic matter to decomposing organisms, which in turn is directly dependent on (i) soil moisture and (ii) soil temperature [5] it is, therefore hypothesised that carbon decomposition and CO_2 efflux in water repellent soils will also be affected when soil in the water repellent state. The CO_2 fluxes will, however, increase once the soil switches to wettable conditions. In a similar way the water repellency affects soil CH_4 fluxes favouring the process of oxidation by methanotrophs in water repellent soils.

The results of the interdisciplinary study of CH_4 and CO_2 fluxes from water repellent soils in field and laboratory conditions will be presented. The study sites include the areas under climatic drought and temperature simulations in the heath-land areas, as well as the sites under natural climatic conditions under grassland and forest land use in the temperate climate.

The results available to date provide a strong indication that C mineralization is reduced in water repellent soil, and, given that the total plant biomass in naturally water repellent soil-vegetation systems appears unaffected, this could enhance soil C sequestration on the long term.

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Keywords：*soil carbon, water repellency, CO_2, CH_4*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

CO_2 Fluxes in Artificial Soil in Mexico City

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We studied gas production, diffusion and emission in anthropogenic chinampas soils in Mexico City. The soils were constructed in Pre-Hispanic cultures in Mexico. Pre-Hispanic cultures developed a specific technology for cultivating wetlands around the lakes in the Valley of Mexico. They constructed elevated fields for agricultural pro¯duction called “chinampas”. The fields were created by the accumulation of materials such as organic mat¯ter and loamy lacustrine sediments which were consolidated into islands separated by a system of channels. Gas production and diffusion were measured in laboratory; CO2 fluxes from the soil with and without plant roots and with a grass cover (total ecosystem respiration) were measured in field.

In general terms, the morphology of the chinampas soils resembles that of deep organic soils (Histosols), but the organic matter content is lower. The morphology of the profile was relatively uni¯form. Minor differences in colour, root density, texture and compaction allowed for division of the 50 cm topsoil into four layers. We desig¯nated these layers as A1, A2, A3 and A4, with A denoting superficial humus-enriched horizon and the numbers indicating sub-horizons which were distinguished by the layered morphology of the horizon. Our study showed the influence of a complex of factors (soil temperature and moisture, oxygen availability and organic carbon content) on the CO2 production rate and its response to temperature. The mean rate of aerobic CO2 production was 58.0 mg CO2 kg-1 d-1 and that of anaerobic CO2 production was 31.2 mg CO2 kg-1 d-1. For all incubation temperatures both aerobic and anaerobic CO2 production increased with the increase in organic carbon in the soil. We found the highest Q10 value in the su¯perficial sub-horizon, which showed also the highest CO2 production rate. Since the upper layer of chinampas soils was formed from excavated organic-rich lacustrine sediments, it has two different substrate pools: one consists of old recalcitrant organic matter of sedimentary origin and the other of recently decomposed and incorporated plant debris. Consequently, the up¯per layer of the studied soil exhibits properties typical both for surface horizons with the high¯est amount of fresh labile organic matter, and for deep horizons with the highest content of recal¯citrant humus fractions. The Q10 values of CO2 fluxes decreased with the increase of the soil moisture content for the soil samples from all the depths incubated under aerobic conditions, but not for those incubated under anaerobic ones. When the soil water content increases, the soil pores fill with water causing anaerobic microbial me¯tabolism. The results of our study showed that the Q10 of anaerobic CO2 production was lower than that of aerobic production. Thus, the in¯crease in soil moisture and the corresponding decrease in oxygen availability caused the low¯ering of the sensitivity of soil microbial respiration to temperature.

The results showed that under the limiting condition of any factor the response of the microbial activity to other factors is modified: 1) when anaerobiosis increases in the soil the limiting effect of the substrate availability on mi¯crobial activity increases, 2) CO2 fluxes be¯comes increasingly dependent on soil moisture under temperature stress (unusually low and high soil temperature), 3) temperature sensitivity of CO2 fluxes is the highest under drought stress (about 10% WFPS). The mean values of total grass ecosystem respiration (rushes, as dominant during rainy season and bristly ox-tongue during dry season) and CO2 fluxes from soil were about 270 and 106 mg CO2 m-2 h-1, respectively. The mean root contribution was 50% of CO2 emission during measuring period. The annual soil efflux amounted to 464.3 ± 52.8 g C m-2 h-1 for chinampas soils. The temperature sensitivities of CO2 emission and total ecosystem respiration in chinampas were higher during cold season, which associated with acclimation of microbial and plant respiration to low temperature.

Keywords：*gas production, emission, temperatura, soil water content, organic content, aerobic/anaerobic*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Characteristics of Nitrous Oxide Emissions and the Affecting Factors from Vegetable Fields in the North China Plain

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Nitrous oxide (N2O) is one of the important greenhouse gases emitted from soils caused by soil nitrogen (N) turnover. Vegetable fields are under intensive management with higher rate N application followed by irrigation, and frequent planting-harvest cropping activities. The area of vegetable fields is increasing in China and the vegetable soil has been one of the important N2O emission sources. However, the researches on specific field measurement on N2O emission from the vegetable fields in the whole year-round and its affecting factors are still less. Specific emission factors (EF) on N2O emission form vegetable fields still need to be investigated in order to mitigate the uncertainty of regional or nation N2O inventory.

N2O emissions from four different fields ? a maize field (maize), a newly established open-ground vegetable field converted from a maize field four years earlier (OV4), an established open-ground vegetable field converted from a maize field more than 20 years ago (OV20), and an established sunlight heated greenhouse vegetable field converted from a maize field more than 20 years ago (GV20) with four different fertilization treatments for the OV4 field were measured using the closed chamber method between March 15th, 2012 and March 14th, 2013 in suburban area of Beijing, North China Plain. The results showed that all the N2O emission peaks occurred after fertilization and the fertilization associated emissions accounted 81.1% (ranging from 77.0% to 87.2%) of the annual N2O emission with 22.2% time duration in the whole year. Both the occurrence data and duration of N2O emission peaks were associated with N input type (chemical or manure) and the application rate. The N2O emission peaks appeared earlier (on the 3rd day after application) and lasted shorter when only chemical N was applied (on the 7th to 10th day after application) and later when a combination of manure and chemical N were applied. The magnitudes of N2O emission peaks increased when the N application rate was higher. Dicyandiamide (DCD) decreased N2O emissions by 30.1% and 21.1% in the spring cucumber and autumn cabbage seasons respectively (averaged of 24.7% over the whole year). The calculations showed that it is critical to estimate the emission factor (EF) by N type. The EFs were 0.20% and 0.42% for manure N in the cucumber and cabbage seasons respectively; and were 0.55-1.30% and 0.8-1.59% for chemical N in the cucumber and cabbage seasons respectively.

Keywords：*Nitrous oxide; vegetable field; greenhouse gas; greenhouse gas inventory*

P1-380

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Greenhouse Gas Emissions from Aggregates of a Mesocosm Soil Worked by Lumbricus Rubellus and Amynthas Agrestis

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The A, E and B horizons of a spodosol soil under a mixed hardwood/softwood forest were used to construct mesocosm to observe the calcium-earthworm-plant interaction for Lumbricus rubellus (L), Amynthas agrestis (A) and a control treatment with no earthworms (N). Howeer, for this study, aggregates were obtained from these treatments after 12 weeks incubation to measure soil Ca, pH, NO3, and NH4 as well as greenhouse emissions from each replicate aggregate set. The aggregates for each replicate had approximately 2-g mass. The aggregates were brought up to field capacity. Half the aggregates received NH4 additions (+), the others did not (-). Lower pH values in aggregates in earthworm soils than in the N(+) treatment ($p(F) < 0.001$) may have been caused by nitrification as NO3 concentrations in the earthworm treatments were greater than in the N(-) treatment ($p(F) < 0.032$). Greater water soluble Ca concentrations in the earthworm treatments could not buffer the pH differences. N2O and CO2 emissions were consistently greater for the earthworm treatments in both NH4 treatments with the exception of A(+) which emitted significantly less N2O than either the L(+) or N(+). For CO2 in soils without NH4 additions, worm type and pH contributed significantly to CO2 predictions ($p < 0.0001$). For treatments with NH4 additions, model predictions ($pH < 0.0096$) were mainly influenced NH4 concentrations. For N2O without NH4 additions ($p< 0.0001$), earthworm type was the only significant contributor to predictions. For N2O emissions with NH4 additions ($P< 0.0001$), NH4 concentrations, NO3 concentrations and earthworm type were significant contributors to the predictions.

Keywords：*Invasive earthworms, Greenhouse gas, hardwood and softwood spodosols*

P1-381

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Effect of Topography on N_2O Emission from Oil Palm Plantation in Riau, Indonesia

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Global warming continues to be a subject of intense public and political debates. Soil and its use, particularly agricultural soils contribute to global warming by increasing emissions of greenhouse gases into the atmosphere as result of human activity. According to IPCC, comparing with emission of carbon dioxide in the weight basis, the quantities nitrous oxide emission has ~ 300 times potential in contributing to global warming and 70% of the total globally emitted N_2O are from agricultural soil. N_2O emissions have been shown to vary across agricultural landscapes in response to variations in several factors such as topography, soil, crop types and managements (Izaurrade et al., 2004; Vilain et al., 2010). The slope in the agricultural land effects the movement of surface and subsurface water and nitrogen cycling in the soil. Assessment of the N_2O emission at landscape scale requires that researchers choose meaningful and multiple sampling sites that represent the range of conditions across the landscape (Corre et al., 1999; Pennock et al., 2005). In general, it has been observed that N_2O emissions were higher in footslopes than in shoulder positions.

The oil palm plantations in Indonesia have been in focus of the debate concerning emission of greenhouse gases, through its association in the public debate with deforestation. Many research reported that oil palm plantations emission of N_2O into the atmosphere which linked to nitrogen fertilizer use. However the interactions of soil properties and topography influencing soil N_2O flux rates are still poorly understood particularly in the tropical region. In Indonesia, oil palm plantation is located in the different land pattern or slope variation. Therefore it is necessary to conduct research consider in place measurement of flux of N_2O based on different slope positions. The objectives of this study to assess the spatial variability by different slope position (upper, middle, and lower slope) on flux of N_2O and to identify the controlling factors of spatial variations at the field scale in oil palm plantations. The studied site was located in Tunggal Plantation, 200 km southeast of Pekanbaru City, Airmolek District, Riau Province, Indonesia. Geographical feature of Tunggal Plantation is categorized as hilly slope area, annual rainfall and mean temperature was 1387 mm and 28°C, respectively. The field observation was conducted from June 2012 through May 2013, along the sloping site 1.3 to 2.2%. N_2O flux and concentration was determined using closed chamber method and gas chromatography. Undisturbed soil core with three replicates and composite soil samples were collected at 0-10 cm depth at each slope position, and physiochemical properties of soil were analyzed in laboratory.

Result showed that landscape position varied on seasonal N_2O flux in the upper slope were ranged from 0.34 to 36.3, middle slope were -4.28 to 34.9, and lower slope were 1.59 to 61.2 μg N_2O-N $m^{-2}h^{-1}$. High peak of N_2O flux was affected by precipitation, however the temperature have no correlation with variation of N_2O flux by different slope position. In a year the cumulative of N_2O fluxes was 460, 560, and 697 g N_2O-N $h^{-1}y^{-1}$ in the upper, middle, and lower slope respectively. Statistically, cumulative of

N_2O fluxes was significantly higher in the lower, however upper and middle slope showed no significant different. Physiochemical properties of soil and the cumulative flux of N_2O in the different slope position showed significant positive correlation with Pearson correlation coefficient at 0.732, 0.795, and 0.861 with the effect of soil organic content of ammonium (NH_4^+), nitrate (NO_3^-), and water-filled pore space (WFPS), respectively. While effect of C/N content found significant negative correlation with Pearson correlation coefficient at -0.667. It is concluded that N_2O flux were varied by topography position, monthly, and precipitation. N_2O flux was higher in the lower slope by process of denitrification, determined by high available NO_3^- and soil moisture (Machefert, 2004). Agricultural landscape plays a role mainly in its relation with hydrological processes which, in turn, regulate the soil factors mainly WFPS and content of soil organics (NH_4^+ and NO_3^-) in controlling the spatial variation N_2O emissions at the micro scale level.

Keywords：*N_2Oflux, topography, oil palm plantation*

P1-382

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Response of Soil CO_2 Flux in a Crop Field to Rain Pulse

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Soil microbes can start utilizing carbon substrate immediately when environmental conditions become favorable, such as when it rains. This is so-called Birch Effect. So often in the literature we see reports which show an enhancement of soil CO_2 respiration (total CO_2 produced inside the soil profile) after rain events, especially for studies from ecosystems when the soil surface is dry. The same cannot be said for soil CO_2 flux (CO_2 transport across the soil surface). Based on a 2-year study over a crop (corn/soybean) field at Mead, Nebraska with a 16-chamber automated soil CO_2 flux system, we found that the response of soil CO_2 flux to rain events depended on the amount of crop residues on the soil surface. For a location where there was no residue on the soil surface, soil CO_2 flux could be decreased after rain events because of reducing the soil conductance for gas transport. While for a location where there was a large amount of crop residue, soil CO_2 flux was always enhanced after rain events. The coefficient of variation (CV) of soil CO_2 flux was found to be increased right after rain events. From a modeling point of view, it is necessary to treat the CO_2 respired from the microbial activities inside the soil profile differently from microbial activity on crop residue at the soil surface.

Keywords：*soil CO_2 flux, rain event*

P1-383

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Isolating Active N_2O Emitters from Boreal Sphagnum Moss Peat and Searching for Natural Substances Suppressing N_2O Emission

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Background: Nitrous oxide (N_2O) is a potent greenhouse gas involved in the depletion of stratospheric ozone. Boreal sphagnum moss peat is a carbon sink and often becomes an active source of N_2O. The objective of our study was to search for major N_2O emitters from hot spots of N_2O emission. Further, we searched for secondary metabolites from boreal sphagnum moss and its bog vegetation.

Methods: For the N_2O emission assay, an excess amount of 0.5 g L^{-1} NH_4NO_3 was added as the substrate for N_2O production to Winogradsky's mineral solution gelled with 3 g L^{-1} gellan gum (10 mL, pH 5.0) in gas-chromatographic vials. The medium was inoculated with an aliquot (100 μL) of the boreal peat soil suspension (mg soil mL^{-1} MilliQ water) or plant tissues of sphagnum moss (10 mg f.w.). After incubation at 15°C for 7 days, N_2O gas in each headspace was monitored using ECD-gas chromatography. Cultured media that produced significant amounts of N_2O were spread on a PDA plate to isolate N_2O-emitting microorganisms. Using the 16S rRNA gene for sequence homology, N_2O-emitting bacteria were identified and characterized. A 10-g portion of sphagnum moss was added to 50 ml MiliQ water and ground to a moss juice, centrifuged (14,000 rpm, for 15 min), filtered twice, autoclaved (at 121°C, for 20 min). The concentrations of insoluble and soluble moss tissues were then adjusted to 0.1 g L^{-1} to 1 g L^{-1} and 0.2 g L^{-1} to 20 g L^{-1}, respectively. The concentration gradients of separated moss juice and active N_2O emitters were added to the medium for the N_2O emission assay.

Results and Discussion: Three strains of bacteria (*Burkholderia* sp. A1, *Burkholderia phenazinium* C1, and *Burkholderia sordidicola* E2) isolated from the culture inoculated with leaves of sphagnum moss (*Sphagnum fuscum*) were identified as N_2O emitters. Among these, *B. sordidicola E2* showed the most active N_2O emission. All of the N_2O emitters produced N_2O more actively from NH_4NO_3 than from KNO_3 and NH_4SO_4. The optimum concentration of NH_4NO_3 was observed to be 1 mM. For all of the N_2O emitters, pH 5.0 was the optimum pH for N_2O emission. Furthermore, the addition of sucrose dose-dependently enhanced N_2O production of all the N_2O emitters, although this treatment did not show any exponential increases, which was unlike N_2O emitters from tropical peat soils. For *B. sordidicola* E2, N_2O production also increased with the temperature in the range of 4°C to 30°C, while addition of sphagnum moss juice accelerated N_2O production dose-dependently. After separating the insoluble and soluble parts of the moss juice, N_2O production increased as the concentration of fragments of insoluble moss tissues increased from 0.1 g L^{-1} to 1 g L^{-1}. This showed that insoluble parts can be used as the carbon source for N_2O emission. In contrast, N_2O production decreased as the concentration of soluble moss increased in the range 0.2 g L^{-1} to 20 g L^{-1}. This probably means that the substance suppressing N_2O emission exists in the soluble parts of moss juice. The extraction and isolation of the active chemical substance that suppresses N_2O emission is important and meaningful in our further research.

Keywords：*nitrous oxide, boreal sphagnum moss peat, N_2O emission*

P1-384

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Effect of Aromatic N-Heterocyclic Organic Compounds on Nitrous Oxide (n_2o) Emission by Soil Denitrifier *pseudomonas* Sp. Isolated from Dent-Corn Cultivated Soil in Andisol Farmland

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Background: Nitrous oxide (N_2O) is an active greenhouse gas contributing to more than 7% of global warming. Globally, nearly 40% of N_2O is produced from agricultural soil; mainly as a product of nitrogen fertilizer. Our focus is to identify chemical compounds that accelerate or repress the production of N_2O by hyperactive or moderate N_2O emitters isolated from the farmland soils. As we have an established, reproducible N_2O emission assay system using a soilless, gellan gum, soft gel medium,1) N_2O-emitting bacteria were screened from culturable soil bacteria isolated from Andisol from a corn farm at the Hokkaido University Experimental Livestock Farm in Shizunai, Hokkaido, Japan and many N_2O-emitting eubacteria were successfully isolated.2) Using these isolates, the effects of some N-heterocyclic aromatic compounds and pesticides on N_2O emission were investigated.

Methods: Five hundred milligrams of nitrogen in the form of KNO_3 (3.6 g L^{-1}) was added to simple Winogradsky's mineral solution (10 ml, pH 5.0), without adding any additional carbon sources, to focus on nitrous oxide emission assay by incomplete denitrification. A 100-μL sample of supernatant from soil suspensions (10 mg wet soil in 10 mL Milli-Q water) was inoculated into 10.0 mL medium and incubated at 20°C for 7 days. The isolated N_2O emitters, pre-cultured on modified MW plates for 2-4 days, were inoculated into the medium for the N_2O emission assay. Some herbicidal compounds (e.g. paraquat and amitrol, from Wako) and other related compounds (e.g. 6-methoxy-2-benzoxazolone and benzoxazolone) were examined at concentrations of 2 and 10 μM. After 4-7 days of incubation at 20°C, headspace gas from the vials was sampled with a 1-mL gas-tight syringe and analyzed with an electron capture detector-equipped gas chromatograph (Shimadzu GC-14B; Kyoto, Japan; Porapack column).

Results and Discussion: In the N_2O emission assay using two active eubacteria, *Pseudomonas* sp. 10CFM5-1B and *Pseudomonas* sp. 10CFM5-2B, isolated from a sample of post-harvest soil of Andisol corn farmland in Hokkaido, we found that 1,1'-dimethyl-4,4'-bipyridinium dichloride (paraquat) at 2 μM significantly repressed N_2O emission by the active bacteria. In addition, 6-methoxy-2-benzoxazolone, a known corn antifungal compound, also repressed these pseudomonad denitrifiers at 10 μM. Other herbicides, specifically simazine, trifluralin, and amitrol (3-amino-1,2,4-triazole), accelerated N_2O emission by *P. chlororaphis* at 2 or 10 μM rather than inhibiting it. Amitrol at 2 μM led to a 2.5-fold higher N_2O emission by *Pseudomonas* sp. 10CFM5-1B. It was thus demonstrated that 1,1'-dimethyl-4,4'-bipyridinium dichloride might make a significant contribution to the repression of global warming by unexpected suppression of N_2O production in farmland soils, while some other herbicides, including amitrol and other triazole-type chemicals, may potentially activate the N_2O emission of soil. In addition to their herbicidal activity, the next generation of herbicides should have the by-effect of reducing N_2O emission.

Keywords: *nitrous oxide emission; N-heterocyclic compound; repression; 1-hydroxy-1H-benzotriaz*

P1-385

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Short-Term Carbon Dioxide and Nitrous Oxide Emissions and Changes in Physico-Chemical Properties from Soils Amended With Different Biochars

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Increased concentration of greenhouse gases in the atmosphere has drawn world's attention to explore novel technologies to combat with climate change and global warming. Biochar is considered as an important soil amendment as it improves soil productivity, carbon storage, infiltration and water holding capacity of soil and has been shown to mitigate greenhouse gas emission in the field through increased carbon sequestration and reduced nitrous oxide emissions. The uses of biochar as soil amendment modify the dynamic of carbon (C) and nitrogen (N) in soil after the application of fertilizers. The adsorption of nutrients and dissolved organic carbon in biochar is fully associated with increased cation exchange capacity and surface area, and the acidic functional groups attached to the surface. A laboratory incubation experiment was carried out with a hypotheses stating that carbon dioxide (CO_2) and nitrous oxide (N_2O) emission patterns from biochar amended soils are closely related to pyrolysis condition and nature and properties of feedstock used during pyrolysis.

The experiment was carried out in glass jars (3 L capacity) intended to mimic the plough layer (0-30 cm) of two agricultural soils (NW Italy) with different physico-chemical characteristics: 1) a sandy soil with sub-alkaline pH and 2) a silt-loam soil with sub-acid pH. The air-dried soil samples (1.5 kg for each replication, sieved at 2 mm) were amended (at 2% w/w) with five different types of biochars (poultry litter and swine manure biochar both at 400 and 600 °C; and wood chip biochar at 1000 °C), 4 replication per each treatment and incubated for 85 days. De-ionized water was added to the soils in order to get the desired water filled pore space of 75%. After 20 days of incubation, all jars were fertilized with ammonium nitrate at a rate of 170 kg ha-1. The measurements of CO_2 and N_2O were performed at different sampling dates using gas chromatography. The whole experiment was carried out in a completely randomized block design within a climatic chambers with controlled environment (20 ºC and 60% RH).

Result from cumulative emission shows that soils amended with poultry litter biochar at 400 ºC emitted higher CO_2 and N_2O whereas wood chip biochar emitted significantly less than the rest of the treatments. The emission patters are extremely related to the specific characteristics of biochars. In general, chars produced at higher temperature emitted less than at lower temperature. This could be the fact that chars produced at lower temperature contains higher percentage of labile carbon and is easily attacked by the soil microbes.

The total cumulative emissions (CO_2 and N_2O) were extremely related to pyrolysis temperature as well as soil types. Pyrolysis condition, quality and nature of feedstock seem to be important parameters during biochar production process in determining the gaseous emission patters when used as soil conditioner. In depth research study on processes and mechanisms associated to these effects are necessary for better understanding and also exploring future use of biochar properties in order to meet the new mitigation strategies.

Keywords：*Soil, biochar, pyrolysis, greenhouse gases, carbon sequestration*

P1-386

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Modelling Nitrous Oxide Emissions from Diverse Australian Wheat Systems

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Nitrous oxide (N2O) is a potent greenhouse gas. The majority of its anthropogenic emissions stem from agricultural production systems. The abatement of nitrous oxide emissions from agricultural soils is therefore an important topic worldwide. In Australia, a collaborative network of 17 field, laboratory and simulation research projects across the country has been established, currently known as the National Agricultural Nitrous Oxide Research Program (NANORP). The overall objective of the program is to develop robust N2O mitigation strategies for Australian agricultural soils while maintaining productive and profitable farming systems. One approach is the application and, if necessary, the advancement of suitable plant-soil simulation models to simulate the impacts of management interventions on carbon/nitrogen dynamics and N2O emissions. Well designed and calibrated process-based models are valuable tools for the development of mitigation strategies. The use of models allows us to estimate the impact of different management and climate scenarios on N2O emissions, and thereby identify the most appropriate mitigation strategies.

During the last few years, a number of field experiments have been set up in various farming systems in different environments in Australia, determining the magnitude and driving factors of N2O emissions under different management practices. In this study, grain crops from three measurement sites using different irrigation and fertilisation systems were simulated with the Agricultural Production Systems Simulator (APSIM). The model is well established for the simulation of soil and plant interactions. It takes into account the production of N2O through the two main pathways, denitrification and nitrification.

The aim was to test the capability of APSIM to predict N2O emissions for a whole crop season and on a daily basis. We examined if a general set of soil nitrogen cycling parameters can be determined for APSIM to allow the adequate simulation of crop growth, soil water, soil nitrogen and N2O emission. More specifically, we wanted to determine which soil nitrogen cycling parameters are universally-applicable and which are site-specific. For a start, the parameters controlling the general soil nitrogen transformations were kept constant for all sites and treatments. The model was calibrated for one treatment at each site by adjusting site-specific parameters (e.g. soil hydraulic and plant uptake parameters) and then validated using the other treatments conducted at the sites, including different irrigation or fertilisation strategies.

Soil water content strongly influences nitrogen transformation processes, so the performance of the two different water dynamics models available to users in APSIM was compared. These models are SoilWat, a tipping-bucket model that predicts water flow as a first-order equation and uses a mass dispersion equation for solute movement, and SWIM3, a Richards' equation model that uses the convection-dispersion equation for solute movement.

Water dynamics and crop development were generally predicted properly. Also, cumulative N2O emissions during the crop seasons were simulated adequately in most cases, whilst the nitrogen cycle parameters in the model were kept constant. However, on a daily basis, predictions were not always satisfactorily. N2O emissions from nitrification were sometimes underestimated while N2O emissions originating from denitrification were overestimated after heavy rainfall or irrigation events.

Obviously in the model, water content has a large influence on denitrification and hence on N2O emission. The soil hydraulic parameters which the simulated N2O emissions were most sensitive to were initial water content, drained upper limit (field capacity) and saturated conductivity in the upper two layers. Furthermore, the initial distribution of the carbon pools and the initial amounts of inorganic nitrogen in the soil profile had a considerable influence on the prediction of N2O emissions and yield.

Keywords：*APSIM, nitrification, denitrification, model calibration, fertilisation, irrigation*

P1-387

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Land Use Change in Indian Western Ghats: Sink-Source Potential For CO_2

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Soil forms a major pool in global C-cycle and the absolute amounts of C stored vary considerably across vegetation types. The rate of C accumulation in a land use system depends on the net balance between inputs and outputs per unit time. The Western Ghats of India provide unique opportunity to take the cross sectional view of the soil C stocks and estimate their CO2 sink-source potentials among different cropping systems.

The semi-evergreen forest systems and areca plantations recorded high annual biomass turnover of > 8.0 t ha^{-1} while, the evergreen, moist and dry deciduous forests and manmade teak and acacia plantations recorded a turnover of 5.0 to 7.0 t ha^{-1}. The soil organic-C stocks per ha of natural forests to a depth of 1 m (t / ha -M) were 195-220 t / ha-M while, manmade plantations and degraded forests were the range of 120-132 t / ha-M. The degradation of forests is likely to lose 57.8 ? 64.4 t of C with a release of 231-258 t of CO_2 to the atmosphere. The replacement of coffee plantations with teak would release 173.2 t of CO_2. The conversion of degraded lands into natural forests is likely to add 103 to 119 t of C to the soil. Similarly, even the establishment of coffee plantations on these degraded lands is likely to enhance soil carbon by about 103 t per ha-M. However, the establishment of perennial cropping systems on the degraded lands would act as sink for atmospheric CO_2. Thus, the change of land use from one cropping system to another would determine the magnitude of CO_2 released or absorbed from the atmosphere.

Keywords：*land use change, cropping systems, SOC, CO_2 sink and source, western ghats*

P1-388

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Soil Redox Chemistry and Greenhouse Gas Emission in Lowland Rice Paddy Soils: Impact of Rice Straw Incorporation and Elevated Temperature

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Intensification of rice cultivation to meet the global food demand not only increase rice production but also increases the amount of rice residue which has big management challenge. Burning of rice straw increases the air pollution and incorporation into the flooded soil increases methane emission. The emission of methane may further increase in future with increasing global temperature along with rice straw incorporation. Pot experiments were conducted with controlled temperatures in a walk-in growth chamber (WGC) in the International Rice Research Institute (IRRI), Philippines. The objectives were to determine the influence rice straw incorporation and elevated temperatures on soil redox potential and emission of CH4 and N2O. Three levels of temperature--29/22, 32/25, and 35/28 oC, representing daily maxima/minima, and two levels of rice straw (0 and 6 t ha-1) were arranged in complete randomized design (CRD) with four replications. The effects of elevated temperature with rice straw application on soil redox potential; CH4 and N2O emission, and rice yield were examined. The hypothesis “rice straw incorporation decrease soil redox potential and increase CH4 emission” was tested. Soil redox potential and CH4 emission were monitored weekly throughout the rice-growing period for two crop cycle. A decrease in soil redox potential to <-100 mV and CH4 emission were observed earlier in pots with rice straw compared to pot without rice straw. Similarly, significantly higher total CH4 emission was observed with rice straw application. However, the increment in emission triggered by rice straw incorporation was higher especially in elevated temperatures. As experiment was conducted in continuously flooded condition, the emission of N2O was not observed throughout the growing season. On the other hand, the high temperature significantly increased spikelet sterility and reduced grain yield ($p<0.05$) of rice. Both increasing global temperature and incorporation of rice straw could alter the soil redox chemistry as well as emission of greenhouse gases.

Keywords：*Elevated temeprature, greenhouse gas emission, rice*

P1-389

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Animal Treading Damages Pasture and Affects Soil Nitrous Oxide Emissions

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Intensively managed grazed pastures are significant sources of nitrous oxide (N2O) due to regular fertiliser nitrogen (N) inputs, animal excreta and soil compaction resulting from animal treading. Animal treading also damages pasture, however, the subsequent effect of this damage on N2O emissions is not known. During and after grazing uneaten pasture, along with the pasture damaged by treading, may become incorporated into the soil. Under winter conditions when soils are very wet, we postulated soil compaction and pasture incorporation could affect N2O emissions. A field experiment was conducted to determine the effects herbage on emissions and soil inorganic-N dynamics. A factorial experiment simulated animal treading (presence/absence) in the absence and presence of herbage, on a poorly drained Temuka clay loam soil, located at a pasture site in Canterbury, New Zealand (43°38.50′ S, 172°27.17′ E). Pasture species were dominated by perennial ryegrass (Lolium perenne L.) and white clover (Trifolium repens L.). Treading resulted in reduced pasture dry matter yield and soil nitrate (NO3-) and ammonium (NH4+) concentrations. However, the soil's water soluble carbon concentration increased. Maximum N2O emissions occurred 2 d after imposing treading to nil-herbage plots. After 47 days, N2O emissions were higher from the trodden plots irrespective of herbage presence with cumulative emissions ranging from 9 to 17 mg N2O-N m-2. Emissions of N2O from the nil-herbage-trodden treatment were higher probably because of partial anaerobic conditions created due to treading as evidenced by lower soil NO3- under treading. When 15N-labelled fertiliser was used to label the soil inorganic-N pool, it was observed that a major fraction of the emitted N2O originated from the antecedent soil-N and/or from plant root-N decomposition under treading. This study uniquely indicates that the enhanced N2O emissions observed under treading are not only the result of antecedent inorganic-N being denitrified but they are also comprised of either soil organic matter-N or root-N made available as a consequence of treading. Future work needs to quantify the mineralisation of soil organic matter-N/root-N resulting from animal treading.

Keywords: *animal treading, N2O, 15N, compaction, perennial ryegrass, white clover*

P1-390

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Spatial Variability and Distribution Of N_2O Emission from a Tea-Planted Small Catchment during Wet Season in Subtropical Central China

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The recent boom and intensification of the tea industry in subtropical central China, with its large fertilizer inputs, lead us to observe nitrous (N2O) emissions from tea fields to investigate the emission characteristics and mitigation potential. In this study, we examined the spatial variability of N2O emissions observed on 5 April 2011 using 147 static mini chambers gridded (15m) almost regularly in a 4.0 ha tea field. The N2O fluxes for 0-30 min (10:00-10:30 am) ranged from -1.73 to 1659.11 g N ha-1d-1 with an average value of 102.24 g N ha-1d-1 and were positively skewed, thus approximating a logit-normal distribution. The geostatistical analysis indicated that the normalized logit-transformed N¬2O emissions (logit(N2O)) exhibited strong spatial autocorrelation, characterized by an exponential semivariogram model and an effective range of 52.1 m. As observed during the wet season, the normalized logit-transformed (NH4N, NO3N, SOC, TSN) were found to be significantly correlated with logit(N2O) ($r > 0.27$, $p < 0.001$). The Tukey's 'Honest Significant Difference' method analysis illustrated that logit(N2O) and some soil properties (normalized logit-transformed (NH4N, NO3N, SOC, TSN)) in fertilisation point had significant differences compared within other three sampling positions. Two-dimensional wavelet analysis was used to extract the latent elevation information correlating with N2O emission from digital elevation model of the tea-planted catchment. LH (high-pass filter to rows, followed by low-pass filter to columns) of the second level was filtered by the wavelet filter -fk6 (DEMLHfk6) had a negative significant relationship ($r=-0.189$, $p < 0.001$) and a similar spatial structure with N2O emissions. Three spatial interpolation methods (ordinary kriging, regression kriging and cokriging) were applied to estimate the spatial distribution of N2O emissions over the study area. Cokriging with (the normalized logit-transformed (NH4N, NO3N, SOC, TSN)) as four co-variables outperformed ordinary kriging, regression kriging with the sampling position as an auxiliary and cokriging with DEMLHfk6 as co-variable. The four kriging interpolation methods predicted total amounts of N2O emissions in the tea field in wet season were 150.5 g N d-1, 208.1 g N d-1, 148.2 g N d-1, 149.7 g N d-1, respectively. The predicted results show that the choice of kriging interpolation methods can greatly affect the accuracy of total amounts of N2O emissions prediction.

Keywords：*Nitrous oxide; Tea field; Spatial variability; Wet season*

P1-391

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Effects of Winter-Flooding, Face (free Air Co_2 Enrichment) and Paddy-Upland Rotation on Methanogenic Archaeal Community Structures in Paddy Field Soil

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Methane is one of the most important greenhouse gases and is generated by methanogenic archaea under anaerobic conditions. Paddy field is a major source of methane emission and methanogenesis occurs during rice cultivation period, while there is almost no methane emission from the drained soil after rice harvest. In paddy fields, methanogenic archaea produce methane by utilizing the terminal products of organic decomposition such as acetate and hydrogen under flooded conditions. Thus, anaerobic soil conditions and substrates for growth are essential for methanogenic archaea to produce methane. My study focuses on changes of methanogenic archaeal community and population in paddy fields with the managements such as extended period of flooding or draining of the field and increase in CO_2 in the field, which are different from the conventional paddy fields. The objective is to reveal the effects of these managements on methanogenic archaeal community structures in paddy field soil.

In this study, three paddy fields located in Japan were used. The first is a winter-flooding paddy field, which was flooded for about 270 days in a year and had longer anaerobic period than conventional paddy fields. Thus, methanogenic archaea could have more substrates to produce methane. The paddy fields consisted of three kinds of treatments: under non-flooding condition during winter with conventional farming (as a control) (CwD), under non-flooding condition during winter with organic farming (OwD) and under flooding condition during winter with organic farming (OwF). Soil samples were collected at three time points (before transplanting, during rice cultivation and after harvest of rice) of the season for two years. The second is a FACE field, which is to represent the CO_2 concentration and temperature after 50 years later. In the FACE paddy field, CO_2 concentration was increased by about +200 ppm and the temperature was raised by 2℃. Elevated CO_2 and temperature could affect plant photosynthesis, increase the rice root biomass and the exudates from roots, and result in increasing substrates for methanogenesis. The field was managed under ambient (as a control) or FACE conditions which consisted of three kinds of treatments (normal temperature [NT], elevated temperature [+2℃] [ET] and low nitrogen fertilization [LN]). Soil samples were collected in July and August (during rice cultivation) of 2011. The third is a paddy-upland rotational field, where soybean was serially cultivated for two or three years and the following paddy rice was cultivated for two or three years. The soil conditions changed from anoxic to oxic for every two or three years in this rotational field. The paddy field consisted of rotational plots and consecutive paddy rice plots (as a control). Soil samples were collected at three time points (before transplanting, during crops cultivation and after harvest of crops) in 2008 and

2009 and one time (during crops cultivation) in 2011. These three types of paddy fields with the different water, CO_2 and crop rotation managements were subjected to analyses of the composition by PCR-DGGE method and population by real-time quantitative PCR method of methanogenic archaea in soil.

In the winter-flooding paddy field, the DGGE band patterns and population of methanogenic archaea were almost identical among OwF, OwD and CwD fields in every sampling period. In the FACE paddy field, the DGGE band patterns and population of methanogenic archaea showed no difference between the ambient and FACE paddy fields and also among the NT, ET and LN treatments. In the paddy-upland rotational paddy field, the DGGE band patterns were different between the rotational and control paddy fields, where some bands of methanogenic archaea belonging to Methanosarcinales disappeared, and the population of methanogenic archaea decreased about one-tenth in the paddy-upland rotational field.

Thus, the composition and population of methanogenic archaea were not affected by the winter-flooding and FACE managements, but affected by the paddy-upland rotation. In conclusion, the composition and population of methanogenic archaea did not fluctuate under the soil conditions which were suitable for methanogenesis (the prolonged period of flooding or increase in supply of substrates for growth), but responsed to the adverse soil conditions for methanogenic archaea to produce methane (the extended period of upland cropping for two or three years).

Keywords：*Methanogenic archaea, Paddy field, winter-flooding, FACE, paddy-upland rotation*

P1-392

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Response of Key Soil Properties to Predicted Climate Change over the Sydney Region, Australia

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This modelling project examined the potential change in the key soil properties of organic carbon (OC), pH and base (nutrient) levels that may occur due to one scenario of predicted climate change over the 10 000 km2 Sydney Region up to approximately 2050. These properties all have a significant bearing on the agricultural potential and ecological character of the soil. Carbon levels are also important for climate change modelling.

Multiple linear regression models combining several major soil forming factors were developed for these properties for three depth intervals (0-10 cm, 10-30 cm, 30-100 cm) for the eastern Australian region. The covariates included mean annual climate data (precipitation (precip) and daily maximum temperature (Tmax) from 1961-1990), a parent material index (silica%), a topographic-slope index (TSI), a land disturbance index (LDI) and an aspect index (Asp). The regression models took the form of:

Soil property = a + b*precip + c*Tmax + d*silica% + e*TSI + f*LDI + g*Asp

Coefficients of determination (R2) values ranged from 0.48 to 0.56 for all models except those for the two lower OC depths which were lower. By running these models firstly using current climate data, then again with future climate predictions (average from 2040 to 2060 projections) for the Region, digital spatial surfaces depicting the projected soil property changes were derived.

The modelling revealed a slight overall rise in organic carbon levels and drop in pH and base content across the entire Sydney Region, however there is significant variation in the degree of change over different parts of the region. The coastal and Blue Mountains areas of the Region are associated with increases in OC but decreases in pH and base content, while the far north and south west are associated with significant decreases in OC and increases in pH and base contents. In the broad central areas, changes in all three soil properties are generally only minor.

The modelling process does not consider the period of time required by soils to re-equilibrate with changing climatic conditions, which should be considered when evaluating the results. Nevertheless, the results may assist natural resource managers in this region to better plan for potential changes in the soil behaviour across their districts, both in agricultural and native ecological landscapes. The project demonstrated a process for predicting the extent of potential carbon sequestration into soils under future climate conditions, which will allow further refinement of climate change models and predictions. It served as a pilot for a more extensive modelling program across all of NSW, which will be undertaken when sophisticated climate simulation data becomes available across the entire State

Keywords：*soil modelling, climate change, organic carbon, pH, bases*

P1-393

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Influence Of Saline Irrigation Water and Gypsum Amendments Addition Upon Methane Emission of Paddy Rice Soil

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Paddy rice fields are considered as one of the major sources of global warming green house gas methane (CH4). However, the extent of CH4 emission from each individual field is largely influenced by soil factors where rice plants are grown and the agronomic practices associated with rice cultivation. From the soil factors, salinity affects 30% of rice fields in the world (Mishra, 2004). Salinity inhibits not only the crop growth but also the three major functions for CH4 emission; transporting CH4 gas, providing carbon substrates, and creating oxidizing site in rhizosphere. To improve the crop growth under Na-enriched or contaminated soil or water, using gypsum (CaSO4.2H2O) amendment as Ca2+ source is a well known amelioration practice. Several studies had been conducted about NaCl effect upon CH4 production potential in laboratory incubation studies. However, there was little information about interaction of salinity originated by irrigation water and Ca- amendment. Therefore, the main objective of this research was to assess the influence of different irrigation water salinity levels and Ca amendments upon CH4 emission with rice cultivation.

To complete this main objective, two pot experiments were conducted. Firstly, to identify the effect of different irrigation water salinity levels and gypsum amendment addition, pot experiment (I) was conducted. There were 6 treatments; control, S30, S90, gypsum 1 ton ha-1(GM), S30 plus GM (S30-GM), S90 plus GM (S90-GM). In case of salinity levels, the results showed that salinity S90 suppressed CH4 emission because of its shortest growth duration period and lower above biomass yield. The amount of CH4 emission in S30 was numerically lower than that in non-saline control but it was not statistically significant different. This numerically lower value in S30 compared to non-saline control might be due to its lower above biomass yield because rice plants serve as the major CH4 transporting function from soil to atmosphere. Based on this result, it seems that S30 level did not suppress methanogenesis but suppressed CH4 transporting pathways. In case of gypsum amendment addition, the addition of GM reduced CH4 emission either in saline or non-saline condition because gypsum contain high amount of Sulfate (SO4) and it might be due to the competition of sulfate reducing bacteria and methanogenic bacteria for the organic carbon substrate in the presence of SO4.

To evaluate the different rates of gypsum application upon CH4 emission under saline condition with rice cultivation, pot experiment (II) was conducted. There were 8 treatments; control, 25 mmolL-1 NaCl (S25), Gypsum 1 ton ha-1 (G1), Gypsum 2.5 ton ha-1 (G2), Gypsum 5 ton ha-1 (G3), S25 plus G1 (S25-G1), S25 plus G2 (S25-G2) and S25 plus G3 (S25-G3). There was no significant difference in dry matter yield among the treatments except S25-G3. However, the total number of dead leaves was significantly higher in saline treatments than that of non-saline treatments. Methane emission in S25 with or without gypsum (except S25-G3) was not significantly different with control. Therefore, S25 level did not suppress CH4 emission. Higher application of gypsum resulted in higher reduction in CH4 emission. The reduction rate was found as 22%, 52%, and 73 % in G1, G2 and G3 respectively. However, the reduction value of CH4 emission due to gypsum addition was lower in saline condition than those of non-saline condition. It might be due to greater contribution of organic carbon source from dead-plant materials in saline condition.

Keywords：*salinity, gypsum amendment, methane emission, crop growth*

P1-394

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Effects of Cropping And Short Natural Fallow Rotation on Carbon Balance in the Semiarid Tropics of Africa

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Introduction

Soil organic carbon (SOC) is an important indicator of soil fertility. In southern Africa, natural fallow is still used for SOC restoration but the recent shortened fallow length in this region might not be sufficient for SOC restoration and may result in SOC depletion.

The slash-and-burn technique is used for land clearing in the Eastern Province of Zambia but due to the low tree biomass, only a parcel of cleared land is burned. Therefore, evaluation of the effects of cropping and short fallow rotation on SOC in burned and unburned fields is required. Measurement of C input into, and C output from, soil can reveal changes in SOC but few studies have investigated the C balance during cropping and short fallow rotation in this area. The objective of this study was to estimate the C balance during cropping with or without burning, and during fallow after different cropping periods.

Materials and methods

The study was conducted in the Eastern Province of Zambia. The mean annual air temperature was 24°C and annual rainfall was 855 mm. The soil was classified as Typic Plinthustalf with a sandy loam texture and total C of 20.4 Mg ha$^{?1}$. The experimental plots were opened by slash-and-burn. The burned and unburned areas covered 16% and 84% of the total opened field, respectively and were cultivated for 1, 2, 3, 4 and 5 years after opening. The cultivated fields were returned to fallow after 1-, 2- or 3-year cropping. A long-term fallow plot was also established. Soil samples at the depth of 0?15 cm were collected in all the plots and analyzed for total C. Input C to the soil was calculated from the amount of plant biomass and rainfall. Output C was from decomposition of organic matter and leachate. Decomposition was estimated by field measurement of the CO_2 efflux without root respiration. Leachate was collected by a capillary lysimeter at the depth of 30 cm and the leachate and rainfall were analyzed for dissolved organic carbon (DOC).

Results and Discussion

1. Cropping period with burning

Burning depleted 7.9 Mg C ha$^{?1}$ of SOC. During 5 years of cropping, the annual decomposition of SOC as CO2 efflux was ~3.3 Mg C ha$^{?1}$ year^{-1}. The DOC in leachate was highest among the treatments in the first year of cropping at 0.08 Mg ha$^{?1}$, because burning partly transformed SOC into DOC. However, the C output was lower than the organic matter input in 1- and 2-year cropping, which led to a significant increase in SOC.

2. Cropping without burning

Annual decomposition of SOC as CO_2 efflux increased in the first year of cropping after conversion of long fallow from 2.2 to 3.7 Mg C ha$^{?1}$ year$^{?1}$. The increase in decomposition was caused by enhanced microbial activity due to the higher temperature and higher substrate availability from the incorporation of organic matter by plowing. The decomposition decreased by 2.5 Mg C ha$^{?1}$

year$^{?1}$ in the fifth year cropping in response to a decrease in organic matter input. The DOC in leachate was only 0.01 Mg C ha$^{?1}$ year$^{?1}$. The highest input in 1-year cropping could compensate the negative C balance during cropping for 2 to 4 years. As a result, SOC did not decrease during cropping for 4 years.

3. Fallow

In unburned areas, the annual decomposition of SOC as CO_2 efflux decreased after returning to fallow with plant litter left on the surface. The loss of SOC by decomposition and leachate was the same during the fallow period after any cropping period at 2.3 and 0.01 Mg C ha$^{?1}$ year$^{?1}$, respectively. The input of organic matter in 2-year fallow after 3-year cropping was highest due to a dominance of herbaceous vegetation instead of tree vegetation, making the C balance positive.

Conclusion

No decrease in SOC during cropping for 4 years was attributed to a higher total C input than output in both unburned and burned field. Without burning, the rotation of 2-year fallow after 3-year cropping was well balanced in terms of SOC.

Keywords：*Sustainable land use, C balance, fallow, leachate, decomposition*

P1-395

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Effect of Different Types of Cattle Manure Application on Increasing Methane Emission in Paddy Soil during Rice Cultivation

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Manure is one of the most important nutrient and organic matter sources in paddy rice systems, while its application poses a great challenge in meeting rice nutrient requirement and simultaneously reduces adverse environmental impacts like increasing CH4 emission. In the farm land level, cattle manures are applied with three different types of like fresh, dried and composted manures, but the effect of their application on increasing CH4 emission was not evaluated well in paddy soil during rice cultivation. In order to determine the effect of different types of cattle manure application on CH4 emission and rice growth and yield characteristics, the fresh manures of Korean cattle, and dairy cattle were collected. The composted and air-dried manures were prepared for the field tests. Under the same chemical fertilization (N-P2O5-K2O=90-45-57 kg ha-1), 5 Mg ha-1 of each manure was applied on dried weight base 2 days before rice transplanting. Methane gas samples were collected once a week using the closed chamber method. Two cattle manure additions significantly increased CH4 emission rates during rice cultivation, but total CH4 fluxes were not significantly different between Korea cattle and dairy cattle manures under the same types of manure application. However, total CH4 fluxes were highest in the fresh manure applied plots. Air-dried manure application slightly decreased CH4 emission rate, mainly due to decreased labile organic C content. In comparison, the composted manure application significantly reduced CH4 emission rates, which was caused by changed chemical composition of organic matter. The manure additions significantly increased rice productivity, irrespective with manure types, but the constant trends among manure processing types were not observed. Therefore, cattle manure management by promoting aerobic degradation through composting could be most promising candidate to suppress CH4 emission in paddy soil during rice cultivation.

Keywords：*Methane, Cattle manure, Rice cultivation*

P1-396

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Nitrate Exposure: A Metric to Describe the Influence of Soil NO3- on N2O Emissions.

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Nitrate (NO3-) is a critical aspect of the soil biological environment. It represents an important nutrient in biosynthesis, a terminal electron acceptor in anaerobic respiration, and a mobile anion. Because of nitrate's dynamic nature, NO3- concentrations frequently exhibit extreme spatial and temporal variability. Further the influence of NO3- on N2O emissions is also variable in time and may be temporally shifted as a result of impacts of NO3- on denitrifier populations or gene expression. Spatial variability of NO3- and its influence on denitrification result in poor correlation between processes such as N2O emissions and point-in-time measurements of NO3- concentration. We examined the utility of a new parameter, NO3- exposure (NE), to represent the influence of nitrate on N2O emissions. The spatial and temporal integration of measurements of NO3- concentration better correlated with cumulative N2O emissions than point-in-time measurements. This observation points to NE as an emergent property reflecting not only the proximal effect of NO3- on a biochemical reaction such as N2O production, but also the more distal processes that control these reactions, enzymes and microbial communities.

Keywords：*nitrate nitrous oxide greenhouse gas microbial communities denitrifies*

P1-397

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

The Microbial Mechanisms for Intermittent Drainages on Methane Cycle in Rice Field Soil

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Intermittent drainages can substantially reduce methane emission from rice fields, but the microbial mechanisms remain poorly understood. The methane emission was mainly regulated by two microorganisms, the anaerobic methanogenic archaea and aerobic the methane oxidizing bacteria. In the present study, we determined the rates of methane emission, the potential rates of methane production and oxidation, the structure and abundance of methanogenic and methanotrophic communities in a comprehensive microcosm experiment in which two water regimes were established, i.e. continuous flooding (FL) and dry wet alternation (DR). We found that alternate dry wet cycles significantly reduced the rate of methane emission. The structure of methanogenic community remained remarkably stable under flooding conditions, and was not affected by drainages. But the quantitative PCR showed that both methanogenic growth and activity were inhibited by drainages. On the other hand, the dry wet alternations didn't affect the structure of methanotroph community (DNA level), but obviously affected the structure of active methanotrophs (mRNA level). Lots of methanotrophs remained inactive in the flooding bulk soil, but the drainages obviously stimulated the expression of the pmoA genes in bulk soil. In contrast, the methanotrophic growth and activity in surface and rhizosphere soil were inhibited by alternate dry wet cycles, probably due to the methane depletion caused by drainages. In addition, pyrosequencing of 16S rRNA genes showed the whole bacterial diversity was significantly changed by the intermittent drainages.

Keywords：*methane emission, drainage, methanogens, methanotrophs, paddy soil*

P1-398

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Microbial Driving Mechanisms of N2O Emission Influenced by Agricultural Practices

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In agricultural systems, large amount of nitrogen fertilizers is used annually for high crop yield, but at the same time, nitrogen loss caused serious environmental problems, e.g about 25% N2O emission is from agricultural soils. However, the understanding of microbial mechanisms of nitrogen cycling is limited. We have carried out researches on soil nitrifiers and denitrifiers in relation to intensive agricultural practices in paddy fields. It was found that long-term application of fertilizers induced various N2O emission potentials. Simultaneously, the community compositions and abundance of denitrifying bacteria were obviously affected by long-term fertilization. Especially, the composition structure of expressed denitrifying genes were more significantly influenced and was closely linked to N2O fluxes. Therefore, the impact of fertilization on the active denitrying communities would be important driving mechanisms for N2O production. During rice growing season, flooding-drying is an important measure in increase rice productivity, but it also results in heavy nitrogen loss through N2O emission. It was suggested that about 40-60% N2O in paddy soil was emitted during this process. When paddy soil was drying from flooding status, the communities of denitrifiers differentially responded to the drying process, the shifts of community containing nitrate reductase gene (narG) closely linked to Eh change and N2O flux, whereas, the community containing nitrous oxide reductase gene (nosZ) did not show such a relationship with N2O emission, even though it was significantly correlated to water content variation. So narG-containing denitrifiers would play a key role in driving N2O flux in wet-drying process. In conclusion, both fertilization and water management could influence the community composition and abundance of denitrifiers in paddy rice soil, but the functional microorganisms differentially responded to the agricultural practices.

Keywords：*nitrogen cycling, denitrification, microbial community, paddy soil*

P1-399

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Effect of Plant-Mediated Oxygen Supply and Drainage on Greenhouse Gas Emission from a Tropical Peatland in Central Kalimantan, Indonesia

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Introduction

Methane (CH4) emissions from tropical peatland soils reported in previous studies were generally lower than those in boreal and temperate peatland soils. One of the possible reasons for this low CH4 emission involved the oxygen supply from tree roots, since wetland vegetation has usually developed specific organs which can supply atmospheric O2 to the rhizosphere, where a part of the O2 may be consumed for CH4 oxidation. We conducted field observation to verify the following hypotheses: 1) dissolved oxygen (DO) supplied from plant roots should oxidize CH4 produced in saturated tropical peat soil and 2) CH4 oxidation should reduce total global warming potential (GWP) in a tropical peat swamp forest.

Materials and Methods

DO and GHG fluxes and dissolved concentrations in a submerged forest were compared with those in degraded peatland areas that have been burned and/or drained. Field observations were conducted in the study sites near Palangka Raya, Central Kalimantan, Indonesia during the rainy season (Dec. 2011 to May 2012). Fluxes of CO2, CH4, and N2O were determined using closed chamber method. Dissolved concentrations of these gases were calculated based on the concentrations in gas samples and Henry's law. DO concentration was measured in situ using a closed cell to avoid contact between the water sample and the atmosphere.

Results and Discussion

1) CH4 fluxes and dissolved CH4 concentrations were significantly influenced by land use and drainage. CH4 fluxes were highest in the flooded burnt sites, followed by the flooded forest sites, the drained burnt site, and the drained forest site (5.75±6.66, 1.37±2.03, 0.220±0.143, and 0.0084±0.0321 (mean±SD) mgC m?2 h?1, respectively). Dissolved CH4 concentrations were highest in the flooded burnt sites, followed by the drained burnt site, the flooded forest sites, and the drained forest site (124±84, 45.2±29.8, 1.15±1.38, and 0.860±0.819 μmol L?1, respectively). DO concentrations were influenced by land use only, which were significantly higher in the forest sites relative to the burnt sites (6.9±5.6 and 4.0±2.9 μmol L?1, respectively). These results suggested that CH4 produced in the peat might be oxidized by plant-mediated oxygen supply in the forest sites.
2) CO2 fluxes were significantly higher in the drained forest site (340±250 mgC m?2 h?1; water table level ?20 to ?60 cm) compared to the drained burnt site (108±115 mgC m?2 h?1; water table level ?15 to +10 cm). Dissolved CO2 concentration in the

drained forest site was also highest (0.6 to 3.5 mmol L?1). These results suggested the enhanced CO2 emission by aerobic peat decomposition and plant respiration in the drained forest site.

3) N2O fluxes ranged from ?2.4 to ?8.7 μgN m?2 h?1 in the flooded sites and from 3.4 to 8.1 μgN m?2 h?1 in the drained sites. The negative N2O fluxes might be caused by N2O consumption by denitrification under flooded conditions. Dissolved N2O concentrations were 0.005 to 0.22 μmol L?1 but occurred at <0.01 μmol L?1 in most cases.

4) GWPs in the flooded burnt sites, which were 20% higher than those in the flooded forest sites, although there was no significant difference. CO2 fluxes in both sites were almost equivalent, and high CH4 emissions in the flooded burnt sites actually increased GWPs at these sites. GWP was mainly determined by CO2 flux. Consequently, GWP and CO2 flux in the drained forest site were the highest for all study sites, and N2O flux made little contribution to GWP.

Conclusion

Our first hypothesis was supported given that 1) CH4 emissions in the flooded burnt sites were significantly larger than those in the flooded forest sites, 2) dissolved CH4 concentrations in the burnt sites were much higher than those in the forest sites, and 3) DO concentrations in the forest sites were significantly higher than those in the burnt sites. Given the high dissolved CH4 concentrations observed in the deeper layers, CH4 emissions in the drained burnt site will likely rapidly increase when this area is flooded again. Our second hypothesis was weakly supported by the observed GWPs in the flooded burnt sites, which were 20% higher than those in the flooded forest sites although there was no significant difference.

Keywords：*Dissolved oxygen (DO), greenhouse gas (GHG), Indonesia, tropical peatland, and water table level.*

P1-400

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

The N2O Emission from Agriculture Soil as Affected by Bulk Density and Soil Water Content

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[Objective] Many studies state non-tillage caused higher N2O emission, but which factors, changed by tillage, control N2O emission was not so clear and need deeper study. So soil core incubation under aerobic environment was conducted to study the combined effect of bulk density (BD), soil water content (WC), and nutrient management (NM) on N2O fluxes from agriculture soil.

[Method] Soil was collected from fertilizer (F) and manure+fertilizer (MF) plots of Shin-Hidaka in Hokkaido, Japan. Sieved soil of 0-2mm was packed into plastic rings, adjusted BD (0.45g/cm3, 0.66g/cm3) and WC (0.45g/g, 0.35g/g) manually to achieve a range of water filled pore space (WFPS) from 29% to 83%. Then put rings into Mason jars, which were filled with compressed air and air + 10%C2H2 (v/v) in headspace and sealed tightly. Incubation was conducted at 15℃ for 10 days. Gas samples were taken from headspace of jars at 1, 2, 3, 4, 6, 8, 10days respectively for N2O, NO and CO2 concentrations analysis. After each gas sampling, replacing the headspace air again. Soil chemical properties were analyzed just after water adjustment and after incubation. Denitrifying enzyme activity (DEA) was measured after incubation and was calculated as N2O in headspace between 2 and 4 h under N2 atmosphere. Net ammonification and net nitrification (mg N/kg dwt) are estimated as the difference of NH4+ or NO3- before and after incubation respectively. Net mineralization is estimated as the sum of net ammonification and net nitrification. Microbial biomass nitrogen (MBN) was measured by chloroform fumigation-extraction method before and after incubation.

[Result and Discussion]

C2H2 had no significant effect on net mineralization or MBN. However there were differences in net ammonification and nitrification rates between air and C2H2 treatments because nitrification was inhibited by C2H2. Net ammonification of C2H2 treatment was significantly greater than that of air treatment. On the other hand, net nitrification of C2H2 treatment was smaller than that of air treatment, and ranged from -0.1 to -18 mg/kg/10 days. Net ammonification of C2H2 treatment was greater in MF plots than in F plot, and not affected by BD or WC.

Cumulative CO2 emission of C2H2 treatment (165 ? 259 mgC/kg) was significantly higher than air treatment (121 ? 162 mgC/kg) ($p<0.001$). CO2 emission tended to be higher in MF plots than in F plot, but there was no clear effect of BD and WC.

There was no significant difference in cumulative N2O emission between air and C2H2 treatments. However, NM ($p<0.001$), WC ($p<0.001$) and BD ($p<0.001$) had significant effect on cumulative N2O emission of both air treatment and C2H2 treatment. Most of time cumulative N2O emission of MF soil was higher than F soil with same WC and BD ($p<0.001$), because NO3- ($p<0.001$) and MBN ($p<0.001$) of MF soil were larger than F soil before incubation, providing enough reactants for dentrification and nitrification. High WC and high BD promoted N2O emission, and cumulative N2O emission of 45%-WC with high BD was extremely high compared to the other treatment. Based on the results of the N2O-N/NO-N ratio, N2O production of 45%-WC with high BD treatments was mainly caused by denitirification, while N2O was produced mainly by nitrification in the other treatments (45%-

WC with low BD, 35%-WC with high BD, and 35%-WC with low BD). There was negative correlation between cumulative N2O production and net nitrification for each headspace gas treatment, which will also indicate the NO3-N reduction by denitrification resulted in high N2O production. WFPS of 45%-WC with high BD treatment with greater DEA was around 80% which provide appropriate environment for denitrification. N2O emission of 45%-WC with high BD under C2H2 treatment was higher than air treatment. N2O emission/[N2O + N2 emission] of 45%-WC with high BD were estimated as 0.4 in F plot and 0.8 in MF plot, and this might be attributed to the inhibition of N2O reductase by high NO3? in MF plot.

[Conclusion] CO2 emission tended to be higher in MF plot than in F plot, but there was no clear effect of BD and WC. On the other hand, N2O emission was controlled by WC and BD. High WC and high BD promoted N2O emission because of the contribution of denitrification. Most of time, cumulative N2O emission of MF plot was higher than F plot with more NO3- and MBN.

Keywords：*nitrogen dioxide(N2O), bulk density, soil water content*

P1-401

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Interaction between Nitrogen and Phosphorus Additions on CH4 Production and Denitrification Processes in Different Wetland Sediments

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Denitrifying bacteria can outcompete methanogenic archaea for substrate and produce toxic intermediates to methanogens. Phosphorus (P) addition can enhance microbial activity such as denitrification in wetland soils, which might strongly inhibit CH4 production in the areas with nitrogen (N) enrichment. However, little is known about the effects of N and P additions on carbon (C) and N cycles and interaction between methanogens and denitrifiers in wetland ecosystems. In order to verify the interaction between N and P additions in relation to CH4 dynamics and denitrification, different nutrients (N, P, N+P) added to sediment obtained from nutrient rich and poor agricultural ditches. The additions were as follows; N (NH4NO3, final concentration in solution, 1mM as N), P (KH2PO4, 0.1mM as P), and N+P (both NH4NO3, 1mM as N and KH2PO4, 0.1mM as P). We measured CH4 production potentials, denitrification rates, abundances and diversities of methanogens and denitrifiers during incubation. N addition significantly inhibited CH4 production, but single P addition enhanced CH4 production in the two different sediments. Interestingly, N+P applications suppressed the production of CH4 more than a single N application. These results indicated that P addition stimulates denitrification rates and increase the abundance of denitrifying bacteria in N added sediment, which leads to increased substrate competition, repressing the activity of methanogens. The latter was verified by acetate addition, which eliminated the N+P effects on methanogenesis. Conclusively, P might play an important modulating role in the effects of N-availability and subsequent denitrification on methane production in wetland ecosystems.

Keywords：*denitrification, methanogenesis, ntrogen , phosphorus, substrate competition, wetland*

P1-402

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Nitrous Oxide Production in Japanese Flooded Paddy Soil as Affected by Different Ph

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Denitrification is a microbial reaction that transforms nitrate (NO_3^--N) into gaseous forms of nitrogen (NO, N_2O and N_2). If this process is incomplete, N_2O, which is a intermediate product, is emitted from soil. Nitrous oxide has attracted great attention as a greenhouse gas and contributes to the stratospheric ozone depletion. Denitrification can be controlled by a number of environmental factors. Soil pH is known as a master variable on this process in unsaturated soil but the effect of pH on denitrification in flooded soil is still uncertain. Flooded paddy fields were considered to be less emission sources of N_2O because N_2O was further reduced to N_2 under the anaerobic condition. Our hypothesis was that low pH reduced the microbial reaction from N_2O to N_2 in flooded soil. The objective of this study was to investigate how different pH affected N_2O production in flooded paddy soil.

Two grams of air-dried soil, which was collected from a paddy in Ushimado town of Okayama Prefecture, Japan, were loaded into a 100 mL glass bottle with 25 mL of 10 mg L^{-1} NO_3^--N solution. Solution pH was adjusted at 5, 7, or 8 with buffering chemicals (pH 5: 0.05 *M* $C_8H_5KO_4$+0.023 *M* NaOH, pH 7: 0.05 *M* KH_2PO_4+0.029 *M* NaOH, pH 8: 0.05 *M* KH_2PO_4+0.047 *M* NaOH). A group of bottles without adding buffer chemicals was additionally used to evaluate the effect of electrical conductivity (EC) on denitrification. The bottles were capped with butyl septums and incubated at 25^oC for 7 days with or without the presence of acetylene (C_2H_2). All treatments were in three replicates. The production of N_2O+ N_2 was estimated by the C_2H_2 inhibition method. The amount of NO_3^--N removal was obtained from the difference between NO_3^--N concentration on days 0 and 7.

There was a significant effect of different pH on cumulative N_2O production and NO_3^--N removal for 7 day incubation ($P < 0.01$). The highest N_2O production (7.0 mg N kg-soil^{-1}) was recorded in the low pH treatment (pH 5), while N_2O+ N_2 production and NO_3^--N removal decreased with decreasing pH. Accordingly, the production ratio of N_2O/(N_2O+ N_2) increased at lower pH. In our experiment, low pH may have reduced the density of denitrifying bacteria and denitrification. The activity of N_2O reductase, which is the enzyme responsible for the conversion of N_2O to N_2, was probably restrained because the N_2O reductase was more sensitive to low pH than other enzymes involved in denitrification. Additionally, the production of N_2O+ N_2 (54.8 mg N kg-soil^{-1}) in the treatment without buffering chemicals (EC 0.28 dS m^{-1}) was higher than in those with buffering chemicals (EC values were 6.0, 6.2, and 7.4 dS m^{-1} for pH 5, 7 and 8, respectively). The EC values with buffering chemicals would be higher than the favor EC value for microorganism activities for denitrification. In conclusion, N_2O production increased in Japanese flooded paddy soil at low pH.

Keywords：*Buffer chemicals, denitrification, nitrous oxide, nitrate removal, flooded paddy soil*

P1-403

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Modelling Nitrous Oxide Emissions from a Bare Soil Against Measurements From Static Chambers and Micrometeorological Eddy Covariance Technique

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Static chambers and micrometeorological eddy covariance (EC) technique are the two most widely used methods to measure nitrous oxide (N2O) emission from soils. Recent studies have indicated that chamber measurements tend to underestimate N2O emission. However, most models that simulate N2O emission are often calibrated against chamber measurements, which may lead to underestimation of N2O emission when the models are used as predictive tools. In this study, N2O emissions from a bare soil were measured using both static chambers and micrometeorological eddy covariance technique during a two months period (April–June) at CSIRO's Ginninderra Agricultural Experimental Station, Canberra, Australia. In addition, soil temperature, moisture and soil mineral nitrogen contents (NH4 and NO3) in the soil profile were monitored frequently. The Agricultural Production Systems model APSIM was validated against the collected data for simulation of soil water and nitrogen dynamics as well as N2O emission from the soil. The results show that APSIM was able to simulate the dynamics of soil water and mineral nitrogen (NH4 and NO3) contents. Using the default parameters in the decomposition and denitrification sub-modules, the N2O emission predicted by APSIM was close to the measurements from the chambers, but significantly lower than the measurements obtained using the EC method. After re-calibrating the model against the EC measurements, the simulated total N2O emission for the 2-month experimental period was higher than those predicted with the original model. This highlights a need for model re-calibration against solid experimental data in order to increase the predictive certainty of N2O emissions from agricultural soil.

Keywords：*N2O emission, APSIM, Eddy Covariance, Static chamber*

P1-404

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Measurement, Modelling and Mitigation of N2O Emissions

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Nitrous oxide (N2O) is primarily produced by the microbially-mediated nitrification and denitrification processes in soils. It is influenced by a suite of climate and soil variables, interacting soil and plant nitrogen (N) transformations as well as land management practices. N2O emission is very dynamic, with strong diurnal variations. A long term continuous measurement is required not only for the more accurate quantification of N2O emission factors but also for validating process based models to simulate N2O emissions.

Due to the large variability of N2O emissions, both spatially and temporally, spatially referenced process simulation models is also a useful tool to derive a long term and regional N2O emissions as well as to identify management practices for mitigation.

We will present the long-term N2O emissions in the wheat, maize, sugarcane, pasture and green tea systems in China and Australia and application of Water and N Management Model (WNMM) to simulate the N2O emission in these systems. We will also report the effectiveness using nitrification inhibitors and controlled released nitrogen fertilizers in N2O emissions, impact of soil microbial properties on N2O emissions and effectiveness of nitrification inhibitors.

Keywords：*N2O, microbial properties, nitrification inhibitors, modenlling*

P1-405

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Modelling Nitrous Oxide Emissions from Pasture

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Nitrous oxide in the atmosphere is a significant greenhouse gas, and emission from soils is its main source. Nitrous oxide comes from natural ecosystems and also from anthropogenic sources due to land use change and agricultural management. A process based model for the emission of nitrous oxide needs to take into account both the soil chemistry and biochemistry and also the soil physics. The amount of water at a position in the soil determines the amount of gas flow, and this governs the availability of oxygen and also the rate of outflow of nitrous oxide. Central to our model of the emission of nitrous oxide is the program TOUGHREACT-N, which couples advective and diffusive transport of water using Richards equation, nutrients and gases with biological and chemical processes to simulate soil nitrogen cycling and losses. A number of scenarios with different soil types, amounts of available nitrogen and rainfall were modelled for comparison with field measurements of nitrous oxide above pastures.

Keywords：*nitrous oxide, soil water, TOUGHREACT, greenhouse gas,*

P1-406

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Impact of Warming and Reduced Precipitation in a Temperate-Boreal Ecotonal Forest in Northern Minnesota, EUA

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Since the start of the industrial era, human activities have been altering the Earth's energy balance and impacting climate due to increasing emissions of greenhouse gases (GHG). Along with carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) are the principal GHGs with increasing concentration in the atmosphere. The global warming potential of CH4 and N2O is 25 times and 298 times, respectively, higher than that of CO2. Major pathways of GHG production and consumption in terrestrial ecosystems are microbial processes. However, the response of functional microbial groups associated with production and consumption of GHG to future climate conditions and its consequences for GHG emissions (feedback responses) are not fully known. In order to improve future projections of GHG emissions and to further understand their different regulatory levels of control between the soil and the atmosphere, feedback responses of GHG emissions to climate change need to be investigated over different climate change treatments. In 2009 a free-air plant and soil warming experiment (B4WarmED) was initiated in two temperate-boreal ecotonal forest sites in northern Minnesota, USA. These sites were under closed and open canopy conditions and were either unwarmed or warmed by 3.4 °C above ambient and in the beginning of 2012 a reduced summer precipitation treatment (≈ 45% exclusion) was initiated. Methane, N2O and CO2 fluxes were measured during the 2013 growing season (May to October) under all combinations of temperature and rainfall treatments in open canopy conditions. Under closed canopy no rainfall treatment was considered. Preliminary analysis indicates that warming resulted in higher N2O emissions under both closed and open canopy conditions, and that CH4 consumption was correlated with soil moisture. Reduced precipitation under open canopy showed an increase in N2O emissions under ambient temperatures but not under warming where a decrease of N2O emissions was observed. Functional microbial groups known to mediate GHG production or consumption in soil are currently being analysed, and will illustrate the role of microbial communities in GHG feedback responses to warming. This work will improve the mechanistic understanding of trace gas feedback responses to global warming.

Keywords: *Greenhouse gas emissions, methane, nitrous oxide, climate change, warming*

P1-407

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Field and Laboratory Data Reveal Potential N_2O Emission Linking to Decomposed CO_2 and N Input

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Soil carbon sequestration in agricultural lands has been deemed a sustainable option to mitigate rising atmospheric CO2 levels through improved management practices such as organic matter applications. Long-term organic matter applications not only increase soil organic carbon but also change organic matter quality such as increasing labile carbon proportion. This may lead to changes in nitrogen mineralization and so as the emission of N2O. Therefore, while mitigation greenhouse gas (GHG) through increased sequestration of carbon in soils by organic matter applications, the trade-off with N2O emission is an issue to concern. However, N2O emission from soils is of small magnitude and highly variable in space and time, and is thus very difficult to estimate. This request the development of N2O model for easy estimating annual N2O emission under vary organic matter applications with satisfied accuracy. In contrast to N2O emission is controlled primarily by soil temperature and moisture. An empirical model using soil C/N ratio and decomposed CO2 to estimate annual or seasonal N2O emission from upland crop fields has been developed. In this study, we collected a range of dataset of N2O and CO2 emission from different organic matter applications with different soil types and land use categories. We use these field dataset to validation the existing empirical N2O model. In the same time, we used a laboratory incubation approach to measure CO2 and N2O emissions from two Andosols managed under conventional fertilizer (CF) and long-term straw compost (RSC) applications, to reveal the mechanism of linking CO2 to N2O emission.

Keywords：*N2O flux, Soil carbon sequestration, Organic matter management*

P1-408

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Greenhouse Gas Emissions from Organic Soils with Different Land Use and Drainage

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Greenhouse gas (GHG) exchange between the atmosphere and land on organic soils has a large influence on the global GHG inventory. In Norway, the primary human activity on histosols is drainage for agricultural use or forest production, which is a major source of emissions within the land use, land-use change and forestry (LULUCF) sector. A key GHG mitigation strategy for organic soils is therefore to change management in terms of drainage and land use. To identify the mitigation potential, national scale estimates of GHG emissions from organic soils are necessary. The Intergovernmental Panel on Climate Change (IPCC) have developed guidelines and methodologies to enable the reporting of national GHG inventories to the United Nations Framework Convention on Climate Change and under the Kyoto Protocol (KP). The IPCC recently released new reporting guidelines with the 2013 Wetlands Supplement (2013 WS) and the 2013 Kyoto Protocol Supplement that raise the requirements for the National Inventory Report (NIR). The reporting guidelines in these supplements are mandatory in the second commitment period under KP (2013-2020) and are to be implemented in the 2015 submission of the NIR. With the new reporting guidelines, the land stratification requirement for KP reporting is more complex. For each land-use category (forest, cropland, grassland, wetland, settlements and other land) and climate zone (boreal, temperate moist, temperate dry, and tropical) areas should be stratified into mineral or organic soil, and furthermore, into drained, rewetted, or other types of organic soils. Areas must be tracked over time starting with the baseline year (1990 for Norway). The overall objective of the study is to determine the baseline areas of organic soil in Norway according to the new IPCC reporting methodologies. Subsequently, we estimate the national GHG emissions and determine the mitigation potential for managing drainage and land use on organic soils.

According to the 2013 WS, emissions of CO_2 (including dissolved organic carbon), N_2O, and CH_4 from drained organic soils used for agriculture (cropland and grassland) and forest lands can be estimated using a Tier 1 method with default emission/removal factors. Drained croplands in the temperate and boreal climate emit 38 Mg CO_2-eqv ha^{-1}, mostly from CO_2 (30 Mg CO_2 ha^{-1}), and less from N_2O emission (6.1 Mg CO_2-eqv ha^{-1}) and CH_4 (1.8 Mg CO_2-eqv ha^{-1}). Deeply-drained grasslands emit 29 Mg CO_2-eqv ha^{-1} (temperate) and 26 Mg CO_2-eqv ha^{-1} (boreal). Drained forest soils emit 13 Mg CO_2-eqv ha^{-1} in the temperate climate zone and 6 Mg CO2-eqv ha^{-1} in the boreal climate zone. Estimates for rewetted and restored natural wetland ecosystems are 6 Mg CO_2-eqv ha^{-1} in temperate and 3 Mg CO_2-eqv ha^{-1} in boreal climates. Per unit of hectare, rewetting croplands in boreal climates has the largest mitigation effect. However, the actual potential depends on the size, location, land use, and drainage condition of the areas of organic soils.

We will present a novel method to evaluate and determine area estimates of organic soils based on available data resource such as the national forest inventory, national soil classification, national geological maps, and land cover maps. Data of high quality, i.e. soil sampling or profiling, do not have national coverage, thus it is necessary to base soil type classification (mineral or organic) and drainage condition (deep or shallow drained, rewetted or neither) on indicators existing in complete land cover maps. With the area estimates we calculate CO_2, N_2O, and CH_4 emissions and removals for Norway, and identify the mitigation potential of land use and drainage management on organic soils

Keywords: *GHG national inventory reporting, organic soil, forests, croplands, grasslands, drainage and rewetting*

P1-409

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Calibration of Rothc is Required for Accurate Prediction of CO2 Emission from Sodic Soils

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Sodic soils are characterized by high percentage of sodium (Na) on the exchange sites of the soil particles (determined from exchangeable sodium percentage (ESP) >15) and low concentrations of salts in the soil solution (electrical conductivity of saturated extract (ECe) >4.0 dS m-1. High ESP leads to dispersion of clay particles, slaking and poor soil structure as well as surface crusting and hard setting. This can affect water and air movement, root penetration and organic matter decomposition. We used cation ratio of soil structural stability (CROSS) instead of ESP for studying the impact of sodicity on C mineralization because it has been shown that dispersion and flocculation of clay particles is not only influenced by Na+ but also by K+. Exchangeable sodium percentage is calculated from the Na+, Ca2+ and Mg2+ concentration on the exchange sites, whereas CROSS takes into account Na+, K+, Ca2+ and Mg2+ for assessing soil structural stability. Carbon models such as Rothamsted Carbon (RothC) that are used to estimate global CO2 emission do not consider the effect of sodicity on CO2 emission. Given the large extent of sodic soils (434 million ha world-wide), this may lead to under- or overestimation of CO2 release. A laboratory incubation experiment was conducted to (i) assess the effect of sodicity on CO2 release, (ii) calculate a rate modifier for sodicity in RothC, and (iii) study labile C dynamics. The soils were left unamended or amended with mature wheat residues (2% w/w) and CO2 emission was measured over 2 months from five soils with different CROSS (8, 11, 15, 18 and 41). Cumulative CO2-C g-1 SOC was significantly higher in the residue-amended soils than the unamended soils. At similar clay content, cumulative CO2-C g-1 SOC was significantly higher in soils with high CROSS (>8). Soils with high CROSS had higher labile organic C contents. Labile organic C decreased significantly over time because of the loss of C as CO2 as shown by a significant negative correlation ($p<0.05$) between cumulative CO2-C and labile C. Modelling of cumulative respiration data using a two compartment model showed that the decomposition of labile C pool is more sensitive to sodicity than that of the slow C pool. There was a significant positive linear relationship between CROSS and the decomposition rate modifier, suggesting that a new decomposition rate modifier should be incorporated into RothC in order to accurately model CO2 emissions from sodic soils.

Keywords：*Carbon, Respiration, RothC, Sodicity*

P1-410

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

The Role of Endophytic Methanotrophs on Diminution of Methane Emission from Peat Soils

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Methane emission from wetlands (145 Tg CH4 annually) is responsible for about 24% of the total CH4 emissions from known sources on the earth. The value of emission is a result of the balance between the processes of its formation (methanogenesis) and sink (methanotrophy). The recognition of methanotrophic activity from well aerated soil surface layers was done rather well. On the contrary, an active role of plants in reduction of methane emission is rather not completely known. Association of methanotrophic bacteria with plants as endosymbionts and epibionts, that live both inside and outside the cells of Sphagnum sp., has been already recognized by Raghoebarsing and coworkers. In our investigation particular attention was paid to the marshland vascular plants from Moszne peatlands, dominated by: Sphagnum sp., Eriophorum vaginatum, Carex nigra and Vaccinium uliginosum .The research was conducted in Moszne tran¯sitional moor (Sphagno-Caricetum rostratae), lo¯cated in the north-western part of the Poleski Na¯tional Park (PPN) (51° 23' N, 23° 63' E) situated in the Polish part of Polesie, a part of the West Polesie Biosphere Reserve, protected under the Ramsar convention as an important wetland site with distinguish values of nature. The composition of plant cover was presented in 10-point Braun-Blanquet scale. The gases emitted from the surface of Moszne peatland were col¯lected using the chamber method from se¯lected points in growing seasons (spring, summer, autumn) through three years. The gas samples were collected after 0 (control), 30 min and 60 min taken through the rubber septa placed at the top of the chamber using a gas tight syringe and transferred to the vented vials (20 ml and analysed by gas chromatograph (SIMADZU, GC 2010) equipped with a flame ionization detector (FID), after CH4 calibration. To estimate the contribution of plants in methane emissions form the peatland, in each investigated point gas sampling were conducted from the surface with the cover by native flora and after its removal. It was found that in the points dominated by Vaccinium sp. and Carex sp. the plant cover positively affected methane flux to the atmosphere and its emission was higher by 26% and 2%, for Vaccinum sp. and Carex sp. respectively, compared to places where vegetation has been removed.

The opposite trend was observed in points with Eriophorum sp. and Sphagnum sp. dominance, where the methane emissions were lowered by 25% and 10% respectively, in comparison to emission from peat soil without plants. Our results show that reduction in CH4 emission was related to plant composition, vegetation period and conditions of the plants. On the basis of genomic analyses of the total genomic DNA originated from endosymbions,living inside of root and leaves cells of the tested plants it was confirmed that the endosymbionts under investigation belong to type I and II methanotrophs, genus of Methylobacter and Methylomonas sps.

Keywords：*methane, peat soil, endophytic methanotrophs*

P1-411

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Modeling of Carbon Dioxide Emission from Cornfield Soils under Different Water Table and Tillage Management in Central Ohio, USA

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To understand the process of carbon sequestration and gaseous emission in soils, process-based modeling is needed to assess soil respiration using air temperature (AT) and precipitation (P) data. The model was validated by field measurements of CO2 emission on a long term water table management experiment in central Ohio, USA. Two models were developed to predict soil temperature (ST), volumetric water content (VWC) and CO2 emission under different tillage and tile-drainage management using AT and P data for 2011 to 2012. Higher CO2 emission under no-till than conventional tillage in no-drainage fields may be attributed to the higher VWC and temperature dependency. In contrast, plow tillage enhanced soil respiration under tile-drainage fields due to its higher water dependency.

Keywords：*no-till, tile-drainage, mineralization, Alfisols*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Effect of Different Fertilizer Types on Grain Yield and Greenhouse Gas Emissions from Paddy Field

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A field experiment was performed to investigate the effect of chemical fertilizer (CF), chemical fertilizer + wheat straw (CF-WS), slow-release chemical fertilizer + wheat straw (SCF-WS), and chemical fertilizer + biochar from wheat straw (CF-BC) at total nitrogen rates of 225 kg-N ha−1 on rice yield and greenhouse gas emissions from a paddy field during two yield in Yangtze River Delta, China. The application rate of wheat straw was 3 ton ha-1 while that of biochar produced from wheat straw was 1 ton ha-1. The plots without any fertilizer (Non-F) were also conducted as control. There are 15 plots and the area of each plot was 60 square meter (10 m×6 m). The rice variety (Oryza sativa L., cv. Huayou14) was cultivated in all treatments under a conventional water regime with once summer middle drainage. The emissions of greenhouse gas were monitored at 9:00-10:00 with a static chamber method once a week throughout the whole rice growing season from June to October in 2012 and 2013, respectively.

There was no significant difference among the grain yields of CF, CF-WS, and CF-BC both in 2012 (ca. 8.9 ton ha-1) and 2013 (ca. 9.3 ton ha-1), which had approximately twice yield than that of Non-F. The yields of all treatments in 2013 were higher than that in 2012, which probably due to higher air temperature in 2013. However, the yield of SCF-WS plots showed significant higher yields than other treatments in these two years (10.5±0.2 ton ha-1 in 2012, 10.7±0.2 ton ha-1 in 2013), which increased by 17.8% and 13.4% compared to that of CF treatment. The increased yield of SCF-WS was probably due to enhanced nitrogen utilization efficiency by slow released nitrogen in soil and higher chlorophyll concentration (SPAD value) in leaves through the whole growing season even after heading period.

Compared to the CF plots, the total CH4 emission of CF-WS during the whole rice growing season were increased by 145% and 164%, while that of SCF-WS were increased by 30% and 158% in 2012 and 2013, respectively. It is suggested that organic matter applied with fertilizer would enhance CH4 emission. However, although the CH4 emission of CF-BC was higher than that of CF in 2012, but decreased and was lower than that of CF in 2013. On the other hand, the total N2O emissions of SCF-WS were higher than other treatments both in 2012 and 2013, which probably due to the slow released nitrogen in soil and provide substrate of nitrification and denitrification reaction through the whole growing seasons.

The global warming potential (GWP = total emission of CH4×25 + total emission of N2O×298) of the CF plots was 2130 kg CO2eq ha−1 and 3047 kg CO2eq ha−1 in 2012 and 2013, respectively. The GWP of the treatment plots with organic matter amendment increased and ranged from 3023 to 5289 kg CO2eq ha−1 in 2012 and from 3215 to 8456 kg CO2eq ha−1 in 2013, respectively. The lowest total GWP was observed in the SCF-WS plots in 2012 compared to other organic matter amended plots, suggested that slow-release fertilizer application would mitigate CH4 emission as well as increase yield. On the other hand, the method that transfer wheat straw into biochar before applied into paddy field also decreased the total GWP compared to wheat straw application directly.

Keywords：*Chemical fertilizer, wheat straw, slow-release fertilizer, greenhouse gas emission.*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Responses of Grain Yield and Greenhouse Gases Emission to Different Rice Varieties and Irrigation Managements in a Rice Paddy Field

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The scarcity in available water resources for rice production process made it urgently in the evaluation of rice grain yield and greenhouse gases (GHG) emission response to drought caused by water scarcity from paddy fields. Two rice varieties (Oryza sativa L. cv. Hanyou 8 and Huayou 14) and three irrigation managements (normal irrigation amount (NA), 70% of NA (NA70%), and 30% of NA (NA30%)) were applied to study their effects on the rice grain yield and GHG emission. Hanyou 8 is a rice variety characterized by saving water and drought resistance. A static transparent chamber sampling and a gas chromatography analyzing for GHG were used weekly in 2012 and 2013 rice growing seasons.

The grain yield had no response to rice varieties during both growing seasons. Irrigation managements did not affect the grain yields in two rice varieties in 2012 growing season. However, during 2013 rice growing season, a clear decrease in grain yield of Huayou 14 was found when reducing irrigation amount. NA30% treatment significantly decreased rice grain yield by 10.1% when compared with NA treatment in Huayou 14, whereas no significant differences in rice grain yield were detected among irrigation managements in Hanyou 8.

The seasonal cumulative CH4 in Hanyou 8 was respectively emitted approximately twice than that in Huayou 14 both in 2012 and 2013 growing seasons. Reducing irrigation amount potentially mitigated the CH4 emission. In comparison with NA treatment, NA30% treatment respectively reduced CH4 emission by 56.2-76.9% and 51.9-60.3% for Hanyou 8 and Huayou 14. Similarly, CH4 emission was decreased by 31.4-39.3% in NA70% treatment for Huayou 14. For Hanyou 8, NA70% treatment increased CH4 emission by 5.9% in 2012 but strongly decreased it by 53.3% in 2013 rice growing season.

When averaged across the irrigation managements, the seasonal cumulative N2O emission was similar between Hanyou 8 and Huayou 14 in 2012 rice growing season. However, Huayou 14 emitted 3.6 times in N2O emission more than Hanyou 8 in 2013 rice growing season. Reducing irrigation amount had a great potential to increase N2O emission, and NA70% treatment always showed the largest N2O emission.

The results indicate that Hanyou 8 is more drought-resistant than Huayou 14 in term of the grain yield. However, Hanyou 8 emitted more GHG, especially more CH4 than Huayou 14. The reduction in irrigation amount strongly decreased CH4 emission, but potentially increased N2O emission. The rice selection for Hanyou 8 in maintaining rice grain yield and decreasing GHG emission in foreseeable relative drought growing seasons may be a promising way.

Keywords：*rice varieties, irrigation management, greenhouse gases, rice paddy field*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Fluxes of CH4 and N2O from Peatland Planted to Acacia Crassicarpa at Bukit Batu, RIAU

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Use of peatlands for development activities has been considered as an important source of carbon emissions, hence, conversion of peatland forests to commercial plantation forests such as Acacia crassicarpa planted forest is intensively assessed. Emission of green house gases (GHG) is also attributed to the release of CH4 and N2O to the atmosphere, including the potential release from cultivated peatland, therefore measurement of fluxes of these two gases from different landuses is recently intensively carried out in addition to flux measurement of CO2. However, the measurement for forest plantation on peatland is still rare.

A continuous measurement at deep peat area planted with A. crassicarpa has been conducted for one year at Bukit Batu, Riau Province, at 1-weekly to 2-weekly interval. Research area was directly converted from pristine peatland forest since 6-9 years ago. Five measurement plots within the plantation area having different condition were selected.

The results show that fluxes of these two gases recorded by closed chamber method were low. The fluxes of CH4 were much lower than those of data obtained from measurement of water logged mineral land. This fact shows that although the peatland is water logged but it would not necessarily reach a reductive condition that makes CH4 formation occurs. The highest flux of CH4 in natural peat forest that is more water logged was 13.0 mg C-CH4/m2/day, whereas those for A. crassicarpa planted peatland ranged between 9.6-13.2 mg C-CH4/m2/day. In addition there was no observed consistence effect of water table. Theoretically, N2O gas is produced anaerobically as result of incomplete process of change of ammonium into nitrate. However, the results indicate that this condition was not achieved for peatland at both natural and cultivated conditions. Data of N2O fluxes obtained from plots with and without litter and roots indicates that the decomposition process that resulted in N2O, generally occurred in the litter, not in the peat layer.

Keywords：*Acacia crassicarpa, CH4 and N2O gases, peatland, peat decomposition*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Effects of Crop Type on Nitrous Oxide Emissions from Vertic Haplustolls

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Concern has been raised as to the potential risk of nitrous oxide (N_2O) emissions from agricultural fields as compared to the benefits of the sink of carbon dioxide. Thus the development of mitigation strategies for N_2O emissions is crucial to deal with future climate change. However the precision of the estimated N_2O emissions are often disregarded even though the default value of IPCC emission factor contains a large variation of uncertainty due to the differences in climate and cultivation. In particular, few studies have investigated the effect of crop type and fertiliser source on N_2O emissions from tropical to sub-tropical soils under a side-by-side setting. Therefore this study aims to investigate the effects of crop type and fertiliser nitrogen (N) source using a common agricultural soil in south-eastern Queensland, Australia. The experiment was designed with a two-factor, complete factorial design with three replicates using repacked columns in a glasshouse. Each treatment consists of the combination of the following two factors; (1) crop type: corn (*Zea mays*), sweet potato (*Ipomoea batatas*), and no crops (NC); and (2) fertiliser type: urea (150 kgN ha^{-1}), sodium nitrate (150 kgN ha^{-1}), and no fertiliser (NF) addition. The N_2O emissions from soil were measured during the initial growth stage (34 d) using static chamber methods with 4-5 d intervals. Plant biomass, leaf area, and N uptake were measured at the end of incubation to investigate the relationships with the cumulative N_2O emissions. Soil solutions were also collected using micro suction cups immediately after the gas measurement to measure the concentration of ammonium-N, nitrite-N, and nitrate-N.

The fluxes of N_2O started to increase 8 d after fertiliser application, and peaked at 15 d after fertiliser application. Corn-urea treatment provided the largest cumulative N_2O emissions during the initial stage followed by corn-nitrate, NC-urea, NC-nitrate, sweet potato-urea, corn-NF, NC-NF, sweet potato-nitrate, and sweet potato-NF. Two-way ANOVA indicated that both the crop type and fertiliser type significantly influenced the cumulative N_2O emissions but there was no significant interaction between the two factors. Urea application increased the cumulative N_2O emissions by 22 to 38% regardless of the crop type compared to the NF treatment. Nitrate application also increased the cumulative N_2O emissions by 23-27% compared to the NF treatment, except the emissions in sweet potato. Corn had no effect on the cumulative N_2O emissions compared to the emissions from NC regardless of the fertiliser treatment; however sweet potato reduced the N_2O emission up to 30 % compared to the NC treatment. The source of N in fertiliser influenced the emission factors in sweet potato and NC. The ammonium-N, nitrite-N and nitrate-N in soil solution showed the peak concentration in 1 d, 8 d and 15 d after the fertiliser application, respectively. The plant biomass and leaf area were significantly correlated with the cumulative N_2O emissions. The results of this study indicate sweet potato has aggressive N acquisition to reduce excess N in soil, or release some kind of root exudate to reduce N transformation in soil compared to corn. The results of this study also suggest that the choice of crop type could mitigate the N_2O emissions from the agricultural soil in subtropical regions. Therefore, it is critical to establish a better understanding of crop effects on emission factors in tropical to subtropical regions to reduce uncertainty in the estimate of global warming potentials.

Keywords：*nitrous oxide, N sources, crop types, subtropical soils*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Evaluation of Climate Change Adaptation Options for Agricultural Systems

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Agricultural responses to climate change suggest an increased vulnerability of crop yields to elevated temperature, decreased water availability, and increased nutrient stresses. The EPIC (Environmental Policy Integrated Climate) model was used to evaluate the potential effects of climate change adaptations on crop yields, carbon respiration, soil carbon dynamics, and nitrate losses in runoff and leaching from representative farms in Alabama, Arkansas, Missouri, Mississippi, Florida, Kentucky, Louisiana, Texas, Georgia, and Tennessee. Adaptations included annual biochar applications, irrigation, and combined biochar and irrigation applications. Baseline (1979 ? 2009) and future (2038 ? 2068) scenarios were used for simulations with baseline and future CO2 concentrations of 360 ppmv and 500 ppmv, respectively. Climatic data for baseline scenarios used NOAA's North American Regional Reanalysis (NARR) database. Climatic data for the future scenarios used the North American Regional Climate Change Assessment Program (NARCCAP) database. Four regional climate models were used for the future simulations to project different patterns of changes in air temperatures, precipitation, and solar radiation that are expected to occur over time. Climate had significant effects on all response variables for at least 2 of the 4 regional climate models. Biochar treatments did not display significant increased yields that were different from the climate effects. Climate had a significant effect on nitrate leachate losses in comparison to the control for all the regional climate models. Although not significantly different from the other treatments, trends indicate that leachate nitrate losses were largest for the irrigation and climate treatments and lowest for the biochar treatment. The trends in the data suggest that biochar was not effective in reducing nitrate loss in runoff. Soil organic carbon dynamics displayed significantly higher accumulations of carbon for the biochar and combined irrigation and biochar treatments for all models. Under some weather scenarios, EPIC simulation results suggest that irrigation and biochar applications may be considered as promising potential adaptation strategies for agriculture in the Southeastern United States.

Keywords：*Climate change, biochar, irrigation, nitrate, adaptation*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Evaluating the Effectiveness of Different Greenhouse Gas Abatement Methods for Manure Application and Identifying the Sources and Microbial Processes Involved

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Land application of manures can increase soil carbon but could also increase greenhouse gas (GHG) emissions. This paper will describe a series of laboratory studies aimed at evaluating i) the effectiveness of different GHG abatement methods for manure application (ii) the reduced GHG potential from manure generated under improved manure storage systems and iii) the sources and microbial processes involved in GHG emissions in soils. A series of microcosms were established in sandy and clayey soils amended with different manure forms. An untreated control and conventional fertiliser treatment were included and all treatments done in triplicate. The effectiveness of four GHG mitigation manure application practices were assessed including immediate incorporation, timing of manure application, increasing the soil pH by liming and high C:N composts. Microcosms were sampled at days 0, 0.08, 0.25, 1, 2, 4, 7, 14, 21, 32, 64 and 128. Nitrous oxide, carbon dioxide and methane (N2O, CO2 and CH4) fluxes were measured by gas chromatography. The soil microbial pathways responsible for GHG emissions were identified using quantitative PCR and next generation sequencing approaches targeting ammonia-oxidizing archaea (AOA) and bacteria (AOB), denitrifiers, methanogens and methane oxidisers.

The results suggest the lowest emissions were found in soils receiving composted manure, sludge and stockpiled manure for 12 months. Molecular analysis showed that microbial communities in manure amended soils are a potential source of N2O and sink for CH4. They also showed that N2O emissions from manure amended soils were likely to be attributed to nitrifying bacteria due to increased availability of NH4+. Thus, approaches that decrease nitrified-N emitted as N2O (increasing pH), or decrease the availability of mineralised N to nitrifiers (addition of inert C or available C), or decrease nitrification activity (immediate incorporation) were investigated. High C:N composts reduced N2O emissions but led to higher methane emissions particularly in clayey soils. The benefits of immediate incorporation were dependent upon both the manure and soil type. Liming and/or applying alkaline manure at a low application rate (5t/ha) may stimulate methane oxidising bacteria (methane uptake). Compost or pelletised compost is the best management option for mitigating N2O and CH4 emissions from soil where N2O emissions are thought to be due to nitrification.

Microbial communities are linked to GHG flux, fertiliser use, manure type and storage and soil type. This information can be used to develop cost-effective mitigation strategies that decrease national livestock emissions with minimal impact on productivity and profitability.

Keywords：*manure applications, methane and nitrous oxide emissions, nitrification, methane oxidation*

P1-418

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Continous Monitoring of CO2 Emission and Geochemistry of Soils from Merapi Volcano, Java Island, Indonesia Tropical Archipelago: The 2010-2011 Eruption and Land Use Planning Application

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CO2 emitted by the soils may have different resources. A biogenic CO2 is the emission by the soils resulted from organic matter decomposition, flora and fauna respiration. In the contrary, a non biogenic CO2 soil emission is causing by the degassing of the terrestrial mantle and magma bodies influenced by volcano activity. Merapi mountain (2930 m) in Indonesia is known as one of the most active volcano. This volcano has sporadic explosive pyroclastic events and long periods of dome growths. This paper aims to analyze the CO2 emission and geochemical characterization of volcanic soils of Merapi. Measurement and monitoring of CO2 and chemical properties of volcanic soils will have significant contributions for proper land use planning and public health risks mitigation.

Soil CO2 emission and geochemistry have been investigated at Merapi volcano (Indonesia) during two inter-eruptive periods (2010 and 2011). More than approximately five hundred measurements on soil CO2 flux were conducted by using accumulation chamber methods to generate CO2 degassing maps that inform the spatial distribution of soil gas. The concentrations of major and trace elements from soil samples were analyzed using X Ray Fluorescence Analysis and followed by mineralogical studies by using Scanning Electro Microscopy techniques.

At Merapi volcano soil CO2 flux concentrations were highly variably and ranged from 1 to 5175 g/m2 per day. Based on the calculation using sequential Gaussian distribution, a mean volcanic soil CO2 emission released from Merapi Volcano through the soil is estimated to be 240-270 t per day. From this total CO2 emitted, this is 65% of the total CO2 flux through soil. Measurement on soil temperature has recorded a range started from 11 to 67 °C. Calculation based on CO2:H20 molar ratio indicates the thermal energy release with respect to diffuse degassing is 27.5 MW. Carbon isotopic composition values of soil CO2 that vary from -10 ‰ to 4 ‰ confirm the occurrence of multiple CO2 sources feeding soil degassing originated from both volcanic and biogenic sources. The average concentration for S, Fe, Mn, Pb and Cd are 214 ppm, 21 ppm, 3 ppm, 0.24 and 0.015 ppm respectively. The samples confirm that SiO2 and Al2O3 are abundant in volcanic soils with the concentration of 71% and 20%. CaO and Na2O3 are next in abundance with the concentration of 9% and 5% respectively. The concentration of MgO, K2O, Fe2O3, and SO3 are less than 5%. The distances of the sample sites to the volcano do not affect the element concentrations. X-ray diffraction analysis on the volcanic soils confirms the presence of albite as the most dominant materials.

Recently, there are three farming villages that located near the volcano. At the locations, majority of housing are built over soils that emit significant amount of CO2 actively, therefore the accumulations of CO2 inside the house have potential harm to the human populations. Eventhough the soils have CO2 manifestation, it was observed that the soils have low heavy metal concentrations with high K and P and pH ranges from 6.4 to 6.9. This indicates that the volcanic soils are not considered harmful and have moderate risk to soil-plant ecosystems, thus it is safe for the agricultural purposes. Likewise, the P and Ca concentrations will benefit the soil fertility. Concurrent measurement of vital and comprehensive volcanic soil properties may provide useful tool for sustainable land use planning.

Keywords：*flux, geochemistry, soil, volcano*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Controlling Factors for Temporal Dynamics of CO2, N2O and Ch4 under Three Adjacent Land-Use Types

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Greenhouse gases (GHG: carbon dioxide, CO2; nitrous oxide, N2O and methane, CH4) are one of the dominating forces for global warming (IPCC 2007). Changing of land-use types can have significant and long lasting effects on soil pH, carbon (C) and nitrogen (N) contents and soil microbial activities (Post and Mann 1990; Murty et al. 2002), and consequently can have a significant impact on GHG emission from the soil (Iqbal et al. 2008). Numerous studies have shown that land-use type is a critical controlling factor for GHG fluxes (Lin et al. 2010; Lang et al. 2011). Generally, forest soils have a large amount of annual soil organic matter (SOM) input. Grassland soils, affected by weeding or grazing, have a small amount of SOM. Orchard soils under long-term fertilization have a large amount of soil nutrients. Comparisons based on observations from adjacent ecosystems with different land management under the same climate and soil conditions can provide a more robust understanding of the specific effects of land-use types on GHG flux. Long-term measurements of GHG flux are needed to explore the characteristics of soil GHG flux and their dependence on the corresponding controlling factors over long time scales. In the present study, two years of GHG flux measurements are reported for three adjacent fields of apple orchard (A), grassland (G), and forest (F) in central Japan. The main aims of this study are to (1) quantify the seasonal variations in CO2, N2O and CH4 fluxes and to (2) quantitatively investigate the responses of CO2, N2O and CH4 fluxes to the dominant controlling factors.

The three main GHG fluxes were determined during the growing season from May 2011 to November 2012. Soil pH, temperature, water filled pore space (WFPS), soil inorganic nitrogen (SIN), soil microbial biomass carbon (MBC) and biomass nitrogen (MBN) were also measured. Results showed that the fluxes of CO2 and N2O showed clear seasonal changes, i.e. highest fluxes were observed in August and lowest values in November in all three land-use types. While CH4 flux did not show any seasonal changes in the three land-use types. Further, significant differences in GHG fluxes were observed among the three soils, following the orders A ~ G > F for CO2, A > G > F for N2O, and A ~ G > F for CH4. Average soil GHG fluxes from A, G and F soils were estimated as 2.90 ± 0.64, 2.77 ± 0.65, 0.86 ± 0.15 kg C m–2 yr–1 for CO2; 194 ± 57, 141 ± 31, 34 ±15 mg N m–2 yr–1 for N2O; and –205 ± 89, –346 ± 53, –970 ±126 mg C m–2 yr–1 for CH4. The average global warming potential of the year of 2011 and 2012 were 96.5, 94.5 and 27.0 t CO2-eq ha–2 yr–1 for A, G and F, respectively. Averaged temperature sensitivity (Q10) for CO2 in the A, G and F were 2.5, 2.5 and 1.9, respectively. Linear regression model provided that CO2 and N2O fluxes showed significant positive correlations with soil temperature. On the other hand, soil temperature accounted for 62.3% and 18.6% of the seasonal variability for soil CO2 and N2O fluxes, respectively. It indicated that soil temperature was a positively controlling factor for soil CO2 flux.

Further, CO2 fluxes showed significant positive correlation with soil MBN and SN. N2O fluxes showed significant positive correlation with soil SOC and C/N ratio in the A and the G lands. CH4 fluxes showed positive correlation with soil MBC and C/N ratio in the G and F lands. CO2 flux showed a significant correlation with soil WFPS in all lands, but N2O fluxes did not show. From the stepwise analyzes, soil microbial biomass contents were the main contributor for CH4 flux in the three land-use types. In conclusion, human activity (vehicular traffic, fertilizer) in the A soils had significantly increased CO2 and N2O emissions while decreased CH4 uptake; while decreased soil microbial properties as well as soil C and N contents.

Keywords：*Land-use types; Temporal dynamics; Greenhouse gas fluxes*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Soil CO2 Flux during Decomposition of Leaf Litter as Affected by Soil Water and N Addition

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The decomposition of litter plays an important role in the global carbon cycle, but its impact in arid and semiarid regions is not well known. To understand how soil CO2 flux responds to soil water and nitrogen (N) addition in a semiarid region during the decomposition of leaf litter, an experiment using potted plants was conducted in a semiarid catchment. Soil CO2 flux and soil temperature were measured from leaf litter of two species of plants (alfalfa and poplar) in two types of soil. In both types of soil and litter, soil CO2 flux was significantly higher in wet compared to dry conditions during the early stages of decomposition but was not affected by water conditions during the later stages. The addition of N significantly decreased soil CO2 flux from the decomposition of alfalfa leaves but increased soil CO2 flux from the decomposition of poplar leaves during the early stages of decomposition. Soil CO2 flux was not affected by N addition in the later stages of decomposition. Our results indicated that soil CO2 flux during the early stages of litter decomposition was regulated by the conditions of soil water and N and that the effects of N addition varied with leaf type.

Keywords：*leaf litter decomposition; N addition; soil CO2 flux; soil types; soil water*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

A Novel Method to Analyse the Effect of Soil Organic Matter on Greenhouse Gas Emissions

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The reactivity and quality of soil organic matter (SOM) are key to determining the occurrence of conditions under which greenhouse gases, such as nitrous oxide, are generated in soils. A novel reaction cell has been developed to analyze the effect of SOM in different soil samples on the formation of nitrous oxide. The reaction cell consists of a diffusion cell that regulates both (1) the flux of dissolved electron acceptors, (oxygen and nitrate), from a feed cell to a mineralization cell containing a reactive substrate (e.g. SOM), and (2) the diffusion of soluble products formed in the mineralization cell into the feed cell (e.g. CO2 and N2O) where their concentrations can be determined. Oxygen concentrations are monitored across the reaction cell using a planar optode. The well-characterized flux of oxygen and the rates of CO2 and N2O production were used to parameterize and validate a sophisticated reactive transport model that describes the oxidation of the reactive substrate under different conditions. The reactive transport model was then used to determine first order rate constants for the mineralisation of SOM from different sources in New Zealand and further understand the role of the SOM C:N ratio on rates of nitrous oxide formation. The results show that SOM C:N ratio can play a key role in determining the conditions under which nitrate in the soil solution is reduced and the amount of nitrous oxide formed under anoxic conditions. A degree of variability in the rate constants of mineralisation of SOM from different sources was also observed, highlighting the importance of gaining a better understanding of the key factors driving this variability.

Keywords：*nitrous oxide, soil organic matter, mineralisation, rate constant, reactive transport modelling, soil carbon*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Bayesian Calibration of Soil Nitrogen, Nitrous Oxide Flux Process at Regional Scale, Central Hokkaido, Japan

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[Introduction and Objective] Process models have been widely developed to simulate greenhouse gas such as NO and N2O flux, but they often require a large amount of input data that is difficult to obtain at a regional scale (e.g, microbial dynamics and biomass) making regional emission estimates difficult to achieve (Bell et al., 2012); moreover, process model are fraught with high uncertainties in their parameters (Lehuger et al., 2009). ECOSSE is developed to simulate N dynamic precisely without need for detailed data that is not available at national scale (Smith 2010). In ECOSSE, amount of N (kg N ha-1 day-1) emitted during nitrification (Nn) is simulated according to NH4 (kg N ha-1), and is described by modification of soil temperature (mt), water (mw) and pH (mpH); amount of N emitted during denitrification (Nd) is simulated as a proportion of NO3 (kg N ha-1), and is described by modification of water content (m'w) and biological activity (m'b) (described as CO2 release during decomposition, kg C ha-1 day-1). For uncertainty analysis, Bayesian statistics has been proved to be a useful tool in terms of posterior density function with 95% confidence intervals (CI) (Ricciuto et al., 2008). Here is thus we develop process-based model based on ECOSSE theory, using Bayesian approach to calibrate the parameters of daily NO and N2O (kg N ha-1 day-1) from nitrification and denitrification process at regional scale.

[Materials and Methods] The model developed with data that is available at a regional scale: soil temperature (T, 5 cm depth); water filled pore space (WFPS, 5 cm depth), soil texture (sand, clay and silt content), NH4 (kg N ha-1), and using field-observed NO and N2O gas fluxes from 15 sites without fertilizer or organic application in a watershed at central Hokkaido, Japan, during non-snow cover season from 2003 to 2009. Using similar approach of ECOSSE, Nn is simulated according to NH4, mt and mw with constant (k), as Nn=NH4*exp(k*mt*mw). In ECOSSE, complete and partial nitrifications are assumed to simulate gaseous N losses during nitrification. In complete nitrification, 2% of fully nitrified N is assumed to be lost as gas (ngas=0.02), with 10% of this gas as NO (nNO=0.1), and 90% as N2O. In partially nitrification, 2% of partially nitrified N (nf=0.02) is assumed lost as gas at field capacity (θf) (the optimum water content for nitrification), and with a linear decrease in this loss as volumetric water content (θc) declines. Therefore, NO and N2O flux during nitrification are described as Nn_NO=ngas*nNO*Nn, and Nn_N2O=((nf*(θc/θf))+(ngas*(1-nNO))) (0< θc<θf), respectively. Using a similar but simpler approach as ECOSSE, N2O emitted from denitrification (Nd_N2O) is simulated according to m'w and m'b with constant (l), as Nd_N2O=l*m'w*m'b. Bayesian approach is developed to calibrate total 9 parameters (including constant (k) and (l)) in Eqn. of Nn_N2O=ngas*nNO*NH4*exp(k*mt*mw), and Nd_N2O=N2O-(Nn_N2O)=l*m'w*m'b by combining two sources of information: prior parameter values and observations. A non-informative prior for the parameters is set, and we conduct 10,000 runs iterations, discarding the first 2,000 iterations to avoid influence of initial vales, and using the rest for evaluation of posterior distribution. The estimated mean value is assumed as the best parameter values.

[Results and discussion] Bayesian calibration clearly revealed that nitrification increase with increasing soil temperature, and decrease when soils are both dry and wet, with the maximum nitrification at optimum WFPS (0.39, with 95% confidence interval

(CI) of 0.36-0.42). And sensitivities of nitrification to WFPS is higher than soil temperature is clearly revealed by calibration result. Increasing biological activity and increasing WFPS caused N2O fluxes to increase exponentially in denitrification, respectively, but control of biological activity was relatively stronger than control of WFPS. Large uncertainties were revealed in denitrification with wider 95% CI interval in effect of soil water and effect biological activity, as a consequence of large variations of daily N2O flux, when compared to NO flux from nitrification.

[Conclusion] Bayesian calibration address that there are larger uncertainties associated with N2O than NO simulation. Process-based model calibrated by Bayesian used in this study evaluates the different responses of N gas flux to environmental factors in nitrification and denitrification process, and it can be applied at regional scale using filed scale measurements.

Keywords：*Bayesian;process-based model;soil N gas flux; regional scale*

P1-423

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Automated Continuous Measurement of N2O and No Fluxes from the Rice Field: Methods and Preliminary Results

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Nitrous oxide (N2O) and nitric oxide (NO) fluxes from the agricultural soils, particularly from rice fields are relatively low. Previous studies reported both positive and negative fluxes. There is a large temporal variation in flux rates. Those large variations of flux rates are a main source of error in estimating reliable cumulative emissions from agricultural soils. Moreover, most of the reported fluxes were measured sporadically with manual gas sampling. The concern is rising about the reliability and accuracy of those measurements since a sporadic (weekly) measurement of fluxes may over or underestimate the cumulative emissions. Contrary, the continuous measurements may improve the accuracy of flux estimates and allow better insight into the short-term variability of the fluxes. We designed an automated closed chamber technique of gas sampling for continuous measurements of N2O and NO from agricultural soils. It was used (i) to study the temporal variations of N2O and NO fluxes from lowland rice fields during rice growing and fallow seasons, and ii) to determine the effects of broadcast application vis a vis fertilizer deep placement in different locations of Bangladesh.

Automated system for N2O and NO flux measurement had four components: (i) automated gas chambers (0.77m x 0.19m x 0.39m, length, width and height) with compressed air-driven lids, (ii) the automated gas sampling unit, (iii) online gas analysis (N2O and NO) system, and (iv) control and data logging unit. Each gas chamber was installed in experimental plots over aluminum base which was made air tight using rubber gasket. This experiment was conducted in two sites of Bangladesh (i) Bangladesh Agricultural University and (ii) Bangladesh Rice Research Institute. There were twelve gas chambers in each site. The automated gas sampling system worked on a three-hour cycle, i.e., one hour for each replication (four chambers). During one hour, each gas chamber remained closed for 40 min and 6 gas samples were collected at 8 min interval (0, 8, 16, 24, 32 and 40 min). NO was measured with a Teledyne API T200 Chemiluminescence Analyzer. N2O was measured with a Teledyne T320U Gas Filter Correlation Analyzer, and calibration gases were made with a Teledyne T700 Dynamic Dilution Calibrator. The sampling and analysis system was controlled and data were collected by a Campbell Scientific CR3000 Data Logger with an AM16/32 Channel Relay Multiplexer (for temperature and soil water potential sensors) and two 16 Channel AC/DC Relay Controllers (for sampling valves and air control valves). N2O and NO flux rates were determined from the slope of the liner regression curves on N2O and NO concentration against chamber closure time. Flux rates were expressed as µg/m2/h. Seasonal cumulative emissions were estimated from hourly emission rates. The preliminary N2O and NO emissions results will be presented.

Keywords：*Nitrous oxide, Nitric oxide, fertilizer deep placement, lowland rice*

P1-424

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Biological Soil Crusts: Source or Sinks of CO2 in Semiarid Ecosystems?

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The increasing importance of climate change research has awaken the interest for quantifying carbon (C) fluxes in terrestrial ecosystems and the knowledge of whether these act as sources or sinks of C. The information about the factors that regulate C fluxes is particularly limited for arid and semiarid areas, despite these ecosystems may have an important role in the global C cycle. In such ecosystems, the interplant spaces are often covered by a thin layer of organisms including cyanobacteria, green algae, lichens and mosses, which are known as biological soil crusts (BSCs) and, though practically negligible, play a fundamental role in regulating gas exchange into and from soil. BSCs represent the main organisms capable of respiration and photosynthesis in the interplant spaces of these regions and are considered the main source of organic carbon in many semiarid ecosystems. BSCs are poikilohydric, meaning that their photosynthetic and respiratory activity begin as soon as moisture becomes available and have the capability to use either large amounts of water coming from rainfall or very small amounts of water coming from fogs, dew or steam. Thus, BSCs respond faster and differently to moisture pulses than other ecosystem components as vegetation. BSC photosynthetic and respiratory activity depends on abiotic factors such as soil temperature and moisture, air humidity and temperature or sun radiation, and biotic factors such as BSC cover and composition. Although several studies have pointed to the predominant role of BSCs as sources of CO2, other studies have emphasized their important role as sinks of CO2 during periods of biological activity. It has been estimated that, globally, the carbon net uptake of BSCs from the atmosphere corresponds to 7% of the net primary production of terrestrial vegetation and to approximately 1% of the carbon content stored in terrestrial vegetation. Despite the recognized role that these organisms play in CO2 fluxes, the influence of BSCs on CO2 exchange has been commonly ignored.

The aim of this study was to verify whether BSCs act as sinks or sources of CO2 and the key environmental factors that control CO2 dynamics in BSCs. CO2 fluxes were measured on representative communities of different BSC types (cyanobacteria and lichen-dominated communities) after several rainfalls and periods of soil drying in two representative semiarid ecosystems of SE Spain. CO2 exchange was measured using infrared gas analyzers (IRGA): net flux was measured with a transparent custom chamber attached to a Licor Li-6400, and respiration with a respirometer EGM-4 (PPsystems). Photosynthesis was calculated from these two measurements.

Our results showed that moisture was the major factor controlling CO2 fluxes in BSCs. During the summer season, when soil was dry, all BSCs showed CO2 fluxes close to 0. However, once it rains and BSCs become active, a significant increase in photosynthesis and respiration rates was found. Whereas respiration was the main CO2 flux in bare soils, in BSCs, regardless respiration was higher, these CO2 emissions were compensated by CO2 fixation through their photosynthetic activity, thus resulting in a positive net flux or net uptake of CO2. Under high soil water content, better developed BSCs as those dominated by lichens showed higher maximum photosynthetic and respiration rates than less developed cyanobacteria BSCs. As soil dried out, cyanobacteria BSCs were able to maintain higher maximum photosynthetic and respiration rates than lichen BSCs. We can conclude that BSCs act as important C sinks during the periods where they are active. This C uptake has important effects on soil carbon store and plant productivity. The results of this study demonstrate the need to consider BSCs in C balance models on local to global scales to improve our knowledge on C quantification and to make more accurate predictions of the effects of climate change in arid and semiarid regions where this type of soil cover is a key ecosystem component.

Keywords：*Biological soil crust, respiration, photosynthesis, CO2 fluxes*

P1-425

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Development of An Improved Method for Estimating Soil Carbon Dioxide Flux

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Carbon dioxide flux to the atmosphere is the major pathway whereby carbon is lost from agricultural soils. Linear interpolation has traditionally been used to estimate carbon dioxide flux when using non continuous flux measurement methods but the resulting curves are not representative of biological systems. Cross validation techniques were used to perform a comparative evaluation of linear, natural cubic spline and constrained cubic spline interpolation methods for estimating soil carbon dioxide flux based on the dual criteria of accuracy and smoothness. Linear interpolation accurately predicted measured data points but produced non-smooth curves whereas natural cubic spline interpolation produced smooth curves but had low predictive accuracy apart from when forecasting local maxima in the data. Constrained cubic spline interpolation produced relatively smooth curves while its predictive accuracy was comparable to that of linear interpolation. This demonstrates that the constrained cubic spline interpolation technique may be more appropriate for estimating soil carbon dioxide flux than traditional linear methods and that this framework may be amenable to the identification of outliers.

Keywords：*Climate Change, Carbon dynamics, Interpolation, Cross validation*

P1-426

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Are CO_2 Emissions from Mineral Soil under Oil Palm Plantation Lower than Those of Peat Soil?

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Determination of CO_2 emission factor from mineral and peat soils faces challenges due to the high variation and unclear difference of measured flux between the two types of soil. Root density and root distribution, and their influence on CO_2 flux create the complication on measured data and their interpretation. In many cases, total respiration from mineral soils is as high as that in drained peat soils, while the reduction of soil carbon stock is more prominent in the latter. We evaluated the spatial variation of CO_2 flux from mineral soil under oil palm (Elaeis guineensis Jacq.) plantation and compare its trend with that from our previous research on peat soil. The spatial variation of total soil flux along the distance from the palm trees was an important aspect of this research. The study was conducted on a 15-year old oil palm plantation on mineral soil (Dystropepts) in Jambi Province, Sumatra, Indonesia, in July 2011. Three oil palm trees were installed with 25-cm diameter and 25-cm tall polyvinyl chloride cylinder closed gas chambers at distances of 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0 and 4.5 m from the center of the oil palm trees. CO_2 concentration entering each closed chamber was measured with an infrared gas analyzer (IRGA) every second for 120 seconds. Root density was evaluated from soil samples taken by trench method along the parallel lines, at 0.2 m distance from each chamber' installation transects. The results showed that at distances (x) from 1.0 to 3.0 m from the palm, CO_2 flux (y, in Mg ha^{-1} yr^{-1}) decreased with the linear relationship of $y = -46.3x + 162.8$ ($R^2 = 0.8804$) demonstrating the higher root-related respirations closer to the palm. At the distances from 3.0 to 4.5 m from the palm, CO_2 flux was independent of the distance from the palm ($y = 34.3$) indicating less influence of roots. Based on our other research (Dariah et al. 2013), CO_2 flux from peat soil at distances of 3-4.5 m from the palm of 38 to 43 Mg ha^{-1} yr^{-1} were only slightly higher than that of mineral soil as found from this current research of 34.3 Mg ha^{-1} yr^{-1}. However, while in mineral soil carbon stock fluctuates only slightly, in drained peat soil it usually depletes significantly, meaning that heterotrophic respiration from soil organic matter is much higher in peat than mineral soils. There are several other sources of soil respiration besides heterotrophic respiration of soil organic matter. These include soil surface litter decomposition, below ground litter (dead root) decomposition and root (autotrophic) respiration. The influence of root exudates and fertilizer also increase the rate of heterotrophic respiration as well as CO_2 flux spatial variation. Litter decomposition contribution could be high and its separation from the total soil respiration may be able to explain the relatively high measured CO_2 respiration from mineral soil. Rigorous evaluation of litter effects on the total soil respiration in combination with soil carbon density changes will be a crucial future research agenda to improve the certainty of soil heterotrophic respiration and hence the quality of the national green house gas inventory.

Keywords: *CO_2 emission, heterotrophic respiration, litter, mineral soil, peat soil, oil palm plant*

P1-427

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Can a Nitrification Inhibitor Improve Nitrogen Use Efficiency in Intensive Vegetable Production Systems?

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Vegetable production systems are intensive, requiring high inputs of nutrients and water to produce good quality products. In Australia on systems where the soils are sandy and highly permeable, inputs of manures, such as chicken manure, to increase the organic content of soil are commonplace. The combination of high nitrogen (N) and water inputs on permeable soils leads to high risk of N loss through leaching of nitrate, or gaseous emissions from manures directly (ammonia (NH_3) or from nitrification-denitrification loss (nitrous oxide (N_2O) and dinitrogen (N_2). One way to reduce leaching, and nitrification-denitrification loss is to use a nitrification inhibitor such as 3,4-Dimethyl pyrazole phosphate (DMPP), however it is not known whether the inhibitor will increase NH_3 loss from applied manures by slowing the rate of oxidation of NH_3 to nitrate.

An experiment was conducted on celery crops (2 treatments, 4 ha each) grown on sandy (98% sand) soil in Melbourne, Australia (38°24'S 144°54'E) to assess the impact of the nitrification inhibitor DMPP on N cycling. The experiment measured gaseous emissions resulting from application of chicken manure (both NH_3 and N_2O) and fertiliser (N_2O only), and quantified the impact of DMPP on these emissions over the growth of the crop (15 weeks). Celery was transplanted to the sites at 4-5 leaf stage (5th April 2013), and calcium nitrate (39 kg N/ha) was applied shortly thereafter (12th April). Chicken manure (7.5 tonnes/ha, 255 kg N/ha) was applied on 6th May and DMPP was applied to one treatment. Further fertilisation involved addition of calcium nitrate (once, 39 kg N/ha) and Nitrophoska® (12.5% N, three times, 39 kg N/ha each time) so that total N input during the crop was 451 kg N/ha. Additional nutrients were applied according to grower standard practice.

Ammonia volatilisation from the chicken manure was measured using an open path Fourier transform infrared (OP-FTIR) spectroscopic system and NH_3 fluxes were simulated using the backward Lagrangian stochastic (bLs) dispersion model (WindTrax) for 2 weeks prior to and 3 weeks after manure application. Nitrous oxide emissions were measured using manual chambers (23 cm diam., 25 cm high inserted 10 cm into the ground) at regular intervals over the course of the experiment. Biomass production was measured from control (no fertiliser), non-DMPP and DMPP treatments at the end of the crop cycle (9th August) from a replicated (5 reps) small plot (17 m^2) trial. Soil samples (0-15, 15-30 cm) were collected across both treatments at regular intervals.

The results showed that NH_3volatilisation from the chicken manure was 12 kg N/ha or 4.7% of the applied manure-N. Adding DMPP caused an increase in NH_3 volatilisation to 15 kg N/ha, or 5.9% of the applied manure-N. Cumulative N2O emission (for 10 days after manure application) was 5.92 kg N_2O-N/ha (2.3% of manure-N) from the non-DMPP treatment and 4.29kg N_2O-N/ha

(1.7% of manure-N) from the DMPP treatment. Use of the DMPP reduced N_2O emissions by 28% over 10 days. Combined NH_3 and N_2O gaseous losses for the 10 days after manure application were <8% of applied N.

Biomass yields were 7.4 ± 1.9, 15.2 ± 0.2 and 14.9 ± 0.6 tonnes freshweight/ha for the control, non-DMPP and DMPP treatments respectively and the N uptake was 33.1 ± 8.6, 68.6 ± 0.9 and 66.9 ± 2.8 kg N/ha respectively. The apparent recovery efficiency of applied N was 7.8 and 7.5 % for the non-DMPP and DMPP treatments respectively. The low recovery efficiency reflects the high N uptake from the non-fertilised plots and high background N in the system, which is typical in many Australian horticultural systems, making it difficult to gain biometrically significant yield differences when the crop requirements were being met even with the measured losses. N loss appears to be a less important factor influencing crop yield in this trial. More work to understand the losses in these systems from N2 and nitrate leaching could lead to improvements in nitrogen use efficiency.
In conclusion, DMPP effectively reduced N_2O emissions from chicken manure and fertilisers, but increased NH_3 loss from the manure, and had no impact on biomass production due to the high background N. The experiment highlighted the need to consider the complete N cycle when developing strategies to improve N use efficiency.

Keywords：*nitrification inhibitor, vegetables, ammonia, nitrous oxide, nitrogen use efficiency*

P1-428

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Antecedent Water Treatment Changes Nitrous Oxide Emission and Production Processes in an Acidic Arable Soil in China

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Laboratory incubations were conducted to investigate effect of antecedent water regimes on nitrous oxide (N2O) emission at different soil moisture content (SMC) and on N2O production processes using 10% (v/v) acetylene (C2H2) inhibitory technique in an arable soil (Typic Plinthodults) at 25°C. The fresh soil was maintained under either moistened (sample M) or flooded (sample F) conditions before the soil was adjusted into SMC of 40%, 70% and 100% water holding capacity (WHC), and then incubated for 168 h. N2O emission increased slightly with the increase at SMC from 40% to 70% WHC, but increased dramatically to 100% WHC. At SMC of 40%, 70% and 100%WHC, cumulative N2O emission from sample M was as 1.45, 1.68 and 0.58 times as those from sample F, respectively ($P<0.05$). Presence of C2H2 had insignificant difference in cumulative N2O emission for sample M at SMC of 100%WHC ($P>0.05$), while cumulative N2O emission increased significantly for sample F in the presence of C2H2 at SMC of 100%WHC ($P<0.01$). After the incubation, the NO3--N content of sample M and F increased at three SMCs, except for sample F at SMC of 100%WHC. Compared with the incubation absent C2H2, the presence of C2H2 increased the increment of NH4+-N, but decreased the NO3--N increment. These evidences indicated antecedent water regime influencing N2O emission amount and production processes in the following incubation. Nitrification including heterotrophic nitrification was the major process of N2O production for sample M even at higher SMC of 100%WHC. Denitrification was the major N2O production process for sample F at SMC of 100%WHC.

Keywords：*acid arable ultisol, heterotrophic nitrification, denitrification, N2O production, antecedent water regime*

P1-429

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Nitrification and Associated N2O Emission in Soil Responds Differently to Temperature

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Nitrous oxide (N2O) emission from soil largely results from a by-product of nitrification and as an intermediate of denitrification. Although the response of nitrification rates to soil temperature is well characterised, there is still some uncertainty regarding the response of nitrification, and particularly the resultant N2O production, at high soil temperatures. Two pasture soils classified as a dermosol and a chromosol were used in a study to investigate how nitrification rates, N2O production and the proportion of nitrified nitrogen (N) emitted as N2O responds to a range of temperatures (10-45 °C) in short term incubations. An acetylene inhibition technique was used to distinguish between the contribution of autotrophic nitrification and denitrification to overall N2O production.

Nitrification and associated N2O production increased with increasing incubation temperature and reached an optimum temperature of approximately 35 °C for nitrification but around 40 °C for the associated N2O emission. The proportion of nitrified N emitted as N2O varied from 0.16-0.70% between 10-35 °C but was significantly higher at 40 °C and 45 °C with more than 1% of nitrified N emitted as N2O, as nitrification rates declined faster than the associated N2O at high temperatures. The existence of different optimal temperatures for nitrification and associated N2O means that the use of simplistic temperature response functions (e.g. Q10 or Arrhenius functions) in models attempting to estimate process rates at high temperatures is problematic.

Most models assume a constant proportion of nitrified N is emitted as N2O, but more recently some models vary this proportion as a function of water content, but not temperature. An exponential equation described the proportion of nitrified-N as N2O as a function of temperature in the two soils in our study. Before this function is adopted in models, it will be important to investigate whether the temperature effect on the proportion of nitrified N emitted as N2O occurs as a consequence of lower oxygen availability, through either lower dissolved oxygen in the soil water temperature and / or through higher respiration rates.

The relative contribution of autotrophic nitrification to overall N2O was sensitive to temperature. At 40 °C autotrophic nitrification was the predominant source of N2O production, approximately 90% in both of the tested soils. Between 25 and 35 °C, autotrophic nitrification contributed to 54-70% of the overall N2O in the chromosol and 33-44% of the total N2O emissions in the dermosol. This was partly related to soil characteristics, particularly bulk density and soil texture.

Keywords：*nitrification, N2O, temperature, soil*

P1-430

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Factors and Processes Controlling Ghg Soil Emissions in Zonal Functional Set of Central Russia Ecosystems

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Current models of global changes in XXI century (IPCC, 2013) show a range of potential global warming from 0.3 to more than 4.5 °C at the end of the century, depending on our ability to control anthropogenic greenhouse gases (GHG) emissions. At current level of emissions it is very likely that we will hit the worse case scenarios, with serious consequences on several economic sectors and our human society. For these reasons contributing to climate change mitigation are among the main ecological challenges addressed by current land-use and land management (Foresight, 2011; Beddington et al., 2012; FAO, 2013; Valentini, 2013). These issues are particularly essential for countries with recent important transformations in land use and agricultural practices. Russia is most interesting among them due to huge territory with complex zonal functional distribution of natural and man-made factors controlling GHG fluxes.

Central Russia region (CRR) is the most populated area in RF, with the population density around 60 people/ km2, total population over 38 million and high level of agricultural and urban impacts on GHG fluxes in various natural zones (from southern taiga till forest-steppe ones) and land-use conditions.

In frame of RF Government grant #11.G34.31.0079 the GHG fluxes and C pools monitoring system has been developed in CRR including zonal set of natural ecosystems (forest/ meadow steppe ones) and their man-changed versions. Each zonal functional ecosystem is investigated with subdivision by principal factors controlling GHG soil emissions: forest/fallow age, mesorelief and soil moisture in natural ecosystems, land-use kind, age and practices in agricultural and urban ones. Detailed intra-ecosystem analysis allowed to evaluate processes controlling C pools and GHG fluxes dynamics and spatial variability that is constitutive for ecosystem services. Methods include the detailed soil profile and cover patterns morphogenetic investigation, soil C pools dynamic analysis, soil CO2, CH4, N2O fluxes decade-based monitoring by exposition chambers with mobile IR-gas analyzer Li-COR-820 or gas chromatograph, and ecosystem CO2 flux seasonal monitoring by eddy-covariance stations.

Monitoring research have shown the high temporal and spatial variability of soil CO2, CH4, N2O fluxes and ecosystem CO2 fluxes due to seasonal and daily dynamics (in 4-8 and 1,5-3 times), bioclimatic and functional zoning (in 2-4 and 1,5-5 times), mesorelief slope form, exposure and angle (1,3-3 times), forest type, age and parcel (1,3-3.5 times), succession kind and stage (1,3-4 times), steppe vegetation type and conservation regime (1,2-2 times), fallow age and use (1,2-2,5 times), agricultural land-use practice (1,2-2 times), crop and agrotechnologies (traditional and no-till ones: 1,2-1,4 times), green lawns types and practice (1,2-1,6 times), microrelief, parent materials and microclimate characteristics (1,3-3 times), soil natural or man-made profile (1,3-2.5 times), soil C pools and humus quality (1,2-2 times), soil biota structure, nutrients, moisture and temperature (1,2-5 times), soil forming and degradation processes character and rates (1,3-3 times).

In case of Moscow megalopolis the highest CO2 emission is typical for green lawns where the soil CO2 fluxes reached 13,7 μmol CO2m-2 s-1 which is 2 times more than the one for the neighboring urban forest, and 3 times more than for adjacent agrolandscapes. The green lawns are characterized by the highest average amount of soil CH4 uptake (0,66 mg/m2day) in comparison with 0,42 and even 0,1 mg/m2day for urban forest and arable soils. The soil N2O emission of green lawns is usually 2 times more than one of urban forest and agroecosystem. The crop factor input is stronger that the agrotechnology one. In case of managed urban lawns (irrigation and fertilization) N2O emission is almost in 2 times more than in non-managed lawns.

Enough broad regional matrix of monitoring objects together with system analysis of their previous investigation results allow one to fix the principal regional typological regularities of C pools and GHG fluxes temporal dynamics and spatial variability coupled with their locally dominated factors and processes combinations. Climate-smart agriculture, forest and urban land-use practices are able to control the soil GHG emissions in zonal ecosystems at the Central European region of Russia. But for this it's necessary to improve our understanding of carbon dynamics and GHG emissions vulnerability to current and predicted land use and farming systems, ecosystem services and land management efficiency, land agroecological quality regional regularities and environmental consequences of land-use practice detailed changes.

Keywords：*Agroecology, climate-smart farming, greenhouse gases, land quality, land-use control, urboecosystem*

P1-431

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

CO_2, N_2O and CH_4 Production/consumption Potentials of Soils under Different Land Use Types in Central Japan and Eastern Hungary

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The production/consumption of greenhouse gases (GHGs) in soils are of great importance in global warming, but the involved soil physico-chemical and biological characteristics affecting GHG production and consumption potentials are poorly understood in different land use types. Carbon dioxide (CO_2), nitrous oxide N_2O) and methane (CH_4) production/consumption potentials from four land use types and 10 soil types in central Japan and eastern Hungary, and their relationships with soil characteristics, were investigated. The average of CO_2 production in Japanese soils was significantly higher than that of Hungarian soils due to the relatively higher microbial biomass carbon (MBC) content. N_2O production from both countries' soils did not exhibit a significant difference. Most soils except Japanese paddy and soybean soils showed the potentials for CH_4 consumption. Forest and grassland soils had relatively higher CO_2 and N_2O production than orchard and cropland soils for both countries. From regression analyses, it could be concluded that soil total nitrogen (TN) and ammonium-nitrogen (NH_4+-N)account for 40.8% and 25.5% variations of the soils' CO_2 and N_2O productions, respectively. The CH_4 consumption was positively correlated with soil carbon/nitrogen (C/N) ratio, while soil MBC availability could account for 15% variation of CH_4 consumption under aerobic conditions.

Keywords：*CO_2, N_2O, CH_4, soil properties*

P1-432

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Tillage and Organic Materials Affect Soil Organic Carbon under Wheat-Rice Cropping System in Typic Calciargids Soils

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Agricultural management practices can significantly increase soil carbon sequestration and reduce emission of greenhouse gases. Literature reports very little work in this regard in Pakistan and especially under wheat-rice cropping system. Wheat and rice crops were cultivated for two consecutive years with deep, conventional, and minimum tillage practices (DT, CT, and MT, respectively) and application of 0, 15 and 30 Mg ha–1 organic materials (OM0, OM15 and OM30, respectively). After first year of cropping, the soil organic carbon (SOC) significantly ($p<0.05$) varied with different tillage and organic materials (OM) in different layers of soil profile. At 0-15 cm, the SOC concentration was the highest (0.114 Mg ha–1) in case of MT with organic material at 15 Mg ha–1 and the CT with OM at 15 Mg ha–1 recorded the highest SOC (0.127 Mg ha–1) at 15-30 cm soil depth. The MT with 30 Mg ha–1 OM resulted in the highest SOC (0.125 Mg ha–1) at 30-50 cm soil depth. The lower soil depths (50-75 and 75-100 cm) recorded the highest SOC in case of DT with OM at 15 Mg ha–1 (0.113 and 0.107 Mg ha–1, respectively). Varying SOC levels were recorded after second year of cropping. At surface soil layer (0-15 cm), the SOC concentration was the highest (0.109 Mg ha–1) under MT where OM was applied at 30 Mg ha–1. This suggests that farm manure application at higher rate increased the SOC concentration compared with mineral fertilization. The CT with 15 Mg ha–1 organic materials resulted in the highest SOC contents at 15-30 cm (0.127 Mg ha–1). For the deeper soil layers (50-75 and 75-100 cm), DT proved the highest SOC (0.114 and 0.109 Mg ha–1) with OM at 15 Mg ha–1. In conclusion, the beneficial effects of different tillage practices and organic material levels on SOC is premature and further work is needed to determine its suitability depending on soil types under various agro-ecological conditions. However, this information may be used to assess the contribution of different tillage systems and application of OM for maximizing crop yield and soil carbon sequestration in semiarid regions of Pakistan.

Keywords：*SOC, carbon pool, Pakistan*

P1-433

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Effects of Biochar on Greenhouse Gas Emissions from Arable and Bioenergy Crops

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Biofuels can provide energy for human use. Two common crops used for biofuel are willow and miscanthus.Biochar is increasingly used as soil amendment as it can improve soil productivity. Thus, there is a prospect to combine biochar production with biofuels. However, if this is going to happen it would be necessary to assess the changes in greenhouse gases emissions caused by biochar. An experiment was carried out in the laboratory to assess the effects of biochar prepared from different feedstocks (sewage sluge, paper mill waste and miscanthus) on N2O and CO2 emissions in an arable soil, a soil planted with willow and a soil cultivated with miscanthus.

Miscanthus biochar increased CO2 emissions for the 3 soils considered. N2O emissions were higher in the arable soil compared to the other soil. N2O emissions diminished by all of the biochars tested in all the soils. The extent of this decrease depended on soil type and on the biochar feedstock.

P1-434

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Nitrous Oxide Emissions from Different N Fertilizer Rates Applied to a Maize Crop under Conventional Tillage in Brazil

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Oxisols and Ultisols are the most important soils of the area used for agriculture in Brazil. The purpose of the present study was to investigate the effect of N fertilizer application on the N2O emissions from an Ultisol of the Atlantic Forest region of Brazil to aid the prediction of emissions from land used for agriculture. The experiment was carried out on the experimental farm of Embrapa Agrobiologia, Seropédica, Rio de Janeiro state. The soil is classified as a Typic Hapludult and was planted with maize with four different rates of N fertilizer (0, 50, 100 and 150 kg N ha-1). Static closed chambers were used to evaluate N2O emissions. The N2O fluxes were strongly influenced by rainfall events and even more after the N fertilizer application, but emissions were of short duration. The water filled pore space was significantly related to the N2O fluxes and seemed to be the most important factor driving the N2O emissions. The different N rates were linearly related to the N2O emissions, which resulted into a direct emission factor of 0.0035 kg N-N2O kg-1 N fertilizer compared to the IPCC tier 1 standard of 0.010 kg N-N2O kg-1 N.

Keywords：*N2O emission factor, greenhouse gas, fertilizer N rate*

P1-435

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Above-Ground Carbon Pools of Citrus Acreage in Pakistan

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A significant portion of carbon pool of a tree is contained in its above-ground biomass (ABG) that consists stump, stem, branches, and leaves. Estimation of ABG is important for forest resource inventory, natural resource management, environmental management, and estimation of carbon sequestration. Objective of this study were to estimate AGB of a citrus tree using a non-destructive method and quantify carbon pools of citrus acreage in Pakistan. One hundred (100) trees were selected at two locations in Faisalabad and one location in Gogra for the measurement of tree height, breast height diameter, wood density, and green volume using standard methods. Regression equations were used to estimate AGB from above plant variables. In Pakistan, citrus is grown on area of approximately 200 thousand hectares with tree density of 40 trees per hectare enabling carbon sequestration equivalent to 1176 tons. These research results may be used as a baseline information for future studying, planning and management of carbon budgets in Pakistan.

Keywords：*Above ground biomass, carbon, Pakistan and Citrus*

P1-436

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

The Potential of Agricultural Practices to Increase C Storage in Soils: An Assessment for France

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Agriculture can reduce its green house gas emissions (GHC) by enhancing the amount of C stored in the soil as soil organic matter. Most authors agree that there is considerable scope for progress but, given the complexity of the underlying processes, estimating emissions is riddled with uncertainty and the abatement potentials are currently less accurately quantified than in other sectors. We examined technical measures liable to store carbon in cropped soils. We estimated their additional C storage potential per unit surface area and we proposed, for France, potential surface areas for application.

To be eligible, measures had to be agricultural practices implemented by the farmer, at least partially located on the farm, involving no major change of the production system nor reduction of production in excess of 10%. Only currently available techniques, with validated scientific knowledge establishing their efficacy were considered, with potential for acceptability and no major negative environmental impacts. Ten measures were examined, among which three are expected to store carbon in cropped soils :
- develop no-till practices. We considered a switch to continuous direct seeding, direct seeding with occasional tillage, one year in five, or continuous superficial (<15 cm) tillage.
- plant more cover crops in cropping systems. The idea is to extend or generalise the use of cover crops (sown between two cash crops) on arable farms, cover crops in orchards and vineyards (permanent or temporary green cover) and grass buffer strips around the edges of fields.
- develop agroforestry (lines of trees planted in cultivated fields or on grassland) and hedges (around the edge of fields).
We reviewed the recent literature to propose additional C storage rates in Mg C ha-1 y-1, compared to the same cropping system without the practice, and considered a constant storage rate over 20 years. Then we analysed the conditions for potential application, in terms of feasibility, acceptance, limitation of yield losses and of other GHG emissions.

For no-tillage, additional C storage rates selected from the literature were of 0.15 (0-0.3) Mg C ha-1 y-1 for continuous direct seeding, 0.10 (0-0.2) Mg C ha-1 y-1 for occasional tillage one year in five, and 0.0 Mg C ha-1 y-1 for superficial tillage. Cover crops were estimated to store 0.24 (0.13-0.37) Mg C ha-1 y-1 between cash crops and 0.49 (0.23-0.72) Mg C ha-1 y-1 when associated with vineyards while grass buffer strips stored 0.49 (0.23-0.72) Mg C ha-1 y-1. Hedges (60 ml ha-1) stored 0.15 (0.05-0.26) Mg C ha-1 y-1. Very little estimates are available for agroforestry system and we proposed a value of 1.01 (0.11-1.36) Mg C ha-1 y-1 for C stored in soil and in the tree biomass for systems comprising 30-50 trees ha-1.

Finally, practices with the higher additional C storage rates were those associated with increased biomass and thus increased C inputs to soil (agroforestry, hedges and cover crops), while the reduction of soil organic matter mineralisation resulting from reduced tillage seemed less effective. When virtually applied to French situations with no major technical constraints (e.g. superficial soils resulting in a strong competition between the crop and the trees in agroforestry) or no adverse environmental effects (e.g. poorly aerated soils were not considered to no-till application in order to limit N2O emissions), these measures allowed to increase French soil C stocks by 0 to more than 1 Tg C y-1, and they may be at least partially combined. Hence these agricultural practices represent an important mitigation potential of GHG emissions. However, our estimates are associated with important uncertainties, due on the one hand to the variability of C storage in soils depending on pedo-climatic conditions and cropping systems, and on the other hand on the few studies available for some practices such as agroforestry under temperate conditions.

Keywords：*carbon storage, C sequestration, green house gas emissions, no tillage, cover crop, agroforestry*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Effect of N Fertilizers on Soil CO2 Flux in a Young Oil Palm Plantation on Tropical Peatland, Sarawak, Malaysia

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Nitrogen (N) is an essential element for vegetative growth and leaf area index which will lead to increase in canopy size, thus improve the net assimilation and biomass production of plant (Engels and Marschner, 1995). The current expansion of large-scale oil palm plantation to meet the demand for food supply has caused extensive utilization of N fertilizer for oil palm's growth and production. The application of N fertilizers is reported to have significant effect on soil nitrogen and carbon status which will affect the plant growth, root respiration, microbial activities and decomposition rate (Allison et al., 2008) which eventually influence the respiration rate. High input of N increased root biomass contributes to higher root respiration, exudates and turnover. The belowground carbon input via root exudates and turnover, resulting in higher microbial activities and biomass (Lee and Jose, 2003; Ramirez et al., 2010). On the contrary, other finding reported that the addition of N significantly depresses soil respiration due to changes of microbial communities which affected the decomposition rate, may well reduce soil CO2 flux (Bowden et al., 2004).
The studies on the effects of N fertilizers on CO2 fluxes in soil are still limited as compared to nitrous oxide (N2O), thus creates uncertainties in soil respiration dynamics and nitrogen fertilizers which are essential for proper management policies and mitigation strategies. Adequate understanding over the soil CO2 dynamics will facilitate in foreseeing changes caused by land use change. The information on the relationship between N fertilizers and soil CO2 flux has cause the status of oil palm cultivation on tropical peatland as a source or sink of CO2 is still fragmentary. Hence, this study aim to fill the gaps by determining the effects of N fertilizers application on soil CO2 flux in young oil palm plantation on tropical peatland.
Monthly soil CO2 flux was measured over a year in a young oil palm plantation on tropical peatland in Sarawak, Malaysia using a closed-chamber technique. The treatments included a control (without N) (T1), conventional urea (T2), 50% coated urea fertilizer (T3) and 100% coated urea fertilizer (T4). Each treatment had three blocks with four sampling points. Analysis of variance (ANOVA) was used to test the effect of treatments to the soil CO2 fluxes while the means of treatments were compared using Duncan's New Multiple Range Test. Relationship between soil respiration and the water table was analysed using regression analysis. Statistical analysis was performed using the Statistical Analysis System (SAS) version 9.2.
There were no distinct seasonal variations for monthly soil CO2 fluxes in all treatments. The soil CO2 ?uxes ranged from 220.4 to 367.9 mg C m-2 h-1 for T1, 170.4 to 334.1 mg C m-2 h-1for T2, 175.3 to 307.3 mg C m-2 h-1 for T3 and 197.2 to 426.1 mg C m-2 h-1 for T4. Soil CO2 flux in the T1 was greater ($p<0.05$) than those soil CO2 fluxes subjected to N fertilizer treatments (T2, T3 and T4). The addition of N fertilizer mostly decreased soil CO2 fluxes compared to T1. This is possibly due to high concentration of NH4+ along with acidity caused by augmented rates of nitrification that would likely reduced the soil microbial activities (Bowden et al., 2004). Furthermore, the competition for soil oxygen in both processes of nitrification and methane (CH4) oxidation in N fertilized soil would probably cause insufficient oxygen for autotrophic and heterotrophic activities in soil; thus lower soil respiration. This study showed that the soil CO2flux in cultivated peatland is not greatly influenced by N fertilization. However, further studies and clarification are needed to obtain comprehensive information on the effects of nitrogen fertilizers to soil respiration which is essential to develop strategies on fertilizer efficiency in cultivated tropical peatland.

Keywords：*Drainage, soil CO2 flux, closed-chamber technique, urea*

P1-438

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Estimating Soil N2O Diffusivity from Fick's Law Using Soil CO2 Concentration Profile and Efflux

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The present work aimed to evaluate a new method to estimate the soil diffusivity of gases to be used in studies of N2O, based on measurements of soil CO2 efflux and the soil CO2 profile. The hypothesis was the soil N2O efflux, estimated from the soil N2O concentrations and diffusivity would not be different from the N2O efflux estimated by using a closed static chamber.

The study was carried out under controlled conditions in a cylinder of 1 m diameter by 0.5 m height, filled in with air dried 2 mm sieved soil up to 0.3 m. A soil air sampling system was built at 5 and 15 cm depth. A closed static chamber was in the soil surface at the same place for gas efflux evaluation. Gas sampling from the different soil depths were taken during 41 days, always at the same time of gas efflux measurement.Each gassample was analyzed for CO2 and N2O concentration by gas chromatography. According to the proposal, gas diffusivity was calculated using the Fick's Law, and the variables gas concentration gradient of each layer and gas efflux determined from the analysis of CO2. The diffusivity was also estimated by the Marshall's model, taking into account the soil tortuosity, calculated using soil moisture and porosity of each layer.

The results have shown that the N2O fluxes calculated from the diffusivity obtained from CO2 data from the 0-5cm soil layer were similar to the fluxes measured using the static chamber. Considering the 0-15 cm soil layer the fluxes were 40% greater than that obtained with the static chamber. Fluxes of N2O calculated using diffusivity from Marshall's model were almost five to nine times greater than the fluxes measured with static chamber.

Keywords：*gas diffusivity, N2O, CO2, Fick's Law*

P1-439

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Nitrous Oxide Emissions from Farm Effluents Application on a New Zealand Pasture

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Nitrogen (N) losses via nitrous oxide (N2O) emissions from land application of farm effluents in New Zealand are one of the major contributors to environmental degradation. Understanding the extent and seasonal variation of N2O emissions from dairy effluent is important for the development of best management practices for reducing N2O losses. A one-year field experiment was conducted on a pasture site at AgResearch's Ruakura dairy farm in Hamilton, New Zealand to quantify N2O emissions from different types of dairy effluent application to a pasture soil in different seasons during 2012 and 2013 and evaluates the potential of dicyandiamide (DCD) to reduce gaseous N2O losses. Fresh or stored manure and farm dairy effluent (FDE), with and without DCD (10 kg ha-1) were applied to field plots on a free-draining volcanic parent material soil in three contrasting seasons. The nutrient loading rate of FDE and manure, which had different dry matter (DM) contents was 100 kg N ha-1. N2O emissions were measured in the field using closed chamber technique. Some soil properties like soil pH, soil moisture and mineral N were measured along with the N2O flux measurement to assess their correlation with variation observed in N2O flux.

Results showed that application of manure and FDE, both in fresh and stored forms, to pasture generally increased N2O emissions compared to the control. Overall N2O emissions from effluent-derived N ranged between 0.01% and 1.9% depending on application seasons and effluent types. Comparing the N2O emissions from all the treatments for the three seasons applications indicated that the proportion of applied N emitted as N2O from effluent applied in spring and autumn were higher than in summer application, because of the generally drier soil conditions in the summer ($P<0.05$). Among the effluents, higher N2O emissions were from fresh FDE (1.7 % of the total added effluent-N) during the spring measurement period, stored manure (1.9% of the total added effluent-N) during the autumn and stored FDE (0.25% of the total added effluent-N) during summer application. The NI, DCD, was effective in decreasing N2O emissions from stored FDE, fresh FDE, fresh manure and stored manure by 24 to 83%, 40 to 80 %, 69 to 76 % and 64 to 68% ($P<0.05$), respectively during the three seasons. DCD was more effective in reducing N2O emission in the spring and autumn seasons compared with the summer season. Our results suggest that a reduction in the use of effluent under wet winter and spring or late autumn conditions in New Zealand could potentially reduce N2O emissions from application of effluent. NIs could further reduce N2O emissions by reducing the levels of surplus mineral-N.

Keywords：*Nitrous oxide, Farm dairy effluent, Manure, DCD*

P1-440

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Mitigation of Ammonia Emissions from Cattle Manure Using Organic Amendments

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Cattle feedlot manure loses 75-80% of N, mainly in the form of nitrous oxide (N2O) and ammonia (NH3). Mitigating these emissions is a global environmental concern. Laboratory incubation study was conducted for 30 day period in 9 chambers (0.49 x 0.33 x 0.33 m) at 20±1 oC, to evaluate the effects of lignite and willow-wood biochar, on NH3 emissions from cattle manure. Synthetic manure matrix (rockwool + synthetic cattle urine + urease enzyme) was filled into the chambers and treated with lignite and biochar, at 30 t/ha rate. Synthetic urine was applied into the chambers, at a rate of 0.43 l/m2. Experiment was arranged in a RCBD design with 3 replicates. NH3 from chambers was trapped in a 0.05 M H2SO4 solution and manure medium was analysed routinely for NH4+ and urea retention, organic C and N, 15N, moisture content and pH. Highest NH3 emissions were recorded during the first 2-3 days of incubation. Ammonia losses from manure amended with lignite were significantly ($p < 0.01$) lower (30 times) than biochar amendment and control. Lignite amendments resulted in significantly ($p < 0.01$) higher NH4+ retention (73%) compared to biochar (2%) and control (8%). Lignite achieved the maximum retention of NH4+ within 6-7 days and then stabilised over the rest of the duration. Urea hydrolysis was completed within 3-4 days in lignite and biochar treated chambers, and this can be related with the highest emissions of NH3 within first 2-3 days. Lignite treated medium maintained a pH of 4.5 throughout the experiment while biochar and control chambers resulted a pH of 8-9. Thus lignite shows a great potential in reducing NH3 emissions from cattle urine compared to the wood-based biochar.

Keywords：*Ammonia, greenhouse gases, manure, lignite, biochar*

P1-441

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Modeling GHG Emissions, N and C Dynamics in Spanish Agricultural Soils

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To date, only few initiatives have been carried out in Spain in order to use mathematical models (e.g. DNDC, DayCent, FASSET y $SIMS_{NIC}$) to estimate nitrogen (N) and carbon (C) dynamics as well as greenhouse gases (GHG) in Spanish agrosystems. Modeling at this level may allow to gain insight on both the complex relationships between biological and physicochemical processes, controlling the processes leading to GHG production and consumption in soils (e.g. nitrification, denitrification, decomposing, etc.), and the interactions between C and N cycles within the different components of the continuum plant-soil-environment. Additionally, these models can simulate the processes behind production, consumption and transport of GHG (e.g. nitrous oxide, N_2O, and carbon dioxide, CO_2) in the short and medium term and at different scales. Other sources of potential pollution from soils can be identified and quantified using these process-based models (e.g. NO_3 y NH_3).

In November 2013, the Spanish Group on Agrosystems Modelling (ReMSAE) was created in the framework of the Spanish Network on GHG Mitigation in Agriculture (REMEDIA). The aim of ReMSAE is to modeling GHG, N and C dynamics in agricultural systems using four different process-based models (DNDC, DayCent/CENTURY, FASSET and $SIMS_{NIC}$) in three contrasting Spanish agrosystems: irrigated crops in Central Spain, rainfed crops in the Northeast and grasslands and forage systems in the North.

DNDC (DeNitrificationDeComposition) (Li, 2000) model is a mechanistic process-based model largely used by the scientific community (i.e. more than 2000 research paper published based on it). Added to the spread use in all continents, and in different ecosystems and conditions, DNDC modelers have produced emission estimates rather similar than the measured ones. On the other hand, the DayCent model (Parton et al., 1998) was developed in the Natural ResourceEcologyLaboratory (NREL) (Colorado, EEUU) in the middle 90´s. It is a dynamic biogeochemical model that allows the simulation of GHG emissions from agricultural soils. DayCent is the daily version of Century model (Parton et al., 1987) used to simulate changes in organic matter dynamics at monthly basis. FASSET (FarmASSEsmentTool) is a dynamic model at farm level useful to simulate soil processes in a daily basis by using information on the crop growth, cattle management, production and management of farm goods. It was developed in the Agroecology Institute of the Aarhus University (Denmark) (Berntsen et al., 2003). Finally, N and C balances at plot and/or farm scale can be simulated by the mechanistic model SIMSNIC (Nitrogen Simulation in Cropping Systems) (Gallejones et al., en rev.). Of recent creation and focused on crop rotations, this model will be also used by ReMSAE. It was developed, using a mass-balance approach, based on N data from field campaigns (i.e. winter wheat crops) in contrasting Spanish areas, and the effect of weather, soil and crop management are among its outputs.

The outcomes of this modeling activity will be focused on validating the mentioned models by comparing the generated estimates with experimental data from field campaigns, already carried out in the framework of national and international projects. Additionally, this work will support the process of calculating emission factors for Spanish agriculture. The aim of ReMSAE is to show some of this work in the 20th World Congress and Soil Science.

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Mechanisms Involved in Greenhouse Gas Emission from Saline Paddy Soils in Bangladesh

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Soil salinity, as an increasingly important process of land degradation, is a major threat to microbial communities and thus strongly alters organic matter turnover process. A laboratory incubation experiment was conducted to assess the effect of rice straw addition in Bangladeshi saline paddy soil on its microorganisms activities resulting in an increased mineralisation and soil respiration. Soil samples were collected from two locations like Batiaghata (B) and Dumuria (D) in Bangladesh. Both soils were then incubated with the percentage of incorporated rice straw (0, 25 and 50%) and three levels of salinity (0, 15 and 50 mg NaCl g-1soil) for 28 days at 25°C.

Result showed that soil respiration reduced with the increase of salinity at different days after incubation in both B and D soils. Although basal respiration declined due to elevated salinity, but due to addition of rice straw, basal respiration was increased in both soils B and D. The ergosterol content were too low and ranged from 0.0959 to 0.2663μg g-1 in both soils B and D with and without substrate addition. Result also showed that addition of rice straw significantly improved the microbial biomass C contents in saline paddy soils treated with NaCl. The ergosterol-to-microbial biomass C ratio was an evidence of fungal dominance in the soil. The ratio increased with elevated salt content, either showing a shift towards fungi, a change in fungal cell morphology, or accumulation of ergosterol in the soil. In addition, both respiratory activities and metabolic quotient qCO2 significantly decreased after the soil treatment with NaCl together with rice straw. The NaCl alone decreased the microbial biomass, rice straw alone as organic substrate was mineralized and utilized by soil microorganisms for their metabolism. The findings were suggested that soil microbial biomass were highly sensitive to salinity and rice straw can be used as a good source for amendment of saline paddy soil. Thus, rice straw can improve soil fertility not only through the release of nutrients in the soil by mineralization but also adding soil organic matter and thereby decrease soil salinity. This study recommended that part of rice straw need to be retained in the saline paddy field in Bangladesh that will help to increase soil health, reduce greenhouse gas emission and improve productivity of saline paddy soil along with declined soil salinity.

Keywords：*Soil respiration; metabolic quotient (qCO2); electrical conductivity; mineralization; nitrification*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Weak Correlation between Methane Production and Abundance of Methanogens across Three Brackish Marshes Zones in the Min River Estuary, China

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Methane production is influenced by the abundance of methanogens and the availability of substrates. Sulfate-reducing bacteria (SRB) also play an important role in the anaerobic decomposition of organic matter. However, the relationships between methane production and abundance of methanogen, pore water substrates in estuarine brackish marshes are poorly characterized, and even to our knowledge, no published research has explored the relationship between methane production rate and pore water dimethyl sulfide (DMS) concentration. We investigated potential methane production rate, abundances of methanogens and SRB, sediment organic carbon contents, concentrations of pore water substrates (acetate and DMS) and terminal electron acceptors (SO42?, NO3? and Fe3+) at a brackish marsh landscape dominated by Phragmites australis, Cyperus malaccensis and Spatina alterniflora marshes zones in the Min River estuary. The average rates of potential methane production at a sediment depth of 30 cm in the three marsh zones were 0.142, 0.058 and 0.067 μg g-1 d-1, respectively. The abundance of both methanogens and SRB in the sediment of the P. australis marsh with highest sediment organic carbon content was higher than in the C. malaccensis and S. alterniflora marshes. Mean pore water DMS concentrations at sediment depth of 30 cm under the S. alterniflora marsh were higher than those in the C. malaccensis and P. australis marshes. Methane production rate correlated weakly with the abundance of methanogens across three marsh zones together, but did not correlate with the SOC content and the concentrations of pore water acetate and DMS.

Keywords：*methanogens; sulfate-reducing bacteria; substrate; electron acceptor; dimethyl sulfide; tidal marsh*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Methane Emission Characteristics of Some Philippine Lowland Rice Varieties

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A field experiment was conducted at Agricultural Experiment Station, Central Mindanao University (CMU), Musuan, Bukidnon, Philippines to investigate methane (CH4) gas emission characteristics of some Philippine lowland rice varieties and to determine varieties which have low CH4 emission but with high yields for use in lowland rice production. It was laid out in Randomized Complete Block Design (RCBD) with six treatments and three replications. Each experimental plot measured 8m x 8m and the treatments are: T1 (no rice plants) as control, T2 (RB 10 line), T3 (Matatag 11 line), T4 (NSIC Rc128), T5 (NSIC Rc158) and T6 (NSIC Rc214). The experiment was conducted for two cropping seasons (September, 2011 to January, 2012 for wet season and February to May, 2012 for the dry season).

Agronomic characteristics of rice as plant height at 30 and 50 days after transplanting (DAT) and number of tillers at 30 and 50 DAT as well as the yield parameters as number of panicles, length of panicles, straw weight and grain yield of the five rice varieties were determined. A closed-chamber method (Rolston, 1986; Ali et al., 2009) was used to estimate CH4 fluxes for the entire cropping periods. Gas samples were drawn off from the headspace of the gas chambers installed in each plot using 50-mL plastic syringes equipped with a 3-way stop cock weekly. Methane concentrations were measured by a gas chromatograph at Soils Laboratory, Gyeongsang National University, Jinju, South Korea.

Results of the study in both cropping seasons revealed that the rice varieties were significantly different in most agronomic characteristics and yield parameters. Also, CH4 emission rates in plots without plants were significantly higher than those in plots planted with the different rice varieties. Furthermore, methane emission significantly differed among the rice varieties. Of the five varieties used, two were identified to have significantly high yields but significantly low total CH4 fluxes.

Generally, methane fluxes during the dry season were lower compared to the fluxes during the wet season. Methane fluxes were not significantly correlated with any of the agronomic and yield parameters of rice measured in this study. Results of the stepwise multivariate regression analysis (MVSTEP) however, showed that the total CH4 flux was affected by the measured plant parameters in the decreasing order of: grain yield, tiller number, straw weight, panicle length, panicle number and plant height but with low coefficients of determination ($r2 = 0.293$ during the wet season and $r2 = 0.328$ during the dry season). These suggest that the measured parameters of rice accounted only 29.3% and 32.8% of the variation in the total methane flux during the wet season and dry season, respectively. Hence, other anatomical and physiological characteristics of the rice plants which were not included in this investigation might be responsible for the 70.7% and 67.2% variations in total CH4 fluxes during the wet season and dry season, respectively.

Hence, proper selection of low-CH4 emitting variety be considered to minimize annual CH4 emissions in Philippine paddy soils and further studies on screening rice varieties with the inclusion of other anatomical and physiological characteristics for suitable eco-friendly mitigation of methane emission be conducted.

Keywords: *gas chamber, methane flux, global warming, mitigation, greenhouse gas*

P1-445

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Effect of Warming and Precipitation Increase on Extracellular Enzyme Activities and Ghgs Fluxes in an Arctic Tundra Soil

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Global climate change models predict surface temperature and precipitation will increase, in particular, in polar region. Arctic tundra soil contains much of terrestrial carbon and this carbon storage may be vulnerable to decomposition under potential climate change. Research group in KOPRI (Korea Polar Research Institute) has conducted manipulation experiment increasing temperature and precipitation at an arctic soil in Cambridge Bay, Canada. During growing season, Open top chambers were installed and distilled water was added to soil every week. This study investigated extracellular enzyme activities which are related to decomposition process and GHGs (carbon dioxide, methane and nitrous oxide) fluxes after one year experiment. Hydrolases (β-D-glucosidase, cellulase, β-N-acetylglucosaminidase and aminopeptidase) activities did not show differences among treatments, however, phenol-oxidase showed higher activity at warming and precipitation increase plot than control plot. GHGs fluxes were not significantly different among treatment after one year experiment, however, methane emission showed week trend to increase at warming plot. Furthermore, carbon and nitrogen stable isotope ratio of soil and plants are being analyzed. Because phenolic compound can inhibit hydrolases, it looks relationship among phenol oxidase, hydrolase activities and soil respiration need to be monitored for long term experiment.

Keywords：*Tundra soil, Extracellular enzyme activity, Warming, Precipitation increase*

P1-446

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Research of Cultivation Techniques for the Reduction of Fertilizer in Greenhouse

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This experiment was performed to select optimum fertilizer type and amount in greenhouse in order to reduce salt accumulation and increase tomato yield. Treatments were non-fertilizer, based on soil-testing, 80% of based on soil-testing, farming practices respectively. A fertilizer used in the farming practices 1 were commonly used fertilizer 14 - 7 - 21 and farming practices 2 were potassium nitrate etc by using hydroponic cultivation. Irrigation methods were applied to the methods of National Institute of Agricultural Science and Technology. The height of plant was the best 194 cm at treatment of farming practices 2. The best response yield of tomato was 3,467 kg/10a at treatment of 80% of based on soil-testing. After the experiment, pH of soil was 6.0, 5.6 at treatment of based on soil-testing, farming practices 1 respectively. EC was the highest 3.2 dS/m at treatment of farming practices 1. Water-soluble nutrients were maintained at an appropriate level during the cultivation.

Keywords：*Greenhouse, Based on soil-testing, Tomato, Fertilizer*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Assessment on Ghgs Emission from the Cropland Sector in Korea

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Farming methods influence at agricultural ecosystem that affect greenhouse gas fluxes. These involve transformation of carbon and nitrogen that are driven by the biological and physical processes.

This study was conducted to assess the greenhouse gas (GHGs) emissions from the cropland sector in Korea since 1990. The GHGs emissions from the cropland sector are calculated in three categories such as rice cultivation, agricultural soil and field burning by IPCC guideline. In the rice cultivation, the GHGs emissions have decreased from 12,083 CO2-eq Gg in 1990 to 6,813 CO2-eq Gg in 2011. The GHGs emissions from paddy field in Korea showed that it was gradually going down as the cultivation area decreased. In the agricultural soil, the total amounts of GHGs emissions have also reduced from 6,370 CO2-eq Gg in 1990 to 5,759 CO2-eq Gg in 2011. In the field burning of crop residue, it showed little changes from 43 CO2-eq Gg to 44 CO2-eq Gg with same duration. The total amounts of emission from the cropland sector have reduced by 31.8% from 18,496 CO2-eq Gg in 1990 to 12,616 CO2-eq Gg in 2011.

Keywords：*Greenhouse gases (GHGs), Carbon dioxide (CO2), Paddy field, Field burning, Crop residue*

P1-448

[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Specific Inhibition of CH4 Production in Soil Using Chemical Analogue of Coenzyme M: A Presequester of Methanogenesis

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Methane (CH4) is the second important greenhouse gas and its annual contribution to global warming is about 40%. Rice paddies are a major source of CH4 emission contributing 12% of the total anthropogenic CH4 budget. CH4 production is mainly carried by methanogens through methanogenesis. During methanogenesis, coenzyme-M (Co-M) is methylated to methyl Co-M (MeCo-M) by methyl transferase for subsequent reduction into CH4 by methyl reductase. A chemical analogues having similar structure with Co-M makes competitive inhibition to obtain methyl group and specifically inhibit methanogen activity. We screened three chemical analogues like 2-bromoethanesulfonate (BES), 2-chloroethanesulfonate (CES) and 2-mercaptoethanesulfonate (MES) as a specific inhibitor to inhibit methanogenesis. BES and CES effectively inhibited CH4 production, but MES increased CH4 production. When compared with CES, BES found effective in CH4 production inhibition. The BES considered as best analogue and then tested the effect of BES application (0-0.4mM) on suppressing CH4 emission during rice cultivation in the pot. CH4 emission rate was measured by the closed chamber method during rice cultivation which significantly ($P<0.001$) decreased with increasing levels of BES. High performance liquid chromatography (HPLC) analysis confirmed that the Co-M concentration was decreased in methanogens with increasing concentration of BES and subsequently reduced mcrA gene (coding for methyl reductase) copy number. BES effectively reduced CH4 emission as well as methanogens activity, but total microbial activity was not affected. Also rice plant growth and yield was not affected by BES application. Therefore, it is concluded that BES could be developed as an additive of soil amendment to reduce CH4 emission during rice cultivation.

Keywords：*Keywords: BES application, Analogue, Coenzyme M, Methanogens, CH4 production*

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Dynamics of Methanotrophic and Methanogenic Communities and Methane Emissions in a Flooded Rice Field Ecosystem

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Methanotrophs and methanogens, in conjunction withmethane emissions and soil chemical properties, were investigated in a flooded rice ecosystemduringrice cultivation. Additionally, CH4 emission rates and expression levels of genes encoding particulate methane monooxygenasealpha subunit (pmoA) and methyl-coenzyme M reductasealpha subunit (mcrA), key enzymes for aerobic methane oxidation and methanogenesis, respectively, weremeasured in rice paddies.Methane emission graduallyincreased after rice transplantation (from 7.2 to 552 mg/day?㎡) until 90 dayswas positively correlated with transcripts of pmoAand mcrAgenes, transcript/gene ratios of mcrA, temperature, and total organic carbon. Methane flux was negativelycorrelated with sulfate concentration.Pyrosequencing analysis showed that Proteobacteria,Chloroflexi,Acidobacteria, and Actinobacteria were predominant in the bacterial community. Methanotrophs represented only a small proportion (0.79-1.75%) of total 16S rRNApyrotag bacterial reads: Methylocystis(type II methanotroph) decreased quickly after rice transplantation, while Methylosinusand unclassified Methylocystaceae(type II) were relatively constant throughout rice cultivation. Methylocaldum, Methylobacter, Methylomonas, and Methylosarcina(type I) were sparse during the early period, but they increased after 60 days, and their maximum abundances were observed at 90-120 days. Of 33,218archaealreads,68.3-86.6% were classified as methanogens. Methanosaeta,Methanocella, Methanosarcina, and Methanobacteriumweredominant methanogens, and their maximum abundances were observed at days 60-90. Only 4reads were characteristic of anaerobic methanotrophs,suggesting that anaerobic methane metabolism is negligible in this rice paddy system.Methanosaetawaspredominant during the rice cultivation and Methanocella, Methanosarcina, and Methanobacterium were also dominant, and their maximum abundances were observed at 60-90 days. Methanococcusand Methanoregula increased quickly after irrigation practices stopped, and their maximum abundances were observed at 120 days.After completing a multivariate canonical correspondence analysis of our integrated data set, we found normalized mcrA/pmoA transcript ratios to be a promising parameter for predicting net methane fluxes emitted from rice paddy soils.Collective results of methanogenand methanotroph communities, CH4 emissions, soil properties, and expression of pmoA and mcrA genesduring the entire rice cropping period will provide a better understanding of CH4 fluxes in rice paddies.This study was supported by the National Research Foundation of Korea (2010-0026359) of MEST, Republic of Korea.

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[C2.5-3] Mechanism Controlling Greenhouse Gas Emissions from Soils

Comparison of Methanotrophicbacteria Diversitybetween Crop Cultivation and Fallow Seasons in a Temperate Mono-Rice Paddy Soil

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Rice is mostly grown in lowlands under fully irrigated orrain-fed conditions, and therefore its cultivation acts as animportant source of CH4 emission. There were numerous studies done about CH4emission characteristics of rice paddy soils. However, such studies were done only during rice cultivation period without the overall quantification of CH4 emission fluxes. In particular, mono-rice paddy soils like in Korea and Japan are flooded for less than 100 days during the cropping season, and aerobically managed under dry soil condition over 200 days a year. Some of CH4could be consumed by methane-oxidizing bacteria (methanotrophs) in the dried paddy soil during the fallow season.In order toestimate the contribution of paddy fields as a source or sink ofCH4, it is important to monitor the effects of the flooded soil and the dried soil during rice and cover crop cultivation, respectively, on the shifts of soil methanotrophs. In thisstudy, the changes of CH4 emission and uptake rates, and methanotrophic bacteria (MB) community composition were compared in a typical paddy soil during the irrigated rice cultivation and the dried cover crop cultivation. Real-time polymerase chain reaction (PCR) anddenaturing gradient gel electrophoresis (DGGE) based on16S rRNA and pmoA genes, respectively, were used toanalyze the soil methanotrophic abundance and communitydiversity during the field study. The typical patterns of CH4emission and uptake were observed inthe irrigated rice cultivating soil and the dried cover crop cultivating soil, respectively.Methane was emitted with high levels in the flooded soil during rice cultivation, but it was consumed with very low rates in dried soil during cold season. The seasons also significantly differed in the MB community composition between rice cultivation and fallow seasons. Cluster analysis based on the DGGE banding patterns indicated that the MB communities were so different between two seasons. The type II methanotrophs dominated in the flooded soils during rice cultivation, but type I methanotrophs showed significantly higher copy numbers in the dried soils during the fallow season.During the rice growing season, the type II methanotrophs might be more profited from such a coexistence of low O2 and high CH4 concentration environment than the type I methanotrophs.However, type I methanotrophs seemed to be morefrequently detected.Cluster analyses based on the DGGE profileshowed that the methanotrophic community mightrespond more sensitively to the environmental variation.Phylogenetic analysis showed that 81% of the obtained pmoAsequences were classified as type I methanotrophs during rice cultivation. Furthermore,the type I-affiliated sequences were related toMethylobacter, Methylomicrobium, Methylomonas, andsome uncultured methanotrophic clones, and those type IIlikesequences were affiliated with Methylocystis andMethylosinus genera.

Keywords：*rice paddy, methane emission, methane oxidation*

P1-451

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Response of Different Plant Species to Boron Concentrations in Sewage Wastewater and Soil

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Boron is an essential element at trace concentration, but is toxic at 1ppm concentration. Its requirements vary in different plant species. The objective of this research is to investigate the effect of using sewage wastewater in irrigation on B accumulation pattern in monocotyledons (C-4) species and dicotyledons (C-3) species.

Maize (C-4) plant and Mandarine (C-3) tree irrigated for different periods of time using raw sewage water at El-Gabal El-Asfar Faem were chosen for this study. The same plant species irrigated with canal water were used as the control treatment.

Boron content in sewage water and canal water and its distribution pattern in plant organs and the soil profile were determined. The data indicated that, in the two plant species boron accumulated mainly in the root. The use of sewage water in irrigation have resulted in more boron accumulation in the leaf and less in the root comparing with their concentration using canal water.

Keywords：*soil, boron, sewage wastewater, Mandarine, Maize,*

P1-452

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Effect of Foliarblend Micronutrient and Npk 15:15:15 Fertilizers on the Growth and Yield of Maize (zea Mays L.) in North- Central of Nigeria

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Micronutrient deficiencies in African soils are assuming alarming rates and may be responsible for the declining yields and quality of crops. Specifically in Nigeria the situation is not different. During the 2011 and 2012 cropping season, field experiments were conducted to evaluate the effect of combined application of NPK fertilizer and FoliarBlend micronutrient application on yield and growth of maize at Kilankwa (longitude 6.79316E, latitude 8.70545N) and Federal Capital Territory Agricultural Development Program (longitude 7°5´31E, latitude 8°56´29N) in Abuja, Nigeria.

This experiment was done as a randomized complete block design with three replications. The treatments were T1 (300kgNPK/ha); T2 (300kgNPK/ha + 500mls of FoliarBlend in 20 litres of water; T3 (500mls of FoliarBlend in 20 litres of water) and control. Soil samples were collected for the determination of chemical and physical properties before planting. Data on growth parameters(plant height, number of leaves and stem girth) and yield parameters(fresh cob weight , dry grain weight) were also collected and subjected to 2 ways Analyses of Variance (ANOVA) and means separated with Least Significant Difference(LSD) at P=0.05.

The results from the field evaluations showed that combined application rate of 300kgNPK/ha + 500mls of FoliarBlend in 20litres of water produced the highest number of leaves(13), plant height(251cm) and stem girth(8.6cm) compared to the least value of 11,123cm, 6.4cm respectively obtained in the control.

The study also revealed that application rate of 300kg NPK/ha + 500mls of FoliarBlend in 20 litres of water had the highest fresh cob weight (10.4t/ha) compared to the control (3.8t/ha) and grain yield of 2.4t/ha as compared to 1.2t/ha obtained in the control.

Considering the overall result, it can be concluded that combined application rate of 300kgNPK/ha + 500mls of FoliarBlend in 20litres performed best with the highest values of the growth and yield parameters than the sole application of either NPK or FoliarBlend.

Keywords：*NPK 15:15:15 fertilizer, FoliarBlend micronutrients, yield, maize, Nigeria*

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[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Rice Nutrition and Zinc Concentrations in Soil of Thailand

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This project is the subproject of zinc situation in soil of Thailand which concern of the effect of zinc in soil to rice productivity and rice nutrition, zinc formula which suitable for rice growing in the area lack of zinc and also developing of zinc test kid for farmer who can test and manage their soil for high yield and good nutrition of rice. Rice takes up elements from soil to form nutrient substances, when soil lack of some elements that will cause low quality of rice. For good health of the poor farmer who grow rice in unfertile and lack of zinc in their soil, the objectives of this project was to study the concentration of zinc in soil of Thailand and also study rice nutrition grown in those soil. To achieve zinc concentrations in rice field, three rice field soil samples were collected in each of 76 provinces. Two hundred and twenty eight soil samples were collected and analyzed for physical and chemical properties such as BD, field moist, pH, EC, OM and CEC and zinc. The results showed that zinc concentrations were in the range of <0.041-94.1 mg/kg. The average concentrations of zinc was 24.88 mg/kg. The results found that zinc concentration was very low in some area of the Northeastern part of Thailand and can be deficient for growing rice. The paper will be described the nutrition of rice samples collected from the area where zinc sufficient soil, zinc deficient soil and also nutrition in rice grain that zinc was supplied during growing period.

Keywords：*nutrition, productivity, rice, soil, zinc*

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[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Effects of the Ratios of Nitrate, Ammonium and Urea Nitrogen In Nutrient Solution on the Yield and Quality of Hydroponic Spinach

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This study investigated nutrient uptake, yield, and quality of hydroponic spinach as influenced by nutrient solutions containing the same amount of total nitrogen (N) but different ratios of nitrate (NO3-), ammonium (NH4+), and urea ((NH2)CO) forms. Results showed that the NO3--N uptake by hydroponic spinach was highest in nutrient solution with the NO3-:NH4+:(NH2)CO-N ratio of 100:0:0, whereas NH4+-N uptake was highest with the NO3-:NH4+:(NH2)CO-N ratio of 50:50:0. As for trace metal elements, iron and manganese contents of spinach were highest (2527.07 and 36.78 mg?kg-1, respectively) in nutrient solution with the ratio of three N sources at 50:50:0; copper content of spinach was highest (16.31 mg?kg-1) with the ratio of three N sources at 55:25:20; and zinc content was highest (964.66 mg?kg-1) with the ratio of three N sources at 100:0:0. The best quality of spinach in terms of biomass yield, total plant N, soluble protein, and vitamin contents was obtained with the ratio of three N sources at 55:25:20 and 45:25:20. Thus, these two NO3-:NH4+:(NH2)CO-N ratios of N sources in nutrient solution were optimal for hydroponic culture of spinach and can be applied in practical production.

The results of hydroponic culture experiment show that applying nutrient solution with an appropriate proportion of the three N forms is conducive to the improvement of spinach yield and quality; at certain proportions, the uptake and accumulation of certain trace elements by hydroponic spinach are promoted. For different crops, properly changing the type of N sources in the conventional formula of nutrition solution will effectively improve the crop yield and quality or the uptake and accumulation of certain trace elements in the crop. The optimized nutrient solution with appropriate proportions of N sources can be applied for agricultural production practices.

Keywords：*spinach; nitrate nitrogen; ammonium nitrogen; urea nitrogen; biomass yield; vegetable quality*

P1-455

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Foliar Application of Zinc Improves Shoot-Grain Zinc Concentrations of Wheat Decreased by High Available Phosphorus in Soil

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Background: High soil available phosphorus (P) was considered as one of main factors which caused zinc (Zn) deficiency in crops, further impacted human health.
Methods: The field experiments were conducted to investigate the effect of different applied P levels on soil available P, shoot, grain and straw Zn concentrations and contents and their relationships during two crop growing seasons. The applied phosphorus levels were 0 (control), 25, 50, 100, 200 and 400 kg P ha-1. The 0.4% ZnSo4.7H2O was sprayed two times.
Result and Discussion: Compared with control, P application increased soil Olsen-P concentration from 0.1 to 5.7 folds in 2012 and 0.7-8.6 folds in 2013, respectively, and decreased shoot Zn concentration 8.1%-55.8% in 2012 and 18.2%-66.0% in 2013, respectively. Shoot Zn content was increased while the applied P was lower than 25 kg P ha-1, after that it was decreased with the applied P level increasing. The similar results were observed for grain Zn concentrations and contents. There was a significant negative correlation between soil Olsen-P and grain Zn concentration or shoot Zn concentration. However, the foliar application of Zn could significantly improve the grain Zn concentration even if the higher P was applied.
Conclusion: Increasing soil Olsen-P concentration reduced shoot and grain Zn concentrations and contents. Favorable yields and grain Zn concentrations were got at 50 kg P ha-1. Foliar application of Zn could improve poor grain Zn nutrition caused by higher P application.

Keywords：*Zinc nutrition, phosphorus level, winter wheat*

P1-456

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

The Role of Flavonoids in Promoting the Mobilization of Fe and Mn in Soil

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Flavonoids are polyphenolic compounds that can be released by plant roots into the rhizosphere as a result of root turnover, root injury, root decomposition or through root exudation. In the rhizosphere, the released flavonoids can have multifunctional roles, such as protecting plants against pests and diseases, regulating root growth and functions, influencing nutrient cycles (e.g. N cycle), interacting with proteins and make protein N more resistant to microbial degradation, and inducing allelopathic growth effects. Much less is known about their role in interacting with soil constituents and promoting the mobilization of mineral nutrients.

In this research we studied the interactions of three flavonoids which can be actively released by plant roots (quercetin, rutin, and genistein) with two different agricultural soils, one acidic and one alkaline. In addition, synergistic and competitive effects with three organic acids usually found in root exudates (citric, oxalic, and malic acid) were assessed for the mobilization of Al, Si, Fe, Cu, Zn, Mn, Cd, Cr, Ni and Pb by using different combinations of the above-cited compounds.

Mobilization processes strongly depended on the soil type and the nature of the element which is being mobilized. More specifically, citrate out of the three organic acids was the most effective in acid soil while oxalate was able to extract more Cu, Zn and Ni in alkaline soil. Furthermore, in acid soil a synergistic effect by organic acids was observed only for Mn. In alkaline soil this was noticed for Si, while for Al, Cu, Zn and Ni a competitive effect occurred.

While organic acids may be mainly involved in complexation and ligand exchange reactions promoting the desorption of elements from soil minerals, flavonoids appear to promote redox reactions which enhance significantly the solubilization of Fe and Mn. In particular, rutin was 25 times more effective than citrate for Fe mobilization in alkaline soil while quercetin was 50 times more efficient than citrate in extracting Mn from the acid soil. In addition, in combination with citrate, quercetin (at μM concentration) can increase as much as five times the amount of Mn which can be extracted by citrate alone.

The mechanisms by which Fe and Mn are mobilized by flavonoids were also investigated. Differently from citrate, rutin mobilized Fe from the alkaline soil by reducing it to Fe(II) (reductive dissolution). As for Mn in the acid soil, two different mechanisms seem to be responsible of the marked solubilization of this element. When quercetin acted alone, only a reductive dissolution was observed, with the reduction of Mn to Mn(II). When quercetin was combined with citrate, besides the reductive dissolution to Mn(II), Mn was also partly reduced by quercetin to Mn(III) which, in turn, was immediately complexed and stabilized by citrate. The formation of this complex could have contributed to the large Mn mobilization observed.

At last, the effects of flavonoids and organic acids on soil mineralogy are also being evaluated by XRD (X-Ray Diffraction) with Rietveld method and SEM-EDX (Scanning Electron Microscopy coupled to Energy Dispersive X-ray spectroscopy).

Our results confirm the importance of studying the combined effect of root exudates and their influence on the biogeochemical cycle of trace elements in rhizosphere soil.

This research was funded by Italian MIUR – FIRB “Futuro in ricerca”.

Keywords：*flavonoids,organic acids, iron, manganese, synergy*

P1-457

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Coprecipitation with Aluminum Oxides Reduces the Efficiency of Citrate in Mobilizing Cu from Calcareous Soils

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It is known that low molecular weight organic molecules with complexing capability (e.g. carboxylic acids, aromatic compounds, aminoacids, phenolics, etc.), released into the rhizosphere, can interact with soil minerals, causing structure destabilization and desorption processes from mineral surfaces. As a consequence, the solubility of many elements is enhanced thus increasing their availability for plant uptake. It has been demonstrated that one of the most effective organic ligands released by plants is citrate, which can be particularly efficient in increasing mineral nutrients mobility (especially Fe) in alkaline soils.

Experimental evidence showed that in a calcareous soil (pH 8.2, CaCO3 61.8% w/w, Corg 0.86% w/w) citrate (1 mM) was not as effective as for Al, Fe and Mn in solubilizing Cu from soil. In addition, Automated Particle Analyses (APA) using Scanning Electron Microscopy coupled to Energy Dispersive X-ray spectroscopy (SEM-EDX) and Cluster Analysis evidenced the formation of a large number of aluminum oxide (AlOx) particles, about 50% of which contained a significant amount of Cu.

The aim of this research is to demonstrate that under peculiar soil conditions (i.e. alkaline pH, high microbial activity) typically found in the rhizosphere of plants grown in calcareous soils, citrate efficacy in increasing Cu mobility is strongly reduced by coprecipitation phenomena within Al (hydr)oxides.

To do this we simulated the process under experimental conditions similar to those of the real soil (100% calcite, pH 8.2, [Al]=17 mg/l, [Cu]=7 mg/l), gradually reducing the concentration of citrate and thus mimicking the action of soil microorganisms feeding on citrate (as also observed experimentally).

As a result, both Al and Cu solubility data can be fitted by similar logistic functions, clearly showing the interdependence of the two elements. In addition, APA analyses on the solid phase revealed the formation of Cu-containing Al (hydr)oxides almost identical (for size, shape and composition) to those observed in the real sample.

Experiments carried out inoculating soil bacteria in the artificial system are being developed to confirm the active role of microorganisms in favoring the formation of Cu-Al coprecipitates.

The following hypotheses can be drawn from our experimental results:

i) citrate has a very high affinity for Al and can mobilize Al from soil minerals thus promoting its transport through the soil solution;

ii) Al can precipitate from soil solution as insoluble Al (hydr)oxides when the concentration of citrate is reduced of ca. 50% (in our experimental conditions);

iii) microbes are responsible of citrate degradation (>50% in 24 h) as well as the alkaline pH of AlOx precipitation; iv) Cu solubility shows a similar solubility trend as Al, therefore the fate of Cu in solution is related to that one of Al;

v) Cu forms very stable coprecipitates with AlOx, thus being trapped in the solid phase and reducing its solubility.

This study can provide a contribution at better understanding peculiar processes taking place in the rhizosphere where the coexistence of soil, plants and microbes can create microscopic reaction environments where, differently from the bulk soil, unexpected phenomena can occur.

This research is supported by grants from Italian MIUR – FIRB “Futuro in Ricerca”

Keywords：*citrate, copper, aluminum, coprecipitation, calcareous soil, microorganisms*

P1-458

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Detection of Siderophores in Natural Environments

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Siderophores are biogenic chelating agents that are exuded by microbes and plants to facilitate the solubilization and uptake of trace nutrient metals. These molecules thus forge a direct linkage between organisms and the solid phase components of soils, sediments, and aqueous environments. Despite their biological and geochemical importance, many barriers exist to the study of siderophores in the environment. Siderophores are operationally defined and structurally diverse, with over 500 different siderophore structures currently known. In addition, they are thought to occur in low concentrations, which may vary significantly over short spatial distances and time periods. To overcome these barriers, a more rapid, generalized assay is required to assess the effective concentrations of siderophores and related chelating agents in the environment. In this presentation, we summarize our efforts to utilize the chrome azurol S (CAS) assay to quantify siderophores at nanomolar concentrations. The results are discussed in terms of the detection of free siderophores in natural waters.

Keywords：*siderophores, trace metals, exudates*

P1-459

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Cotton Yield and Quality Responses to Sulfur and Zinc Applications under No-Tillage

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Sulfur (S) is an essential macronutrient in plant growth and development. Sulfur deficiencies in crops have increasingly occurred due to less to no addition of S to soil because of increased use of S free fertilizers, greater S removal from soil by crops with enhanced yield and under more intensive cropping systems, less S deposition to soil from the atmosphere due to tightened environmental regulations, and declined use of S containing pesticides. Zinc (Zn) is essential for plant growth and development, but the amount of Zn required by plant is not large. Symptoms of Zn deficiencies have been observed more frequently in Tennessee cotton (Gossypium hirsutum L.) in recent years. However, there is little information available in the current literature on yield and fiber quality responses of cotton to S and Zn fertilization and their interactions, and there are few guidelines about S and Zn fertilization to optimize cotton yields and fiber quality in Tennessee and other states in the Cotton Belt region. The objectives of this study were to examine the effects of S and Zn applications and their interactions on cotton lint yields and fiber properties of economic importance under no-tillage and estimate S deficiency impacts on cotton yield components. A field experiment was conducted on an S- and Zn-deficient soil at Jackson, TN in 2007-2010, to evaluate cotton yield and fiber quality responses to S and Zn applications. Sulfur treatments of 0, 11, 22, and 34 kg S ha^{-1} were broadcast before planting. Zinc treatments of 0 and 0.29 kg Zn ha^{-1} were foliar applied at matchhead square. A container-grown cotton trial was also conducted to study the effects of S deficiency on yield components. Plants were fed nutrient solutions with adequate or low S concentrations. In cotton grown in a non-irrigated Dexter loam soil, application of 22 or 34 kg ha^{-1} of S increased lint yields by approximately 8 to 9% averaged over the three normal growing seasons (2008-2010). Foliar Zn spray had no significant effect on either leaf Zn levels or lint yields. Sulfur or Zn application had no effects on gin turnout or fiber quality properties except that application of 22 or 34 kg S ha^{-1} increased micronaire values by 4 to 5%, relative to zero-S averaged over the three normal growing seasons. Our results suggest that S application is beneficial for lint yields and fiber micronaire of no-till cotton on low S testing loam soils in Tennessee and similar environments. However, a single foliar spray of Zn fertilizer during the early growing season may not be effective in improving cotton Zn nutrition or lint yields and quality on low Zn soils. In container-grown cotton, low S treatment induced visible S deficiency symptoms and reduced S concentration in leaf, but concentrations of other nutrients tended to be higher in S deficient plants. Sulfur deficiency reduced seedcotton weight per plant at maturity in three out of four years. Sulfur deficient plants tended to produce fewer bolls per plant, with a greater proportion of bolls at first position fruiting sites. Sulfur deficiency also tended to reduce locules per boll. Our results indicate cotton yield components are affected by S deficiency during key growth stages. In conclusion, more attention needs to be paid to potential S requirements of no-till cotton in Tennessee and other cotton producing states where more S deficiencies may be occurring because of increased use of S-free fertilizers, enhanced adoption of high yielding cultivars and more intensive cropping systems, and lower atmospheric S deposition.

P1-460

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Interaction between Fe Plaque and Zn Uptake in Rice

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Rice (Oryza sativa L.) is the staple of food of more than 3 billion people globally. As a result, plant nutrient deficiencies affect the health and livelihood of farmers and consumers, particularly in developing countries. Zinc mineral deficiency is particularly common, with over 50% of cultivated rice experiencing deficiency symptoms. The most common cultivation method, paddy (flooded) rice, is particularly susceptible to such deficiencies. Effects include delayed growth and flowering, lower biomass, reduced and delayed yields. Furthermore, any Zn deficiency in the plant during rice growing can adversely impact grain Zn concentrations causing deficiencies in humans. In humans Zn is vital for cellular growth and immune system function.

Previous work has shown that Zn deficiency symptoms in rice are not necessarily related to total soil Zn, but rather to the availability of plant accessible Zn (Kirk et al., 1995). The reducing conditions present in paddy soils strongly favour the formation of minerals such as carbonates, hydroxides and sulphides (Kirk et al., 1995), which are not plant accessible Zn forms. However, not all rice cultivars are equally affected by low Zn availability. Some cultivars have greater “Zn efficiency” i.e. the ability to mobilise Zn from these unavailable mineral forms (Wissuwa et al., 2006). Cultivars with greater Zn efficiency experience better growth and higher yields. The increased efficiency may be due to a range of factors, including root induced changes in rhizosphere chemistry.

Under reducing conditions, rice roots exude a range of compounds including protons, organic acids and oxygen, resulting in the oxidation of ferrous bound Fe and the subsequent formation of ferric Fe coatings on the root surface. It has been suggested that the root exudates responsible for mobilising Fe may also solubilise Zn (Kirk et al., 1995). It has been further hypothesised that the speciation in the Fe-plaque itself affects Zn uptake in aquatic plants, since the presence of an Fe coating the surface of roots could both inhibit or enhance the uptake of Zn. We will investigate the role of the Fe plaque, and hence the potential role of root exudation, in the both mitigating Zn deficiency in rice, and mobilising Zn from the soil, in a series of hydroponic and soil growth trials.

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Keywords：*Rice, Fe Plaque, Zn mineralogy, Zn deficiency*

P1-461

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

The Soil Acidity on Wugong Mountain's Meadow Degradation Areas

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Introduction:

Soil acidity directly affects physical, chemical and biological properties, even affects the nutritive element which is necessary for the plant and makes it in poor growth. Phosphorus is the essential element for the plant growth. When it is involved in cell division and the synthesis and transport of characteristics and energy, it has the functions that can't be replaced and it is also an important part of soil nutrients, even the available phosphorus is the main phosphorus resource for the plant. The soil available phosphorus has become the limitation factor of the soil nutrient for the plant. The PH of soil is one of the important properties of soil, changes some properties of soil and is closely related to the formation, transformation and validity of soil nutrient.

Methods:

Sampling methods: respectively take different samples at different elevations, such as 1600 m, 1650 m, 1700 m, 1750 m, 1800 m, 1850 m and 1900 m in Wugong Mountain. There are three repeatedly experimental samples in different elevations of the mountain meadow area (the vegetation coverage is less than thirty percent). The size of experimental sample is one hundred square meters. It has 21 samples at seven elevations. We choose five points at each sample with drilling samples in soil along the two diagonals. The buried depth of one sample is from 0 to 20 cm, and another is from 20 to 40 cm. Each soil sample is about 1 kg. There are 42 samples which need dry and sifting before the experiment.

Test method: 1) The soil available phosphorus: the dried samples through the mesh about 1mm with using acid ammonium fluoride to soak the dyke and molybdenum antimony colorimetric method to determine the soil available phosphorus; 2) The soil hydrolysis of total acidity: the method of the neutral titration of the sodium acetate hydrolysis; 3) Exchangeable acidity: the method of the neutral titration of potassium chloride exchange; 4) The soil pH value: the method of pH potentiometric.

The experimental data uses Excel2003 and SPSS17.0 software for analysis.

Results:

The variational rang of the soil hydrolysis of total acidity, exchangeable acid and soil active acidity (pH value) at Wugong Mountain meadow degradation areas is respectively 14.8 ~ 30.6cmol/kg, 5.1 ~ 9.8cmol/kg and 4.4 ~ 5.0.

Analysis of variance showed that the available phosphorus in soil, the hydrolysis of total acidity and exchangeable acid are significantly higher at 0-20cm soil layer than 20-40cm. The altitude has extremely remarkable influence on water acidity in Soil, but it has no influence on available phosphorus in soil.

PH, the hydrolysis of total acidity in soil and exchangeable acid show a remarkable negative correlation.

Conclusion：

1)The depth of Wugong mountain meadow degradation areas will has influence on the content of organic in soil, temperature, humidity and other factors, and thus it has a remarkable impact on the hydrolysis of total acidity in soil and exchangeable acid.

2) Exchangeable acid mainly include exchangeable hydrogen and exchangeable aluminium, the acidity at the study's area more relies on the impact of exchangeable acid, to be precise, it's restricted by the content of exchangeable aluminium.

3) The available phosphorus in soil at the study's area is mainly affected by the exchangeable acid, and the next is the hydrolysis of total acidity. when the variational range of pH is small, it has little influence on the available phosphorus in soil.

Acknowledgement：

The work reported here has been funded by National Natural Science Foundation of China (30960312) 、（31360177）and National Science and Technology Support Project (2012BAC11B06),The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Wugong Mountain, Meadow degradation areas, Soil acidity*

P1-462

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Variations of Available Nitrogen along the Upland Meadow in Wugong Mountain

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The meadow in Wugong mountain mainly distributed in altitude 1600-1900 m. In this paper, researcher took different altitudes and different extend of the damage of upland meadow in Wugong mountain as the research object to measure the soil available nitrogen. The results show that, the soil available nitrogen content of the top layer soil is higher than that of the follow layer at different altitudes. And with the increase of altitudes, the soil available nitrogen content without interference and that with light interference both peaked at altitude of 1850 meters, Other samples of soil nitrogen content varies with altitude obvious trend, showing a weak correlation with the altitude, and available nitrogen content in the soil that was moderately interfered and seriously interfered reaches a maximum at the lowest meadow altitude of 1600 meters , and showing decreases substantially with increasing elevation.

Acknowledgement:The work reported here has been funded by National Natural Science Foundation of China (30960312)、（31360177）and National Science and Technology Support Project (2012BAC11B06),The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Available nitrogen; Wugong mountain; Upland meadow*

P1-463

[C3.3-1] Mobilization of Essential Micronutrients by Exudates

Soil Phosphorus Availability of Plantation in Degraded Sub-Tropical Hilly Red Soil Region

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Three types of undisturbed and homogeneous landform forests, namely, Pinus elleottii forest, Liquidambar formosana forest, P. elliotti-L. formosana forest and naturally restored grassland (control) were randomly selected from the long-term reforestation experimental sites in Jiangxi Province. Three plots with the size of 20m×20m squares were set in each vegetation type. The purposes of this study are to clarify the differences in P and its' availability of soils under different vegetation types and different soil depths in hilly red soil of subtropical region; and to evaluate the advantages and disadvantages in artificial afforestation in hilly red soil of mid-subtropical region. The main research results were as follows: 1. Vegetation restoration in degraded hilly red soil region has greatly changed soil P availability. In contrast to naturally restored grassland (control), the available P, microbial biomass P and organic P in 19-year-old forest soil were improved significantly, and surface gathering was found from each P. Soil available P and microbial biomass P in Liquidambar formosana forest and P. elliotti-L. formosana forest were significantly greater than those in Pinus elleottii forest; 2. O-P, Ca-P and total P in planting sites were significantly lower than those in naturally restored grassland, but an opposite trend was noticed for Al-P and Fe-P;3.Microbial biomass P and available P in rhizosphere soil of plantations were significantly greater than that in non-rhizosphere soil; 4. Soil available P was positively correlated with Al-P, Fe-P, organic P and microbial soil biomass P, suggesting that soil organic P, microbial biomass P, Al-P, Fe-P were potential resources of soil available P in forest soil of red soil region. Revegetation in degraded red soil would be helpful in improving accommodating soil activated P, especially in increasing the integration of Al-P and Fe-P. Better improvement effect was achieved in the broad-leaved forest and broad-leaved and conniferous mixed forest than in coniferous forest.

Keywords：*hilly red soil region; plantation; phosphorus availability*

P1-464

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Management of Sodic Soils Through Cropping and Afforestation

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Soil salinization and sodication are of great concern in arid and semi-arid regions of the world. Salt-affected soils are widely distributed in India which covers about 6.73 million hectare (Mha) of land of which 3.77 and 2.95 Mha are sodic and saline, respectively. About 2.0 Mha of abandoned sodic land is lying unutilized in north India only. Besides, rapid salinization and sodication of land in the irrigated landscape is inflicting unacceptable environment damages. Efforts are underway to rehabilitate such lands in agriculture and forestry sectors as per country's policies. Several institutions are providing science and technology support to manage these lands in productive land-use systems. In this study, monoculture plantations of Terminalia arjuna, Prosopis juliflora, a mixed forest ecosystem and agroecosystem (cropland), which were developed by CSIR-National Botanical Research Institute on degraded sodic lands a few years ago, were evaluated for their effectiveness in order to reclaim and rehabilitate degraded sodic lands. Physicochemical, nutritional, biological and biochemical soil properties were assessed in rehabilitated land-use systems, non-sodic soils and degraded sodic lands from two depths (0-15 and 15-30 cm). Afforestation on such lands with monoculture and mixed species and diversified agroecosystem reclaims the soils with different efficiencies.

Physicochemical properties like bulk density, pH, electrical conductivity (EC) and exchangeable sodium percentage (ESP) decreased with the effect of afforestation and cropping over the years; whereas water holding capacity (WHC), soil organic carbon (SOC), soil nutrients increased considerably. Microbial biomass (MB) [carbon, nitrogen and phosphorus], microbial counts, CO_2 flux and enzyme activities (dehydrogenase, ß-glucosidase, protease and acidic phosphatase) showed significant improvement in the soil quality of rehabilitated sites. In comparison to sodic soil, at 0-15 cm soil depth of reclaimed land use systems, SOC, nitrogen, phosphorus, MB (carbon and nitrogen) and activities of studies soil enzymes were significantly greater, while other soil properties showed land use specific trends. The concentration of soil nitrogen and phopsphorus was significantly higher in agroecosystem soils in comparison to monoculture plantations and forest ecosystem. When we compared changes in soil properties of rehabilitated ecosystems to non-sodic reference sites, the indices of microbial biomass C, N, P and enzyme activities were quite low. The activities of soil enzymes such as dehydrogenase, β-glucosidase, protease and acidic phosphatase, except alkaline phosphatase, were lowest in sodic soils and highest in non-sodic soils. These properties were relatively higher in afforested soils in comparison to cropland soils. All the rehabilitated soils have higher bacterial and fungal counts in comparison to degraded sodic land and in these measures the rehabilitated cropland indicated better achievements than that of plantations; but the rehabilitated mixed forest remained superior to all other land use systems. P. juliflora plantation promoted to a group of bacteria i.e. phosphorus solubilising bacterial (PSB).

Soil sodicity and fertility parameters were correlated through appropriate trend analyses (linear, logarithmic, exponential and polynomial) using data across the land use systems (control sodic land, rehabilitated plantations, forest and agroecosystem and non-sodic soils). It was observed that most of the diagnostic soil properties decreased significantly with increasing soil pH or ESP, except alkaline phosphatase. Ca: Na ratio, alkaline phosphatase and protease showed a strong correlation with soil pH; MBC was moderately correlated with pH; whereas organic carbon, total nitrogen, bacterial counts and DHA activity were weakly correlated with soil pH. Similarly, most of the soil properties were negatively correlated with ESP except alkaline phosphatase. Ca: Na ratio, MBC and DHA activities were strongly correlated with ESP. Cropping rotations, mixed plantation, with proper levelling and suitable drainage are the important factors for sustainable development and scientific management of sodic lands in north India.

Keywords: *Microbial activities, Rehabilitation, Sodic soils, Soil enzymes*

P1-465

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effect of Different Leaf Litters on Carbon, Nitrogen and Microbial Activities of Sodic Soils

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The understanding of the effect of leaf litter quality on carbon, nitrogen and microbial activities of sodic soils is limited, while this information is important for better management of sodic soils. There are two main factors i.e. litter quality and soil quality which affect decomposition process and change in soil microbial activities. In this study, we investigated the effect of single leaf litter of Terminalia arjuna (Ta; non-leguminous) and Prosopis juliflora (Pj; leguminous), mixed leaf litters (Ta, Pj, Azadirachta indica (Ai) and Albizia procera (Ap)) and rice straw (Rs; Oryza sativa) on chemical properties and microbial activities of slightly sodic (SS), moderately sodic (MS) and highly sodic (HS) soils during 1 year in vitro decomposition process. We hypothesized that addition of different litters to the slightly, moderately and highly sodic soils would have specific trends of increase in carbon, nitrogen and microbial indices from highly sodic to slightly sodic soils. For this purpose, recently-senesced leaf litter was collected from representative vegetations, i.e. T. arjuna, P. juliflora, A. indica and A. procera plantations. Soils were sampled randomly from sodic land (pH = 10.5, EC = 1.83 dS m ^{1}), monoculture plantations (pH = 8.5, EC = 1.12 dS m^{1}) and mixed forest (pH = 7.5, EC = 1.06 dS m^{1}) and considered as HS, MS and SS, respectively. The equal amount (60 g) of single leaf litter [Ta (C: N = 43) and Pj (C: N = 38)], mixed leaf litters [MLL; 1/4 Ta, 1/4 Pj, 1/4 Ai and 1/4 Ap (C: N = 30)] and Rs (C: N = 107) was added to equal amount (600 g) of SS, MS and HS soils. After addition of different litters changes in soil organic carbon (SOC), available nitrogen (Nav), microbial biomass carbon (MBC), microbial biomass nitrogen (MBN), soil respiration (SR), soil microbial quotient (C_{mic}: C_{org}; the ratio of soil MBC to SOC) and metabolic quotient (qCO_2; the ratio of soil respiration to the MBC) were observed at two months intervals for whole year. The results showed significant effect of different leaf litters, soil types and their interactions on SOC, Nav, MBC, MBN, SR, Cmic: Corg and qCO_2 of all three sodic soils. At the end of the experiment, annual increment in SOC and Nav was highest in MS soil (40 and 45%), whereas soil MB and SR showed decreasing trend from HS soil (39 and 29%) to SS soil (28 and 21%). The highest SOC was mineralised in the MS (42%) and HS (32%) soils containing litter of Ta; although, greater (20%) accumulation of SOC in SS soil noticed when MLL was added. Despite the highest C: N ratio (107) Rs was found as an easily decomposable and efficient for fast accumulation of organic carbon. But maximum increase in soil nutrients, microbial biomass and soil respiration at the end of the incubation was observed in MS and HS soils treated with litters of Ta, Pj and MLL. In conclusion, as far as the aim of this paper is concerned, soil carbon, nitrogen and microbial indices proved to be indicators of the types of litter addition and soils being amended. Study conclude that litter decomposition actively being affected by (i) types of substrate to which various leaf litter types are applied and (ii) types of leaf litters being applied to various types of substrates. The study reveals that moderately and highly sodic soils comparatively showed fast decomposition of litters and significant increase carbon, nitrogen and microbial activities.

Keywords：*Litter decomposition, Microbial biomass, Microbial quotient, sodic soils, soil respiration*

P1-466

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effect of the Integration Program Recommendation for Soil Management and Fertilizer on Farm and Organic Materials Application on Soil Organic Carbon Stock and Rice Production in Saline Soil, Thailand

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This study aims to investigate the suitable soil management in the rainfed salinity paddy field to increasing soil organic carbon (SOC) stock and rice (Oryza sativa) yield, to study the effect of SOC stock on soil properties, and to study the potential of Program Recommendation for Soil Management and Fertilizer on Farm for reducing the conversion costs for rice production. The trial was conducted in salinity area in Khon Kaen Province, Thailand during 2011-2013. A randomized complete block design was employed with three replicates per treatment that were a farmer method (control), and six combined chemical fertilizer and organic materials (compost fertilizer, rice husk, Sesbania rostrata) treatments. As chemical fertilizer rates were calculated by Program Recommendation for Soil Management and Fertilizer on Farm that has been developed by Land Development Department. The field experiment was set up on Kula Ronghai series (fine-loamy, mixed, active, isohyperthermic Typic Natraqualfs) and rice variety is RD.6. Soil samples were collected before and after the experiment at 0-15 cm. depth and analyzed soil chemical and soil physical properties. The study showed that applying chemical fertilizer incorporate with plowing down Sesbania rostrata 12.5 ton/ ha in saline paddy field (ECe 5-9 dS/m) could maximize SOC stock (76 %) and rice yield (79 % comparing with farmer method). This technique provided the highest benefit. Also rice yield was enhanced by increasing SOC stock. Moreover, the trial pointed that the SOC stock is related with organic carbon in organic residual. As the effect SOC stock on soil properties, increasing SOC stock has a positively correlation with soil organic matter, cation exchange capacity, nitrogen, and calcium but it is negatively relation with sodium in soil. Furthermore, Program Recommendation for Soil Management and Fertilizer on Farm was effective at calculation fertilizer rates to suit the soil characteristics, thereby reducing the cost of chemical fertilizer for rice production in saline soil.

Keywords：*saline soil, soil organic carbon(SOC) stock, organic material, rice production*

P1-467

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Soil Salinity Variability and its Driving Factors at Multiple Spatio-Temporal Scales in the Oasis Of Xinjiang, China

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Locating in the inland arid area of central Asia, salt-affected farmlands in Xinjiang take up one third of its total irrigated land area. Spatio-temporal variability of soil salinity and the underlying mechanism are fundamental problems challenging the sustainability of oasis agriculture in China. In this study, data on total dissolved solids (TDS) were measured for soil samples collected from 27 representative study areas. The coefficient of variation (CV) and stratification ratio (SR) of TDS were used to describe lateral and vertical soil salinity variation, respectively. Weekly, monthly, and annual changes in soil salinity were also determined. Results showed that the soil salinity at 0-20 cm was highly variable (CV > 75%) for most studied areas. Lateral variation of soil salinity was significantly correlated with the sampling interval, as a result, a maximum interval of 9 m was found for reducing evaluation uncertainty. Salt in top 0-20 cm soil accounted for about 25.2% of the total salt in 0-100 cm soil. Average SR value of 20-40 cm to 0-20 cm was 0.92. Irrigation reduced salinity in top soil by 0.52 g kg^{-1}, and 14.6% within the first week. On average, soil salinity from May to September was 58.2%. A 27-year experiment indicated that cultivation increased soil salinity by 44.4% at a rate of 0.14 g kg^{-1} $year^{-1}$. At small spatio-temporal scales, soil salinity variation was mainly affected by anthropogenic factors, such as irrigation and land use. However, natural factors, including groundwater, topography, and climate conditions mainly influenced soil salinity variation at large spatio-temporal scales. This study displayed the highly variable nature of soil salinity in space and time. Those driving factors identified in this study can provide guidelines for developing sustainable agriculture in oasis and combating salinization in other arid regions of the world.

Keywords：*soil salinity, soil salinization, spatial and temporal variations, oasis*

P1-468

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Dynamics and Driving Forces of Salt-Affected Land Degradation in the Yellow River Delta

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Taking Kenli County in the Yellow River Delta, China, as the study area, using field survey data and digital satellite remote sensing Landsat-TM and CBERS-CCD images, this paper aims to delineate dynamic changes and driving forces of salt-affected land degradation in the Yellow River Delta region. Land degradation information was extracted by a decision tree classification model and establishing a Land Degradation Index (LDI), based on the systematic spectral analysis of ground objects in the study area. Spatial and temporal changes were detected by comparing land degradation grades in different times and in sub-regions divided in the study area. A buffer analysis was performed to analyze land degradation spatial variations with the distance to Bo Sea and to the Yellow River. Comparison and correlation analysis were also carried out between LDI and related natural and human induced factors, to identify driving forces for salt-affected land degradation. The results showed a dramatic change of salt-affected land degradation in the study area, with an overall land degradation tendency of heavy-light-heavy from 1987 to 1998 and 2005. Land degradation was spatially close related with the distances to Bo See and the Yellow River. High evaporation-precipitation ratio and highly concentrated shallow groundwater, as well as adverse human activities such as reclamation of grassland, excessive use of farmland, and irrational use of water were driving forces to salt-affected land degradation in the study area. This study provided a remote sensing approach and useful information for the sustainable utilization of land resource and environment protection in the Yellow River Delta region.

Keywords：*salt-affected land degradation; dynamic change; driving force; the Yellow River Delta; remote sensin*

P1-469

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effects of Sodic Soil Reclamation Using Flue Gas Desulphurized Gypsum on Soil Pore Characteristics, Bulk Density, and Saturated Hydraulic Conductivity

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Soil pore structure is critical to water, air, and solute movement in soils. Sodic soil reclamation using flue gas desulphurized (FGD) gypsum is expected to improve soil physical characteristics. However quantification of complex pore structural changes during the reclamation process, as well as their relationships to sodic soil properties, remain elusive. The objectives of this study were to evaluate the impact of different sodic soil reclamation methods using FGD gypsum on soil pore parameters based on computed tomography (CT) and to identify quantitative relationships between sodic soils pore parameters and saturated hydraulic conductivity (Ksat). A field experiment with nine different treatments (three levels of FGD gypsum amount × three levels of leaching water) was conducted in Hetao irrigation district in northern China. Undisturbed soil cores (40 mm diam. by 9 mm height) were collected with two replicates from four depths (0-10, 10-20, 20-40, and 40-60 cm) in each treatment after two years. Two images were acquired from two specific positions in each soil core using a Micro CT with 0.034 mm × 0.034 mm pixel resolution and then the images were quantified for various soil pore parameters. Soil dry bulk density and Ksat were also measured using intact soil cores collected in situ. The results indicated that the reclamation treatments with both FGD gypsum and leaching water increased soil total porosity, macroporosity, mesoporosity, elongated porosity, irregular porosity, regular porosity, fractal dimension, and Ksat, and decreased bulk density in 0-20 cm depth. However, high water leaching treatment had no positive influence on pore space at 20-40 cm depth. Treatments with only FGD gypsum or leaching water only positively influenced pore structure at 10-40 and 0-10 cm depths, respectively. Macroporosity plus bulk density explained most of the variability in Ksat (R2=0.768). This study offers the quantitative evaluation of changes in sodic soil pore features with various FGD gypsum-based reclamation approaches, which can guide practical reclamation strategy and has implications for enhanced chemical modeling in sodic soils

Keywords：*sodic soil reclamaiton, pore structure, Flue gas desulphurized gypsum, Computed tomography, saturated hydraulic conductivity*

P1-470

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effect of Deforestation on Soil Salinity and Sodicity in Cordoba, Argentina

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Quantification of soil salinity and sodicity following deforestation is important to sustainable management of soil. In the middle-east of the province of Córdoba, Argentina, soils have evolved from dry forest vegetation, where carobs (Prosopis spp) are the most common tree species along with shrubs and a herbaceous layer dominated by grasses. The removal of the dry forest has allowed the production of pasture for livestock or agricultural use, being alfalfa, soybeans, peanuts and corn the most frequent crops. The research site belongs to the geomorphological region called 'flat pampa', has a subnormal topography and soils are silty loam of loess origin. The medial annual rainfall is 800 mm per year with a monsoon type distribution. The average depth and electrical conductivity of groundwater was 4.00 m and 1.30 dS m-1, with clear predominance of sodium bicarbonate salts. Since the native forest exerts a significant control on the regulation of water balance, it is hypothesized that its removal would cause changes in water recharge and evapotranspiration, which are major balance components and, hence, in the redistribution of salts and sodium profile. The objective of the study was to evaluate the effect of deforestation on soil salinity and sodicity under different uses in the middle ? east of Cordoba, Argentina. The selected research area is located at 32 ° 08 ' S latitude and 63 ° 15 ' W longitude. The sites analyzed are: forest, livestock use and agricultural use. Each site was divided, into 'tree' and 'grass' for dry forest, and 'patch' and 'normal' for livestock use and agricultural use, representing the phenomenon of 'patch crop' characteristic of the area. This “patch crop” is characterized by alternating areas of less developed crop with areas where the crop has a normal appearance. The age of the trees that grew in the sampled soils was also estimated. Three repetitions of each site were considered and the samples were extracted from 0-18 cm, 18-38 and 38-60 cm deep, corresponding to the first three horizons. The variables evaluated were electrical conductivity in the saturation extract (ECe), sodium adsorption ratio (SAR), and pH. Data were analyzed by univariate statistical techniques. The main results show that between 38 and 60 cm deep, the higher ECe values correspond to “forest tree ' with an average value of 4.23 dS m^{-1}, the highest values being found in older trees. In 'forest grass ', values are slightly lower, while in the 'agricultural use' and 'livestock use' sites, both for 'patch' and for 'normal', values are less than 1 dS m^{-1} higher content of salts in the 'forest tree' profile is attributed to the fact that the carob roots extract water with salts from the water table and accumulate near the surface in the rhizosphere. They do not leach due to the major absorption rainwater carob roots. The lower salt content of the site 'forest grass' is attributed to reduced rooting depth and thus there is no connection with the water table and hence lower rise of salts due to less groundwater absorption. Regarding SAR between 38-60 cm depth, 'patch' sites being always significantly higher than 'normal' for both 'livestock use' and 'agricultural use'. The higher pH values of 9.36 and 9.21 correspond to the 'patch ' sites for “livestock use ' and ' agricultural use' respectively, while the lowest values correspond to 'forest tree' and ' forest grass', these values being 8.06 and 7.27 respectively. In the first depth evaluated, 0-18 cm, the same tendency is maintained, but with lower values for all parameters considered. It is preliminarily concluded that the removal of the dry forest causes a decrease in salt content and an increase in soil alkalization, inferring from this a possible evolution of the “forest tree” site to the “patch” site and of the “forest grass” to the 'normal' site.

Keywords：*dry forest, pH, sodium adsorption ratio , electrical conductivity*

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[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Using Vis-Nir Spectroscopy for Digital Mapping of Selected Soil Properties in a Coastal Area

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Soil mapping is a process of determining the spatial distribution of physical, chemical and description soil properties and presenting it in an understandable and interpretable form to various users.

In the last 20 years, the advancement of technological and theoretical, have lead to the formation of Digital Soil Mapping (DSM) to meet the requirements of soil science in precision agriculture. Moreover, DSM has attracted more and more soil scientists' attention. In this regard, How to measure, model and map the soil is central to the response.

Fortunately, visible and near infrared reflectance (vis-NIR, 100-2500 mm) is a rapid, proximal sensing method that has great potential for quantifying constituents of dried/ground soil samples. It is becoming increasing important to improve the soil properties prediction and spatial resolution of soil maps as a fundamental information layer for soil classification, mapping and so on.

In coastal China, there is an urgent need to increase land for agriculture. One solution is land reclamation from coastal tidelands, but soil salinization poses a problem. Thus, there is need to map saline areas and identify appropriate management strategies via rapid and accurate approach. In the present study, vis-NIR reflectance spectra collected in the field in-situ were employed as an indicator for the prediction of some soil properties. Stepwise method was used to search for all possible subsets and sort out the best one from a large number of spectral variables. And the PLSR was adopted to build up the predicted model for some soil properties. Our work demonstrated the potential of vis-NIR to predict the SOM, TN, CEC, AN, AP and AK from the field measurements. In this instance, the largest explanation proportion for AP achieved 98.9% with an RMSE of 2.92, and the RPD value of 9.98 is evidence of an acceptable model; even the smallest one for TN can explain 87.4% with RMSE and RPD of 0.56 and 3.15, respectively. Digital mapping of the measured and predicted soil properties showed similar patterns and value ranges, though there are some minor differences between them. The results demonstrated the ability to use this methodology as an indicator for rapid and reliable soil assessment and mapping. Secondly, the results indicated that ordinary kriging method can be used to create a contour maps of the predicted soil properties and that these maps are comparable to the measured soil properties. The use of these techniques will facilitate the implementation of assessment and digital mapping the soil properties by a rapid and reliable form.?

Keywords：*Visible and near infrared reflectance (vis-NIR); Digital soil mapping (DSM); Stepwise regression; Pa*

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[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Shallow Sand-Filled Niches Beneath Drip Emitters Made Reclamation of an Impermeable Saline-Sodic Soil Possible: Ameliorative Effect on Soil Nutrients and Related Enzymes Activities

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Shallow sand-filled niches beneath drip emitters while cropping with Lycium barbarum L. was adopted to reclaim an impermeable saline-sodic soil, with ECe = 10.3 dS m-1, pHs = 9.4 and SAR = 38.9 (mmol/L)0.5, in 0?40 cm, in Ningxia Plain, northwest China, and considerable reclamation was achieved. However, nutrient behaviors and related enzymes activities during the reclamation also affect land productivity of salt-affected soils, and require detailed evaluation, so soil transects with different planting years were intensively sampled, and then the water and salt properties, total and available nutrients, and urease, alkaline phosphatase and sucrase activities were assayed. The results showed that the soil nutrients status and the enzymes activities were improved significantly, with the amelioration of soil water-salt environments. After 3 planting years, the soil total N and organic C content in root zone were 0.50 g kg-1 and 4.39 g kg-1 respectively, increased by 63.9% and 16.3% compared to the uncultivated. With a low available P in uncultivated soil, the reduction in soil pH mobilized some nonavailable soil P after planting, and the available P contents increased considerably. Extremely very low enzymes activities were detected in the original soil, and increased remarkably with the increasing planting years. Significant increase in enzymes activities generally occurred after 2 planting years, and the levels decreased with the increasing soil depth. In a word, a beneficial soil nutrients and biological status could be formed in a highly saline-sodic soil while cropping Lycium barbarum L. with drip irrigation.

Keywords：*drip irrigation; enzyme activity; Lycium barbarum L.; takyric solonetz; soil nutrient*

P1-473

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

The Features of Arid Territories Soil Salinization (on The Example Of The Volga Delta)

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Arid territories occupy about 75 million hectares of the Russian territory. There is a number of river deltas among which one of the largest is the river Volga delta within arid territories. River deltas in arid regions are insufficiently studied from the point of view of soil formation proceeding processes. Due to rich natural resources (ground, water and biological) and due to the geographical position river deltas play a special role and have the main ecological and economic value. Here one can find the richest resources such as pasture soils, suitable for all-the-year-round use by various kinds of livestock, water-marsh grounds which are the natural spawning areas for fishes.

Soil salinization was one of the main objects of study in many countries around the world throughout the soil science history. About 10% of the total land area are saline soils of different types with none of the continent has been spared. Saline soils include all soil formations, in which the water-soluble salts are present in the amount exceeding a certain limit and, therefore, have an adversely affect to the physical, chemical and biological properties of soils. As a result, the soil of this type have lowered perfomance.

Diagnostics and characterization problem of soil salinity, despite the long history of the study, is not solved. Characterization of salt processes requires not only a detailed study of individual components and environmental factors that determine the salinity of soils but it also requires exploring the relationship between them. Therefore, knowledge of the mechanism of soil salts distribution, their characteristics, specific character of soils in the Volga delta is a key element of the proper soil use, protection it from degradation and rational use of natural resources.

While choosing the objects of research the following factors were taken into consideration: anthropogenous loading; soil cover complex structure; soil, climatic, geomorphological and hydrological conditions; a variety of vegetative communities typical for deltoid ecotopes. Baer Mounds with adjoining landscapes in the eastern and western parts of the Volga delta can be chosen as these objects. Landscapes included Baer Mounds, spaces around and between them up to water bodies.

Baer Mounds are long (from 150 m up to several kilometers) narrow hills extended in latitude direction. Their height reaches 5-10 m. Desert and semidesert vegetative associations are specific for Baer Mounds. Vegetation is thinned and more than a half of the soil cover is bared. Specific brown and light-brown colour of soils sharply differs from dominating green or reddish space around.

The method of horizontal-section researches was used for the characteristic of contemporary soil cover conditions and studying of physical and chemical properties of mound soils of the western and eastern parts of the Volga delta. As the criteria of horizontal-section choice were the changes of vegetative communities' basic types and geomorphologic conditions. Horizontal-section landscape method allows us to study in detail the soil and vegetation cover, common factors and characteristics of the spatial distribution of soils and plant associations of delta arid areas.

The soil cover of every object has a highly individual water regime determining the drifting of salts and their distribution over the horizontal - section. Topoizopleth analysis of saline soil conditions showed the fact that landscapes are characterized by marked heterogeneity.

Analysis of the obtained material revealed that soil conditions and characteristics of soil salinization in the Volga delta are due to a number of factors that have a certain effect on salt accumulation in the Volga delta.

There are two types of natural ecosystems according to the features of salinity and salt accumulation in the contemporary Volga delta: 1. ecosystems with contemporary automorphic soils 2. ecosystems with contemporary hydromorphic soils. Natural salinity and the processes of contemporary salt accumulation differ sharply in them.

The territory of the Volga delta is characterized by the complexity of soil, determined by salinity. This complexity is defined as the difference in the mode of flooding of different areas of the delta and the presence of specific elements of the relief landscape of Baer Mounds. The combination of processes, desalination and salinity creates diversity in the content of salts in the landscape.

Keywords：*soil covering, arid territories, alkali soils, freely soluble salts, ecosystems*

P1-474

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Chemistry of Salt Affected Soils in Lower Mesopotamian (lmp) in Iraq

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Salt affected soils have been covering more than 70% of Lower Mesopotamian Plain in Iraq. Many researches have been achieved and accomplished concerning to this aspect. Two main types of these soils speared over the agricultural lands at LMP were domestically grouped depending on their morphological and chemical properties. These groups are Sabakh and Shura saline soils. Two locations in mid and southern part of Iraq consisting of both soils were sampled depending on morphological diagnosis of the profiles slashed at these sites. Chemical and some physical properties of each horizon and ground water were fully characterized at summer, Autumn, winter, and spring.

Data revealed that CEC values of these soils weren't as different as each other ranged from 16-27 and 17-26 Cmolc Kg-1 for Sabakh and shura soil respectively. Sabakh soils contained a high percentage of organic matter ranged (33-41) gKg-1 at the upper horizons which makes this soil appear in dark brown colored. Considerable amount of gypsum were found in both soil.

Intensive salinization processes in both soils make ECe values of upper horizons approach to be very high ranged from (390-450) and (130-340) dSm-1 for salt crust of sabakh and Ap horizon to shura respectively. Inverse and considerable relation between ECe and pH (r2= 0.84) was found in sabakh soil, whereas this relation was a trend to be negative and weak relation in shura soil (r2=0.33).

Data of ion accumulations and behaviors were as different as in both soils. Sodium and chloride had linearly accumulated in both soils and might be dependent on ECe. Coefficients of determination (r2) to the correlation of ECe and ion concentration were (0.914 and 0.974) for sabakh soil whereas these values were (0.985 and 0.991) in shura soil to sodium and chloride respectively. Behavior of Magnesium and sulfate was different in both soil. Accumulation of those had been about 80% dependent on electrical conductivity of the saturated extract in shura soil, whereas it was 64 % and 52 % in sabakh soil respectively. Calcium behaved and accumulated mainly on other factors rather than ECe values in both soils, however coefficient of determination values in sabakh was as high as in shura which were 0.334 and 0.112 respectively. Data of salts behavior in both soils manifested that accumulation of sodium chloride was strongly dependent on ECe (99 and 91 %) for shura and sabakh soil respectively. Behavior of Sodium sulfate and magnesium chloride in shura soil was strongly dependent about 97 % on ECe, however sodium sulfate had disappeared in sabakh soil and magnesium chloride might be subjected to other processes in this soil. Calcium chloride accumulation had been partially dependent on ECe (r2= 0.51) in the same soil and certain processes might contribute in reactions of this ion in soil solution. Chemistry of ground water of sabakh soil wasn't as big substantial differences as shura soil.

Keywords：*Salt Affected Soils, Sabakh and Shura*

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[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effect of Carbonate/bicarbonate Ion on Phytosiderophore Release by Puccinellia Chinampoensis Ohwi, Gramineous Plant Tolerant to Sodic-Saline Condition in Northeast China

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At present, area affected by alkalinization and desertification in soil is increasing all over the world, for example, in northeast China northeast China. In such areas; Na carbonate/bicarbonate is accumulated in soil and raise pH value of soil to higher than 9.0. EC value of soil is also much enhanced. High concentration of Na^+, Cl^-, or HCO_3^- is considered to have harmful effects on plant growth. In order to overcome desertification, plants with tolerance to the condition may be useful tools. Puccinellia chinampoensis Ohwi (P. Ohwi) was selected as a tolerate plant to the condition by Jilin Academy of Agricultural Science of China. It can grow on the condition whose pH is around 10.0. P. Ohwi is now utilized for recovery of grass lands in northeast China. We think that the mechanism to tolerate the condition in the plant needs to be investigated. In such conditions, the plants must absorb and utilize metal micronutrients such as Fe effectively. In these experiments, we compared P. Ohwi and barley (Hordeum vulgare), non-tolerant plant, in their activity to release mugineic acid family of phytosiderophores (PS), plant-born Fe chelator specific to gramineae, and examined the activity of the plants to uptake Fe in the sodic-saline condition.

At first, P. Ohwi and barley was grown hydroponically in the growth chamber with 14 hours days at 17℃ and 10 hours nights at 10 ℃ in the medium with 0, 20, 40, and 80 mM $NaHCO_3$. The PS release by P. Ohwi roots was not reduced up to 80 mM $NaHCO_3$. The PS release of barley roots, however, was much reduced at all the levels higher than 20 mM $NaHCO_3$. The reduction was considered to be due to repression in the growth of the barley roots by $NaHCO_3$. It was shown that P. Ohwi could maintain the PS release and grow under the condition with high concentration of $NaHCO_3$. In the next step, barley was similarly grown on the medium with 80 mM NaCl or $NaHCO_3$ and amount of PS produced or released by the roots was measured. The result showed that production and release of PS in barley treated with NaCl were not affected, but those in barley treated with $NaHCO_3$ were much reduced. It was suggested that the PS production and release by the roots were reduced by HCO_3^- and not by Na^+ or Cl^-.

Then, P. Ohwi and barley similarly grown were treated with –Fe deficient medium, whose pH was 10, for 10 days and Fe chlorosis in the shoots was induced. Then, the plants were transferred to the medium containing 80 mM $NaHCO_3$ and PS release of the plants was measured for 3 days. Release of PS by barley was much reduced on the next day of the transfer to the medium with $NaHCO_3$, but that of P. Ohwi did not affected by the treatment of $NaHCO_3$. Similar result was obtained by the treatment with $KHCO_3$. It was suggested that the system for PS formation/release in P. Ohwi had tolerant mechanism to HCO_3^- ion in rhizosphere, and that the plant can release PS under the condition with high concentration of HCO_3^-.

Subsequently, P. Ohwi was similarly grown and treated with the media of –Fe and elevated concentrations of $NaHCO_3$, 0, 40, 80, 120 mM for 3 weeks. The amounts of PS produced and released by the roots were measured. According to the increase of concentration of $NaHCO_3$, dry weights of the shoots and roots were increased and the leaves came to be greener. In addition, amount of PS produced and released by the roots were increased according to the elevation of $NaHCO_3$ concentration in the media. The result showed that $NaHCO_3$ had promoting effect on the plant growth. The soil condition with higher concentration of $NaHCO_3$ was advantageous to the growth of P. Ohwi. Phosphorus concentration in the shoots may be related to the greening of the leaves, because P concentration of shoots is decreased by the treatment of $NaHCO_3$. It was reported that the decrease of P concentration in shoots induced greening of the leaves because of the competing effect of P with Fe. Further experiments to clarify the physiological mechanism of P. Ohwi to tolerate sodic-saline condition will be conducted.

Keywords：*desertification, grass, mugineic acid, phytosiderophore, vegetation*

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[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Aluminum Toxicity in Plants under Sodic-Saline Soils Whose Ph is 10

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Protection of lands for food production is an important global issue. Now the total land area in the world is 148.94 × 10^5 ㎢. It is known that 11 to 12 % of the land surface is generally suitable for food production, and 24 % of land surface is used for grazing. These areas, however, are decreasing because of land degradation every year. Thus, the studies to maintain and promote plant growth in such area where land degradation is proceeding are essential.

Soil sodification is one of the land degradation. It is known that Na_2CO_3 and $NaHCO_3$ accumulate on the surface of soil in some areas in the world, and the soil becomes sodic and saline. As a result, soil EC and pH become high and soil physical properties are aggravated. Especially, sodic-saline soils have high soil pH (approximate pH 10) because of CO_3^{2-} and HCO_3^- coupled with Na^+. The alkaline soil is classified into 2 groups depending on the accumulated salts. One is calcareous soils ($CaCO_3$ accumulated) and the other is sodic-saline soils (Na_2CO_3 accumulated). Sodic-saline soils are located in the inner Eurasia.

Generally, soils contain approximate 7 % of Al, and Al is the most abundant metal in soils. Aluminum is one of the amphoteric metals, so it is dissolved under acidic conditions or alkaline conditions. But the alkaline soils that have been studied mainly in the world are calcareous soils located in the Europe and America, whose pH is approximate 7.5-8.5. Under the pH of calcareous soils, Al is not dissolved. Thus, it has been considered that Al toxicity in plants occurs only in acidic soils.

In the 1st experiment, we investigated the solubilization of Al in sodic-saline soils. The result showed that Al was easily solubilized by deionized water from sodic-saline soils and Al concentration of extracted solution was much higher than those of acidic soils or calcareous soils. Values of pH of sodic-saline soils, however, are higher than that of calcareous soils.

It was also assured in the separate experiment that Al was solubilized in the $AlCl_3$ solution at the pH higher than pH 9. This result was consistent with the fact that much amount of Al could be solubilized by deionized water from sodic-saline soils. Generally, it is well known that Al is harmful to plants when the Al ion form is Al^{3+} and $Al(OH)^{2+}$. There are, however, no clear reports about the toxicity of $Al(OH)_4^-$ which is solubilized under sodic-saline conditions.

At present, there are few reports about plants growing on the sodic-saline conditions. Thus, we are conducting physiological and nutritional studies about monocotyledons growing on the sodic-saline soils. We cultivated hydroponically under the pH 10 condition barley and Puccinellia chinanpoensis Ohwi (P. Ohwi) that is one of monocotyledons tolerlant to the sodic-saline condition. Both plants could grow under pH 10 condition with some repression in the growth as compared to pH 6.0. According to the increase of Al concentration under the pH 10 conditions, dry weights roots and shoots of barley were largely repressed and those of P. Ohwi were not decreased. Aluminum contents of roots of both plants increased. Thus, it is suggested that Al toxicity may be induced in plants at pH 10. Furthermore, it was also found that Al is more harmful to plants under the pH 10 conditions than under acidic conditions (pH≤ 4). This result suggested that $[Al(H_2O)_2(OH)_4]^-$ might be more harmful to plants than $[Al(H_2O)_6]^{3+}$.

In the other experiment; we washed the sodic-saline soils by deionized water. By washing with water, soil EC was much decreased, but soil pH remained higher than 10. Under the natural conditions, when sodic-saline soils are washed with rainfall, soil pH will be kept at 10 and Al may be dissolved in the soil solution. Therefore, Al toxicity may be remained and solubilized Al may aggravate plant growth chronically in sodic-saline soils even after being washed by rainfall.

The results obtained in our study suggest that Al may be harmful to plants in sodic-saline soils. More studies are required about Al toxicity in plants under sodic-saline conditions to prevent expansion of sodic-saline area and promote recovery of vegetation in those areas.

Keywords：*Aluminum, toxicity, sodic-saline, sodium bicarbonate/carbonate, grass*

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[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Isolation and Evaluation of Salt Tolerant Microorganisms and Their Impact in Adaptation of Faba Bean To Salinity Stress.

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Eight isolates were isolated from different locations in Kafr El-Sheikh Governorate. These isolates were cultivated on YMA medium supplemented with different NaCl concentrations (0, 2, 4 and 8 dS/m), using Leonard's jars to evaluate the most salt-tolerant and efficient isolates. The most salt-tolerant rhizobia R2 and R6 were selected in addition to A-mycorrhizae for inoculation of faba bean grown in pots. The soil had artificially salinized with different salinity levels. The results were different in significant, highly significant and not significant. Increased salinity was deleterious for dry weights of plants, number and dry weight of nodules, legumes and seeds. Total chlorophyll, N, P, K, Mn, Zn, Cu and Fe concentrations had also decreased with increasing salinity levels. However, Na concentrations and proline increased in plant and seeds. On the other hand, inoculation with the selected bacterial isolates and/or A-mycorrhizae enhanced the abovementiond parameters except Na%. Salinity had negative effect on the microorganisms of soil and inoculation had the positive effect. In conclusion, salt-tolerant rhizobial isolates isolated from salt-affected soils are more efficient than isolates from normal soils. Application of salt-tolerant rhizobia and/or A-mycorrhizae is beneficial, effective and enhancing plant growth parameters and productivity, under salinity stress conditions.

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Keywords：*Salinity, inoculation, salt-tolerant isolates, A-mycorrhizae, Rhizobium leguminosarum biovar viceae,*

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[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Alas Soils Saline Phytoproductivity Dynamics in Central Yakutia

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The main grasslands of Central Yakutia are alas meadows that make up to 80 % of the forage. The study of the phytoproductivity saline alas soils dynamics was conducted on the basis of stationary alas IBPC SB RAS in 1997-2012. Alas is closed basins system within which over the years is an active accumulation of soluble salts. In alas basin there are three types of soils differing in the degree of salinity. The highest content of soluble salts is observed on alas sod- meadow soils mesophytic habitats. The maximum concentration of salts has been found in the upper layer, where the content of the solid residue comes to 1.34 %, with the depth of the salt content decreases. Magnesium and sodium hydrogen carbonate, sodium carbonate salinity type dominates among the water-soluble substances. Big soda content in the composition of soluble substances causes alkaline reaction of the soil (pH 7.6-8.5). In the composition of vegetation on these soils and the main indicator of salinity is Puccinellia tenuiflora (Griseb.) Scrib. et Merr. as the most salt-tolerant species. This species forms dense (covering up to 75 %), high (50 cm) pure grass stands. The areas with the highest degree of salinity are characterized by the presence of Glaux maritima L. with covering to 30 %. On these saline soils the species composition of communities is uniform, from 3 to 11 species. Nevertheless, this type is one of the most productive alas grasslands. Productivity of meadows for studied period ranged from 15.5 in 1997 to 35.2 c/ha in 2006 (absolutely dry weight), more than 2 times. On average, the productivity of meadows in these soils was 23.1 c/ha.

The sod-meadow soils by salinity are followed by alas peaty-gley soils hydromorphic areas. Type of salinity - hydrocarbonate. The content of the solid residue in the upper layer reaches 0.55% in the salt composition predominate sulfates and sodium hydrocarbonates. The reaction of the soil in the whole profile is alkaline (7.6 - 8.2). The dominant species are Alopecurus arundinaceus Poir. with covering to 70 %, Beckmannia syzigachne (Steud.). In the composition of the grass stand, there are between 6 and 16 species. Here productivity varies from 18.5 in 2003 to 48.3 c/ha in 2005. Average value of this productivity meadows is 36.3 c/ha.

Alas steppe (gray) soils of high xeromorphic sites have poor salinity throughout the profile, especially in the root zone of 0-50 cm In the layer of maximum consumption of moisture (at a depth of 0-10 cm) salt content is more than in other horizons (solid residue content reaches 0.15 %). Alcium and magnesium hydrocarbonates dominate in this horizon in terms of salt composition. Salinity type is hydrocarbonate. The reaction of the steppe soil is alkaline (pH 7.6-8.2). Here the vegetation indicators are Poa pratensis L., Agrostis trinii Turcz., Poa botryoides (Trin. ex Griseb.) Kom. and Elytrigia repens (L.) Nevski covering up to 50 %. Botanical composition of phytocenoses is highly varied: on area of 1 m2 there are from 15 to 37 species of vascular plants. Productivity values vary from 6.9 in 2011 to 21.3 c/ha in 2000. On average, steppe meadow productivity is 11.7 c/ha.

The degree of soil salinity alases has expressed dynamics data, it increases fast in years with insufficient moisture. Productivity phytocenoses decreases when soil salinity increases. Thus, the minimum productivity of wet and steppe meadows was recorded in 2003 and 2011 (18.5 and 6.9 c/ha, respectively) and is associated with an increase in soil salinity of these habitats. In years with the optimum moisture, water content increases and soil salinity decreases which leads to an increase of meadows productivity. For this reason, the productivity of the real meadow reached in 2006 (35.2 c/ha). Thus, the long-term studies of phytoproductivity saline alas soils revealed a close relationship between alas meadows productivity with soil salt regime.

Keywords：*Phytoproductivity, soils saline, dynamics, alas, Central Yakutia.*

P1-479

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effects of Impoundment of the Three Gorges Reservoir on Salt-Water Dynamics in the Yangtze River Estuary

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As the largest hydropower project in China, the impact of the Three Gorges Project (TGP) on the environment has aroused international attention and has been studied from various aspects, which makes the study of the impact of the TGP on the environment very important. This project could change the environment and hydrological regime of the Yangtze River and the estuary area, and affect the salt-water balance, the evolution of soil salinization and ecological environment in the estuary, especially the estuary areas where seawater intrusion is strong and salt-water regime is complicated. For investigating the influence processes of the Three Gorges Reservoir（TGR）on salt-water dynamics in the Yangtze River Estuary (YRE), a field experiment was carried out to monitor the salt-water dynamics, and impact of the project on salt-water movement was assessed. Result showed that the outflow of the reservoir decreased as the result of impoundment process, and the reservoir outflow was affected by the water storage speed. Runoff at Datong station in the estuary was affected by the outflow of reservoir from the result that runoff at Datong station was significantly correlated with the outflow from the TGR. Significant positive correlation was found between the river runoff at Datong station and the river water level in the estuary, and the impact time of the river runoff on the river water level was delayed around 20 days. Similar changes among the runoff, the water level and the river water salinity were observed in the estuary, and the best synchronization is found with 10 to 20 days time lag. A statistical model was established for predicting water salinity of the Yangtze River with data of the runoff and the water level in the estuary, and acceptable agreement was achieved in the prediction model. Significant positive correlation between salinity of the river water and groundwater was also observed, while influence extent of the river water salinity on groundwater salinity is enhanced from distant to the nearby zone of the river's bank. Significant correlation was also found between groundwater salinity and soil salinity, which suggests that salt accumulation in topsoil was closely associated with groundwater or bottom soil salinity under shallow groundwater table circumstance.

Keywords：*Three Gorges Project; salt-water dynamics; the Yangtze River Estuary; impoundment*

P1-480

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Suspended Organic Particulate Reduces Effluent Seepage and Limits Salinisation Under Intensive Livestock Effluent Ponds

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A rapid increase in intensive livestock farms has occurred in recent years in order to address the global demand for meat and dairy products. Intensification of animal head per hectare results in high effluent load per hectare, which must be dealt with regularly. Effluent liquid and organic particulate runoff caused during washing practices and rainfall is usually captured in effluent ponds to avoid overland flow. The effluent and salts are now intensified at a point scale and cause concern for immediate soil and groundwater salinisation due to pond seepage. Contaminated landfill seepage limits suggest that seepage be no greater than 1.0 x 10-9 m/s (~31.5 mm/year), which has been adopted in Australia as an acceptable guideline for effluent pond construction. Typical practices to achieve such a low permeability are to use compacted clay liners. Prior research from Kansas, United States of America, has suggested that sludge layers built up in a matter of days and caused by settled suspended organic particulate can achieve such a low infiltration rate. Further, that the permeability of the clay liner is inconsequential, as the hydraulic gradient of this layer approaches unity due to the sludge layer. However, in Australia, sediment traps are used to filter larger sediment and such sludge layers are not readily observed. This paper investigates the mechanism of pore blockage, in particular blockage cause by organic particulate similar in size to clay, and reports on the ability of two soils to achieve the guideline limit and reduce salinity risk. Subsequently, the guideline limit appropriateness is discussed. A medium clay and sandy clay loam were used. Soils were compacted to 98% of the maximum dry density and pore blockage was shown to occur in majority due to the clay sized fraction of organic particulate. Larger particulate had some additional effect in reducing soil permeability. Guideline limits were achieved for the medium clay and extrapolation of the sandy clay loam showed that the limit would be achieved. Solute leaching, measured as TDS, was reduced by more than 90%. By interaction of compacted clay liners and suspended organic particulate, the salinity risk to the environment was reduced, although further modification of current guidelines could maintain reduced risk and decrease potential invested capital for farmers.

Keywords：*Salinity, effluent, seepage, pore blockage*

P1-481

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Remaediation of Sodic Soil by Calcium Carbonate and Pig Manure Compost

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In the manual for reclamation of saline and sodic soil after Tsunami by the earthquake on March 11, 2011, Japanese government recommends leaching of soluble salts as well as adding calcium amendments. Application of calcium carbonate ($CaCO_3$) is recommended for soils having pH lower than 6, and calcium sulfate ($CaSO_4$) is that for pH higher than 6. However, since $CaCO_3$ has low solubility to water, it has not been often used in reclamation of sodic soils (Shainberg et al, 1989).

Solubility of $CaCO_3$ is controlled by CO_2-H_2O-$CaCO_3$ equilibrium in water. The concentration of calcium ion in water (m_{Ca}^{2+}) is affected by CO_2 concentration of air phase. Partial pressure of carbon dioxide ($[P_{CO2}]$) can approximately determine calcium ion concentration as $m_{Ca}^{2+}=(10^{-6.0}[P_{CO2}]/4)^{1/3}$ (Appelo and Postma, 2005). The higher partial pressure of CO_2 causes the higher concentration of CO_2. In general, addition of organic fertilizer such as manure may enhance soil respiration and increase partial pressure of CO_2 in soil. This may potentially enhance solubility of $CaCO_3$.

Increasing Ca^{2+} in soil solution decreases exchangeable sodium percentage (ESP) of the soil. Lower ESP may inhibit soil dispersion. Dissolution of $CaCO_3$ increases pH. The increase in pH generally enhances soil dispersion and thus reduces aggregate stability. Stability of aggregates has a role on soil permeability, and it affects efficiency of leaching practice.

Objective of this study was to investigate the effect of the CO_2 concentration change by organic manure decomposition on dissolution of $CaCO_3$, and following Na^+-Ca^{2+} ion exchange and permeability of a Tsunami affected soil.

Soil was collected at a former paddy field at Terashima, Miyagi, Japan, where was damaged by Tsunami at the Great East Japan Earthquake. EC (1:5) of the soil was 5.2dS m^{-1}. The soil was mixed with pig manure compost and/or $CaCO_3$, and then packed into plastic columns of an internal diameter of 5cm and a height of 6cm with the bulk density of 0.85g cm^{-3}. Amount of pig manure compost and $CaCO_3$ application was 5t ha^{-1} and 1t ha^{-1}, respectively. The soil columns were incubated at 25℃ for 0, 1, 7, 14 days. During the incubation period, water was supplied periodically to sustain degree of water saturation around 0.5. CO_2 concentration at head space of the columns was continuously monitored to evaluate CO_2 efflux from the soil.

After the incubation, the columns were leached by tap water (EC=0.27dS m^{-1}). The leachate was collected for further analysis of EC, pH and the concentration of Na^+ and Ca^{2+}. After the leaching, the soil columns were separated for each 2cm. Each 2cm thick soil sample was used to measure EC, pH, soluble Na+ and Ca^{2+}, and exchangeable Na+ and Ca^{2+} of the soil.

The amount of CO_2 evolution from the soil with $CaCO_3$, and the soil with both $CaCO_3$ and manure were more than that from the soil with only manure.

During the leaching after the incubation, depression of permeability of the soil with $CaCO_3$ and the soil with both $CaCO_3$ and manure were smaller than that of the soil with manure.

After the incubation and the leaching, soil exchangeable Na+ decreased at all the layers of all the treatment, especially at 0-2cm deep layer. Both the soil with $CaCO_3$ and the soil with $CaCO_3$ and manure showed greater increase in exchangeable Ca^{2+} than the soil with manure. The soil with $CaCO_3$ and manure showed quick increase in exchangeable Ca^{2+} at early stage during the incubation. Those results suggested that higher Ca^{2+} concentration of soil solution following higher CO_2 due to mineralization of applied manure could enhance Na^+-Ca^{2+} ion exchange and restrict reduction of permeability during permeability during leaching by tap water.

Keywords：*sodic soil, calcium carbonate, manure compost*

P1-482

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effect of Soil to Water Ratios on Cation Exchange Equilibria in Salt-Affected Soils: Case Study of Mugerero Paddy Soils in Burundian Lower Rusizi Plain

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Cation exchange properties of salt-affected soils have been studied extensively all over the world. Most of these studies focused on Na-Ca exchange using selectivity coefficients that may vary with intrinsic properties of the soil. The aim of this study was to investigate the effects of soil to water ratios on chemical properties of salt-affected soils of Mugerero paddy area in burundian lower Rusizi plain and to establish the relationship between Exchangeable Sodium Percentage (ESP) and Sodium Adsorption Ratio (SAR). To attain this purpose, nineteen composite samples of the surface horizon were taken from 13 paddy parcels and 6 ancient paddy fields currently abandoned; 34 other samples were collected from three horizons of soil profiles dug in 3 abandoned fields and a rice parcel. After drying and sieving, extractable cations (Ca2+, Mg2+, Na+, K+) were analyzed in ammonium acetate (pH 7) and sodium acetate (pH 8.2) extracts using ICP-AES. Soluble ions, pH and electrical conductivity were analyzed in soil solutions extracted from five soil/water ratio suspensions (w/v) (i.e. ratio 1/2, 1/3, 1/5, 1/8 and 1/12). Exchangeable cations for each moisture content were calculated by difference between extractable cations (Na at pH 7 and K, Ca, Mg at pH 8.2) and soluble cations. Gapon and Vanselow conventions were adopted to assess Na-(Ca+Mg), for estimating ESP-SAR relationship, and Ca-Mg exchange equilibria. Ionic composition values of soil solutions show that all soil extracts, for all soil to water ratios, are dominated by two ions, Na+ and SO42-, which are positively well related (r2 > 0.90) whereas calcium and magnesium concentration are almost equal for all solutions analyzed. Electrical conductivity decreases with increasing moisture content. It has been noticed that univalent soluble cation concentrations (K+ and Na+) expressed in millequivalents per weight unit of soil, exhibit an increase tendency with dilution whilst divalent soluble cations (Ca2+ and Mg2+) decrease with dilution. Moreover, due to valence effect, exchangeable Na and K increase whereas Ca and Mg decrease with increase of water content; ESP therefore decreases with moisture content. Relationship between Exchangeable Sodium Ratio (ESR=ESP/(100-ESP)) and SAR reveals a curvilinear relationship of the form ESR= 0.0003 SAR2 + 0.0074 SAR (r2=0.84) that characterizes Na-(Ca+Mg) exchange equilibrium between the solution and exchangeable phases indicating that Gapon coefficient (KG) is not constant and increases with the increasing sodic charge in solution. However, based on a more rigorous thermodynamic approach by plotting mole fraction ratio between Na and Ca+Mg versus SAR obtained after correcting cation activities for ion pairs, we found that our data are well depicted using a single value of the Vanselow selectivity coefficient (KV=0.5) over the entire range of sodic charge (i.e. up to ESP = 65% in our soil collection). As far as Ca-Mg equilibria are concerned, we found a selectivity coefficient of 1.5 in favor of Ca whereas the classical ESR-SAR approach considers a single pool of divalent cations assuming a same affinity of these cations for the exchange complex.

Keywords：*Salt-affected soils, soil to water ratio, cation exchange equilibria, chemical properties, ESP, SAR,*

P1-483

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Isolation of Salt Tolerant Microorganisms in Salt Affected Soils of East Anatolian Region, Erzurum, Turkey

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Soil salinization is a severe problem worldwide and around 20% of the world's cultivated land and 50% of cropland is affected. Soil salinity adversely affects plant growth or function due to osmotic stress, decreased absorption of essential nutrients or cause ion toxicity. The excessive salt amounts not only affect soil physical and chemical properties, but also the microbiological processes and diversity of microorganism. All of these negative effects in turn prevent seedling emergence and inhibit plant growth. Salinity deteriorates soil structure and plant growth and reduces microbial community of the soils. The maintenance of adequate soil physical and chemical properties in saline land can be achieved by using good quality water, rational use of soil fertilizers, and applications of appropriate microorganisms that tolerate high salt, improve soil properties and increase crop salt stress. It is well known that abiotic stress, such as drought, salt and nutrient deficiency can be eliminated by increasing the number of salt tolerant bacteria. Microorganisms are critical in decomposing organic residues and recycling soil nutrients. In these processes, microorganisms are breaking down complex organic molecules into simpler organic and inorganic molecules. The availability of nutrients in part helps plants to counteract with salt stress. It has been shown that increasing salinity reduces the biomass, diversity of microorganism and species richness. A decline in microbial activity in saline soil may lead to an accumulation of non-decomposed organic substrates, due to slower transformation of organic substances. This will negatively affect the subsequent release of nutrients for plant growth.

In this study, we aimed to isolate salt tolerant bacteria in salt affected soils of East Anatolian region Erzurum, Turkey for the potential use in agriculture. In total 45 salt tolerant bacteria were isolated on Moderate Halophilic medium (MH). The obtained isolates were identified and characterized by conventional (morphology, physiology and biochemical tests) and molecular techniques [fatty acid methyl ester profile (FAMEs) and 16 rDNA]. Regarding the results of phenotypic and genotypic data, 21 isolates were identified at species level and 24 isolates at genus level. In total, we have characterized 15 genus, including Halomonas, Halobacillus, Zhihengliuella, Nesterenkonia, Oceanobacillus, Marinibacillus, Virgibacillus, Jeotgalibacillus, Staphylococcus, Promicromonospora, Planococcus, Terribacillus, Thalassobacillus, Gracilibacillus and Microbacterium. Further studies are required in order to determine the potential of these isolates in improving soil properties and crop salt stress.

Keywords：*Salt-affected soils, halophilic bacteria, molecular techniques*

P1-484

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effect of Land Use Patterns on Soil Carbon Sequestration and Its Management in a Typical Coastal Salt-Affected Area of China

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Salt-affected soils cover approximately 7% of the total land area in the world and they are important potential sequester of soil organic carbon (SOC). Coastal salt affected soils are spread in China along coastline and such soils are charactered with high soil salinity, poor soil physical and chemical properties, low fertility and soil organic matter content. The importance of such soils as SOC sequester is increasing since such soils are still expending in area along with the tidal-flat area exploitation practice in China recent years.

Representing coastal salt affected region in China, Dongtai County of Northern Jiangsu Province is selected as a typical study area for investigating the effects of land use patterns on soil carbon sequestration and regulation of SOC in coastal salt affected area. Space distribution of soil organic carbon in coastal area of Dongtai County was analyzed, and coastal soil organic carbon density and storage were also preliminarily estimated. Based on investigation of the SOC and relevant soil physical-chemical properties of different land use patterns (including uncultivated, upland cropping, paddy-upland rotation and woodland) in different reclamation ages, main factors affecting SOC accumulation in the coastal salt affected area were analyzed, variance of SOC sequestration rate under different land use patterns was compared, and measures on enhancing SOC sequestration were discussed.

The results showed that the SOC of the coastal soils increases gradually from the tidal flat side to the inland. The SOC density is relatively low in newly reclaimed coastal land, while organic carbon densities of earlier reclaimed coastal salt affected soils both in surface layer and in 100 cm profile reached 5 times and 12 times of new land in maximum, respectively. Obvious parallel distribution of SOC variation to the coastline with a strong spatial correlation is observed in the study area. The soil carbon storage in coastal salt affected area of Dongtai county is generally below the average level in Jiangsu Province.

It is showed by comparative analysis of topsoil organic carbon among different land-use patterns in different reclaimed ages that, the SOC increased gradually with the growth of the reclamation years while extent of the increase varied significantly to different land use patterns. The topsoil SOC density of the newly reclaimed coastal mudflat was only 0.305 kg m-2, the lowest. With the natural succession to Suaeda and Phragmites, the SOC density increased by 9.6% and 22.5%, respectively. The highest SOC density was observed as 1.34 kg m-2 in paddy-upland rotation land reclaimed in 1975, which is 91% and 83% higher than that of upland and woodland reclaimed in same year, and even 8.1% higher than that of woodland reclaimed in 1955, respectively. The fastest soil carbon sequestration rate is found in the case of paddy-upland rotation. Land use pattern had more significant effect on soil organic carbon accumulation in coastal salt affected area, comparing to the reclamation age. The soil carbon sequestration rate was 93 kg C hm-2 a-1 in natural succession of coastal salt affected, while the rate reached 288 kg C hm-2 a-1 under paddy-upland rotation. It is suggested that paddy-upland rotation contributes greatly to enhancing soil carbon sequestration rate in coastal salt affected area.

Tillage management was an important factors affecting soil organic carbon accumulation under different land use patterns in coastal mudflat area. In the early natural succession stage of coastal mudflat, high salinity and low fertility were major factors restricting SOC accumulation. Water stable macro-aggregate were significantly increased along with decrease of soil salinity, and such macro-aggregate played important roles in increase of SOC. Straw retuning and mulching could accelerate accumulation of SOC under upland cropping. SOC increased significantly with years of farming under paddy-upland rotation, while available nutrients, clay content, and water stable aggregates increased synchronously along with decrease of soil salinity. The SOC of woodland also increased with the reclamation age, though the increasing extent is not as high as paddy-upland rotation. Higher soil carbon sequestration rates are observed under paddy-upland rotation pattern and under upland cropping pattern with straw retuning and mulching practice in coastal salt affected area.

Keywords：*Salt affected soils, Soil carbon sequestration, Land use pattern, Coastal area, Management*

P1-485

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effects of Drought and Irrigation Water Salinity Increases on Quantity and Quality of Sugarcane Production in South West Iran Weather Conditions

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Increase in irrigation water salinity is one of the serious problems that in the near future make agriculture impossible in many parts of the world.

Like most crops, Increase in irrigation water salinity beyond the threshold values for plants, quality and quantity of sugarcane production will affect. This study was designed to investigate and exactly determine consequences of drought and water salinity increase on the sugarcane production in recent years at the southwestern of Iran weather conditions.

In order to implement this study, daily irrigation water salinity and weather recorded parameters from 2000 to 2012 were collected, then changes in quality and quantity of farm productivity that affected with irrigation water salinity levels and air as well as soil surface and sub surface temperature were compared. Results showed that in this time period irrigation water salinity average increase from 1.44 to 2.53 dS.m-1 (irrigation water salinity average in 2006 and 2012 respectively).

The results showed that after increase in irrigation water salinity from 1.44 to 2.53 dS.m-1, sugarcane and sugar produced reduction 17 and 19% respectively, but lead to a little change in the sugarcane juice quality.

In this period average of summer air and soil surface (0-30 cm) temperatures have 2 and 1 C degree raised and reached to 35 and 29 C respectively.

Irrigation with water that have EC= 2.53 dS.m-1 and summer air and soil surface temperature increase, lead to high salt accumulation in the soil surface and depth, and 16% decrease in soil penetration because of formation more harden of the soil surface layer as well as 20% increase the soil resistance against post harvest tillage operations.

These results showed necessary more attention to water salinity and weather conditions in sugarcane farms in order to maintain the quantity and quality of the produced sugarcane in long term and intensive cultivation periods.

Keywords：*Keywords: sugarcane, salinity, water quality, quantity, accumulation of salts in the soil*

P1-486

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

CO_2 Flux in Salt Affected and Alkaline Soils Under Cotton in Tarim Oasis (china)

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Up to now, the measured CO_2 flux into soil during the night at desert and oasis cotton fields in Xinjiang, northwest of China is not understood which has been reported on oasis cotton fields at night. Three research teams, one from China (Key Laboratory of Oasis Ecology and Desert Environment) and two from Germany (Hohenheim University and Göttingen University) will cooperate and use their complementary techniques to assess the causes and the extent of this nocturnal CO_2 fluxes into soil. We assume that physicochemical processes (e. g. recrystallyzation as pedogenic carbon, higher solution in cool soil water) than biological processes (e.g. incorporation in soil microorganisms or plant roots are responsible for this CO_2 flux into soil. We assume that the factors that control soil respiration are different to those affecting CO_2 flux into the soil. The basic hypothesis of this study is that CO_2 flux into the soil measured on the soil surface is caused by abiotic factors (e. g. precipitation as pedogenic carbonates with Ca^{2+} ions in soil). To explore the process causing CO_2 flux into soil, CO_2 production and transport in soil as well as increased dissolution in the soil water and recrystallization of pedogenic $CaCO_3$ will be investigated. Isotopic labeling with $^{14}CO_2$ in the laboratory and with $^{13}CO_2$ in the field will help to understand mechanisms of CO_2 fixation. Application of $14CO_2$ under defined environmental conditions (temperature, moisture, day/night) to microcosms with and without plants will enable us to trace 14C in soil water, soil air, plants, pedogenic carbonates, microorganisms and the air above the soil. Considering the elucidated mechanisms of CO_2 flux into and out of the soil, field experiments with $^{13}CO_2$ will be conducted. Measurements of CO_2 concentrations and isotopic composition in all compartments will enable us create a model which elucidates the phenomenon of CO_2 fixation in saline soils.

Keywords：*CO_2 flux, Oasis cotton field, recrystallization, pedogenic carbonates, $^{13}CO_2$, $^{14}CO_2$*

P1-487

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Saline and Sodic Vertisols and Vertic Soils in European Russia

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The information on geographic distribution of Vertisols and Vertic soils in Russia is scarce. Large areas of these soils (slitozems in Russia) were described in the Northern Caucasus Piedmont (Bystritskaya, Tyuryukanov, 1971; Khitrov, 2003). Swelling-clay alluvial soils with gilgai microrelief were studied within the Volga-Akhtuba floodplain (Kozlovskiy, Kornblyum, 1972).

Recently, an inventory of Vertisols has been performed. The outcrops of swelling clays were recorded using soil, geological, topographic maps, and space images for the Central Chernozemic (Khitrov, 2012), Middle and Lower Volga regions, central and west parts of the North Caucasus Piedmont between 45°N and 54°N. These places were visited, and studies on key plots were arranged. As a result more than 100 new soil areas of Vertisol and Vertic soils have been found.

In terms of the WRB system, the soils studied belong to Vertisols proper and to the RSGs of Chernozems, Kastanozems, Phaeozems, Solonetz, Stagnosols, Luvisols, Fluvisols, Cambisols with 'Vertic' prefix.

Diversity of Vertisols and Vertic soils in Russia is explained by vertigenesis intensity and combination of different pedogenetic processes: humus accumulation; migration of salts, carbonates and gypsum; solonetz process; redox, eluvial/illuvial phenomena, biological activity, and pedoturbation.

Landscapes where Vertisols occur are diverse: uplands, plains, lowlands, river terraces, floodplains.

Climate of these regions is arid or semiarid with strong deficit of water due to potential evapotranspiration exceeds precipitation for year as a whole and especially for summer. This is one of the reasons for existence of salt accumulation in different soils including Vertisols.

The main source of soluble sodium salts for Vertisols and Vertic soils at the European territory of Russia is swelling clays of marine origin. Their age varies from Quaternary to Jurassic.

Electrical conductivity of saturated extracts (ECse) in different elemental soil areas of Vertisols varies from 0.4 to 14 dS/m. As a rule the vertical distribution through soil profile has general trend of increasing from the topsoil to the bottom of profile. About 20% of observed areas of Vertisols have not soluble sodium salts at all. Sodium activity in saturated extracts is less than 0.5 mol/m3. About 30% Vertisol areas have low sodium activity in soil solutions (from 1 to 20 mol/m3), but they could not be classified as hyposalic qualifier due to ECse<4 dS/m. With that some of these soils have exchangeable sodium percentage (ESP) from 6 to 10% that can be classified as hyposodic and bathyhyposodic qualifiers.

About 50% of Vertisol elemental soil areas have ECse>4 dS/m and ESP>6% within layer 0-100 cm or 100-200 cm. That corresponds to qualifiers hyposalic and hyposodic or bathyhyposalic and bathyhyposodic.

Elemental soil areas of Vertic soils has the wider ranges of ECse (from 0.5 to 16 dS/m) and ESP (from 0.5 to 20-25%). The highest values of ECse and ESP occur in Vertic Solonetz. The occurrence of taxonomic soil classes of Vertic soils is as follow. About 25% areas of Vertic soils in Russia have very low sodium activity (<0.5 mol/m3). About 30% areas have 6<ESP<15% and ECse<4 dS/m. They are hyposodic or bathyhyposodic. About 30% have ECse>4 dS/m and 6<ESP<15% - hyposalic hyposodic or hyposodic bathyhyposalic or bathyhyposalic bathyhyposodic. About 15% areas have ECse>4 dS/m and ESP>15%. These Vertic soils are sodic hyposalic or hyposodic bathysodic bathyhyposalic or bathysodic bathyhyposalic.

The study was carried out at the support of Russian Foundation for Basic Research, projects no. 06-04-08323, 08-04-01195, 11-04-00710, 13-04-10174, 14-04-01694.

Keywords: *Vertisol, Vertic soil, hyposalic, hyposodic, exchangeable sodium percentage*

P1-488

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Diagnostics of the Development Degree of the Solonetzic Process in Natural and Agricultural Soils

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Solonetz soils are widely spread in many countries of the world. These soils represent complex natural systems and their genesis is still poorly understood which causes difficulties in their diagnostics. Solonetzic soil complexes were actively used in agriculture in the second half of the 20th century. Melioration of solonetz soils often leads to destruction of the original soil profile and disturbance of the diagnostic solonetz horizon. Irrigation by low quality water and rise of saline ground water can cause secondary alkalinization and/or restoration of the solonetzic process. Diagnostics of these processes is complicated by the impossibility of identification of the diagnostic solonetz horizon although physico-chemical conditions might be favourable for solonetzic process development. Traditionally diagnostics of soil secondary alkalinization is based on the increase of the content of exchangeable Na. However, the increase in the content of exchangeable Na occurs not only during secondary alkalinization but also during secondary soil salinization. Therefore, the aim of this work is to compare methods of diagnostics of solonetzic process in natural and agricultural soils.

Two methods of diagnostics of the solonetzic process were analyzed in this research. The first is the method of Grachev and Kornblum; it is based on the occurrence of a short-term delay of wet soil swelling, which is characteristic for materials with physico-chemical alkalinity such as solonetz soils. The second is the method of Khitrov which is based on soil morphological features and calculation of the specific parameter “B” that is calculated from the coupled data on the content of exchangeable Na and electrical conductivity. For natural soils this method was used for diagnostics of the development of the solonetzic process, whereas for agricultural soils it was used for assessment of the risk of solonetzic process development.

Study objects included soils of semi-hydromorphic and hydromorphic solonetzic complexes in forest-steppe zone of Western Siberia and in forest-steppe and dry steppe zones of the European part of Russia.

Development of the solonetzic process in solonetz horizons of natural soils with distinct morphological features is indicated by the swelling kinetics method as well as by the method based on the parameter “B”. Both methods also point at the absence of the solonetz process in the upper horizons and in subsolonetzic horizons with presence of carbonate and gypsum. Thus the results of the two methods coincide if the solonetzic process is distinctly expressed or if soil conditions are unfavourable for its development.

In agricultural soils results of the methods coincide in 68% of samples. The parameter “B” is more sensitive to the changes in physico-chemical conditions than the “swelling delay” parameter. Perhaps this is due to the fact that the parameter “B” is calculated directly from the chemical properties which are quite dynamic. Also, it can be supposed that changes in hydrophysical and structural properties of soil material caused by the changes in exchangeable Na content require some time. Dependence of swelling delay from the exchangeable Na content is more complex. Presence of gypsum and carbonate in soils might cause coagulation of colloids and changes in the sample swelling character during analysis.

According to the results of this research, appearance or absence of a “step” on the curve of swelling kinetics and magnitude of the parameter “B” are not proportional to the degree of development of morphological features indicating solonetz horizons. If morphological features are similar, the swelling kinetics and the parameter “B” are most probably affected by the exchangeable Na content and presence of gypsum and carbonate. The appearance of the “step” on the swelling curve indicates development of the solonetzic process, while the parameter “B” points at the risk of its development and/or presence (or absence) of physico-chemical conditions for its occurrence.

Obtained results indicate that both methods can be used as a test assessment of solonetzic process development in soils when it cannot de diagnosed morphologically. The outcomes of this research therefore can be applied in assessment of the efficiency of melioration and monitoring of the ecological status of solonetz soils.

Keywords：*Solonetz, solonetzic process, agricultural soils, diagnostics of solonetzic process*

P1-489

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Spatial Distribution Patterns of Soil Salinity in the Heavy Salinization Zone at Different Scales in Yinchuan Plain

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Soil salinization is one of the major limiting factors affecting agricultural production, knowledge of the spatial distribution patterns of soil salinity in saline area is helpful to soil salinization rehabilitation. The objectives of this study are to explore the spatial variability of soil salinity and its influencing factors at different scales in the heavy salinization zone of Yinchuan plain, China. The electromagnetic induction combined with geostatistical method to analyze the soil salt distribution of soil profiles at four nested scales: Pingluo county scale (1587 km2), village scale (5 km × 5 km), farm scale (1 km× 1 km), and field scale (100 m× 100 m). The results showed that soil salinity at all scales exhibited moderate variation in the horizontal direction. The mean salt content for four scales were 2.65, 2.37, 1.70 and 1.33 g kg-1at 0-10 cm depth, 2.15, 1.29, 1.30 and 1.09 g kg-1 in 10-20cm depth, showing a decreasing trend with the scaling down. The salt content of the same scale was also reduced at vertical direction. The spatial correlation distances of soil salinity for four scales were about 25 km, 1 km, 800 m and 80 m respectively, also showing a decreasing trend with the decreasing study areas. The degree of spatial autocorrelation of soil salinity at all scales increased as the soil layers deepened. Salt accumulation occurred at all scales, the soil profile salinity descended vertically. Spatial distribution of soil salinity at four scales are obvious different. At county scale, soil salinity content showed a decrease trend from northwest to southeast, the highest soil-salt-content area was in Xidatan district with unused land type. At village scale, soil salinity content reduced from southeast to northwest and it became lower with the increasing distance to Yellow River. At farm scale, soil salinity was decreased from the southwest to the northeast, while it decreased from west to east at field scale. The main soil salinization types at county and village scales were belonged to light and moderate degree and only a little heavy salinization zone. The salinization type at farm and field scales was mainly belonged to light degree of soil with some parts as moderate degree. The influencing factors of soil salinity distribution were different at different scales. At county and village scales, the topography, groundwater table, land use patterns, and the concentrated irrigation canals and drains towards were the main factors. At farm scale, soil salinity distribution was most influenced by micro-relief and the distance from the drainage ditch. At field scale, the presence of the irrigation drains, soil texture, groundwater table were the main factors. With the nested-scale sampling, larger scale could provide the rough trend of soil salt content, while the more precision information can be obtained at the smaller scale. Therefore nested-scale study could better reflect the whole situation of soil salinity in study area. The status of soil salinization in Yinchuan plain still severely and it should take some measures to prevent soil salinization.

Keywords：*soil salinity, different scales, electromagnetic induction meter, geostatistics, influencing factors*

P1-490

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Characteristics of Soil Salinity in Typical Zone of South Xinjiang

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Characteristics of soil salinity of the Kongque River Valley in Xinjiang was studied using classical statistics and geostatistics methods, based on data of regional investigation of soil salinity. Results showed that the coefficient of variation of soil salinity varied from 0.664 to 0.713, which illustrated the moderate spatial variability of soil salinity in this study area. The soil salinity nugget effect ratio of semivariogram parameters was from 0.0259 to 0.1373 in different depth, which showed strong spatial correlation. Soil salinity of the main study area was moderate or severe degree of salinization, which showed that there were more common and severe soil salinization in the study area. Profile soil salinity changed greatly with depth, showing different types of profile distribution characteristics in different locations across the study area. The severe soil salinity was mainly distributed in the northwest part of the study area, and profile distribution of soil salinity was characterized by bottom accumulation.

Keywords：*Kongque River valley；Soil salinization；geostatistics analysis; Kriging interpolation*

P1-491

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effects of Sodium Ion in Different Cultural Media on Salinity Tolerance for Seedling Stages Of Rice Plants (oryza Sativa L.)

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Soil salinity is one of the major environmental stresses for crops. Low precipitation with high temperature often tends to salinize soils. Saline soils occupy about 800 million ha of land, worldwide. In addition, resent sea level rise due to the global climate change may make cultivation areas more saline. Effects of salinity stress on plant growth are attributed to osmotic stress and ionic toxicity. Plants need to maintain a high K^+/Na^+ ratio. Excess sodium ion at the root surface, however, may inhibit potassium ion adsorption. This may result in sodium ion toxicity. The salinity tolerance of rice plants varies among varieties. The IR66946-3R-230-1-1 (FL530) is known as a salinity tolerant variety. Khao Dawk Mali 105 (KDML105) is prone to salinity stress. The 221-3 crossbred by FL530 and KDML105 is tolerant in a hydroponic culture but not in a clayey soil culture. We hypothesized that the different appearance of salinity tolerance in soil and hydroponic cultures may attribute to clay particles adsorbing sodium ion. Clay particles usually negatively charged so that they attract cations. When NaCl is added to a clayey soil, sodium ion replaces other cations that are already adsorbed on the surface of clay particles. It is conceivable that sodium ion adsorption by clay particles in soil decreases the influx of sodium ion into rice plants because there are less sodium ions in soil solution than in hydroponic solution. In contrast, it is difficult for sand particles to adsorb sodium ions on the surface. The objective of this study is to compare temporal changes in sodium ion concentration in root tissue and soil solution in different rice plant varieties at seedling stage, as salt concentrations are altered in hydroponic solutions, and clayey and sandy soil.

Seeds of indica rice (Oryza sativa L. cv. FL530, KDML105, and 221-3) were germinated to soak in tap water in plastic containers for 3 days. For hydroponic culture, after germination, the seedlings were transferred to sponge and grown for 3 days. Then, the plants grown in sponge were sown in holes of Styrofoam board which floated on water adding nutrition. For clayey and sandy soil culture, 5-days-old plants were transplanted in the pot filled with clayey or sandy soil. The pots soaked in the water pool adding nutrition. At 26 days after germination, 150mM NaCl was added in all culture medium. In clayey and sandy soil pots, we added the salt to water in the pool. Roots were harvested at 0, 2, 6, 24 and 120 hours after adding salt, and dried in 70℃. Dried materials were extracted in acetic acid (100 mM m-3, 90℃, 2h). Sodium ion and Potassium ion concentration was determined in the extract by ion chromatograph (ICA-200AS; DKK-TOA Corp.). Soil solution samples were collected to use porous cups at 0, 2, 6, 24 and 120 hours after adding salt, and analyzed sodium ion concentration using ion chromatograph. Electrical Conductivity (EC) in clayey and sandy soil cultures was measured every 1 minute using four-electrode probes. We used EC sensor to measure the EC in hydroponic culture and water pool soaked clayey and sandy soil culture pots at 0 and 48 hours after adding salt. There were no significant varietal differences in Na^+/K^+ ratio in root tissue. The result of sodium ion concentration in soil solution showed that the concentration in clayey soil culture is higher than in hydroponic culture. Moreover, the concentration in sandy soil culture is lower than in clayey soil culture for all three cultivars at 120 hours after adding salt. These results were opposite to the hypothesis. The EC in clayey soil culture at 120 hours after adding salt was 1.5~3.0 dS/m, and in sandy soil culture was 2.5~3.0 dS/m. In addition, the EC in the water pool soaked clayey soil pots was 12.0 dS/m at 48 hours after adding salt, and in the pool soaked sandy soil pots was 15.2 dS/m. It is conceivable that salt movement into soil was not enough. In hydroponic culture, the EC was around 5 dS/m at 0 hour after adding salt, and 18 dS/m at 48 hours after adding salt. Results will be discussed at the meeting.

Keywords：*salinity tolerant, rice, seedling stage, sodium ion*

P1-492

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Variability of Salt Affected Soils in Khorat Basin, Thailand

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A study on variability of salt affected soils in Khorat basin, Thailand was carried out on 11 representative soil areas of Kula Ronghai series and Thung Samrit series mapping units. Methodologies included pedon analysis in the field, laboratory analyses of soil samples on their physical, chemical, mineralogical properties and micromorphological characteristics, soils fertility assessment and analysis of the relationship of properties for soils that have different particle size classes with salt effects.

Results of the study revealed that these soils are saline-sodic and sodic soils. The soils can be classified according to Soil Taxonomy as Typic Natraqualfs for Kula Ronghai series and Typic Natraquerts for Thung Samrit series. Kula Ronghai series have developed on wash deposits over residuum derived from sedimentary rock on low terrace with moderate to moderately high profile development whereas Thung Samrit series developed on alluvium over residuum derived from sedimentary rocks on lower part of low terrace with moderate profile development. They are very deep, generally poorly drained with slow permeability, slow runoff, variable salt effect with clay accumulation in their subsoils. The Typic Natraquerts are clayey having pressure faces and slickensides in the profile and cracked in dry season.

Kula Ronghai series: micromorphologically, most of these soils have abundant quartz skeleton grains in their surface soils and clayey materials in subsoils. All soils have clay coatings on pore walls and as large accumulation spot in their subsoils. Their texture varies from loamy sand to clay. Their bulk density ranges from medium to high (1.49-1.86 Mg m-3) and their saturated hydraulic conductivity varies from very slow to very rapid. These soils have variable chemical properties. They are very extremely acid to moderately alkaline (pH 4.0-8.2). Their organic matter content ranges from very low to medium (0.06-24.94 g/kg), total nitrogen is very low (0.007-0.060 g/kg), available phosphorus varies from very low to vary high (0.29-57.11 mg/kg) and available potassium varies from very low to high (6.47-87.44 mg/kg). The sum of their extractable base varies from very low to medium (1.05-7.24 cmol/kg). Their extractable acidity ranges from very low to moderately high (0.98-5.88 cmol/kg), cation exchange capacity varies from very low to very high (1.23-44.71 cmol/kg) and base saturation percentage ranges from low to high (22.36-87.93 %). Their electrical conductivity ranges from 2.5–86.1 dS/m, sodium adsorption ratio are mainly higher than 13 (a range of 2.88-160.13) and exchangeable sodium percentages mainly higher than 18 (a range of 1.05-182.84) indicating that they are saline-

sodic soils. Minerals in their clay fraction include kaolinite, illite, quartz and their silt fraction is clearly dominanted by quartz. These soils have low fertility.

Thung Samrit series: micromorphology of these soils shows clayey materials and clayey texture in both topsoil and subsoil. The coefficient of linear extensibility ranges from medium to very high (0.05-0.23). Their pH ranges from strongly acid to strongly alkaline (pH 4.5-8.5). The organic matter content of these soils ranges from low to high (0.01-42.98 g/kg), total nitrogen content from very low to low (0.002-0.112 g/kg), available phosphorus from very low to moderately high (1.17-23.01 mg/kg) and available potassium from very low to high (20.49-175.59 mg/kg). Their extractable acidity ranges from low to high (1.90-13.28 cmol/kg). Cation exchange capacity for all soils varies from very low to very high (1.87-36.64 cmol/kg) and their base saturation percentage from medium to high. These soils have very low to low electrical conductivity in a ranges of 0.7-5.3 dS/m, sodium adsorption ratio of mainly higher than 13 (a range of 8.2-40.2) and exchangeable sodium percentages of mostly higher than 15 (a range of 4.37-66.20%) indicating that they are sodic soils. Kaolinite illite, smectite and quartz are major minerals, but without any mineral dominant. They have medium fertility.

Keywords：*Typic Natraqualfs; Typic Natraquerts, saline-sodic soils, sodic soils*

P1-493

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Hydrostratigraphic Analysis Using Electromagnetic Induction Data and A Spatially-Constrained Algorithm for Quasi-Three-Dimensional Electrical Conductivity Imagi

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Efforts are being made to improve the irrigation efficiency in the Murray-Darling River Basin, Australia, to deal with predicted rainfall decline and to reduce the incidence of secondary soil and water salinisation. The latter commonly occurs as a result of locating water reservoirs upon relic drainage channels. To better manage irrigation, information is required about the spatial distribution of soil type and the stratigraphic features capable of redistributing deep draining water. In previous research, electromagnetic (EM) induction instruments (e.g. EM38 and EM34) have been used to map the distribution of soil type, hydrological processes (e.g. deep drainage) and vadose-zone features. The aim of this research is to demonstrate how a joint inversion of EM38 and EM34 data, using a one-dimensional spatially constrained algorithm for quasi three-dimensional (quasi-3D) electrical conductivity imaging, can be used to infer the areal distribution of soil salinity and physiographic and hydrogeological units. The quasi-3D modeling of true electrical conductivity provides a framework for future environmental monitoring and management to mitigate the hydrological processes that drive localized secondary salinization in the study area.

Keywords：*EM38, EM34, salinity mapping, 3-d inversion modelling*

P1-494

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Soil Surface Salt Accumulation Phenomena Dominated by Shallow Groundwater Fluctuations under Arid and Semi-Arid Climate

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Shallow groundwater tables and associated salinity problems have become dominant features in agricultural areas around the world. There have been numerous studies on groundwater associated salinity but more information is required on the effects of groundwater frequent and high fluctuations on soil salinization. In the present study, field investigations in salt affected areas in South Tunisia (Metouia oasis), laboratory experiments and numerical simulations using HYDRUS-1D model were carried out for this purpose. Field investigations showed that in such arid and semi-arid environments with saline shallow groundwater tables, the capillary rise of water and salts from the groundwater to the soil surface seems to be a major contributor to salt accumulation within soil profile. Metouia Oasis was subject to a high measurement frequency based assessment (30 minutes interval) of shallow groundwater fluctuation from March to November 2009. The resulted hydrograph showed a dynamic groundwater level fluctuation which was the consequence of climatic conditions as well as several hydrological processes taking place in the observation site and in the upstream areas. Interestingly, water table has been shown to rise during rainless periods owing to lateral subsurface groundwater inflow from irrigated upstream areas in the Oasis. The experimental and modeling results showed that groundwater fluctuation not only caused more salt to accumulate in the soil profile compared to a stable groundwater, but also an enhancement of the mechanism. Water table fluctuation induced a much greater spreading of the bromide (Br) tracer within the column than the constant water table. The Br content was in average five orders of magnitude greater under a fluctuating water table than under a constant one. Further, the numerical simulations showed that an increase in the groundwater fluctuation frequency brought about an increase in soil surface salinization under the same evaporation boundary conditions.

Keywords：*salt affected soil, groundwater fluctuation, salt accumulation, arid climate, HYDRUS-1D*

P1-495

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Sandy Soil Layer Alleviates Down-To-Top Enrichment of Salts in Saline Fields

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Down-to-top enrichment of salt components along with soil profile is widely recognized as a critical driving force of soil salinity. We investigated vertical transportation of water and salt in vertical soil profile in two adversely salt contaminated fields at Xinjiang, northwest China during summer. Two separate experiments were designed as: 1) to conduct comparative study in the sites with and without sandy soil layer (in the depth of 60-100 cm) was conducted to reveal the effect of sandy soil layer on salt enrichment; 2) to further reveal the mechanism of sandy soil layer affecting water and salt movement using different coverage on topsoil including non-mulching, straw mulching and plastic mulching in the fields with sandy layer. The data indicated that the minimum soil moisture, electrical conductivity (EC) and total soil salt content were observed in sandy soil layers and the maximum topsoil temperature was found in plastic mulching treatment. At the end of the strong evaporation period (30th, August), the top soil (0-60 cm) salt content increased by 73.42% compared with the early strong evaporation period in the site without sandy soil layer; in the site with sandy soil layer, the top soil salt content increased by 21.27% and 8.01% with non-mulching and straw mulching treatments, while the top soil salt content decreased by 24.89% with plastic mulching treatment. The ratio of total cations to anions (∑cations/∑anions) in the top soil with sandy soil layer was 10.6:1, the data slightly lower than the site without sandy soil layer. It suggested that the sandy soil layer strongly inhibited the salt down-to-up enrichment and decreased the loss of the electrical charge balance degree. The sandy soil layer with plastic mulching was found to be best combination to inhibit upward enrichment of salt ions but improve water permeability. Our results suggested that sandy soil layer settings with plastic mulching might be a critical technical strategy to manage salt contaminated fields in cold and arid areas.

Keywords：*Sandy soil layer, Top enrichment, Salt ions, Topsoil temperature, Manas River watershed*

P1-496

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Phyto-Remediation of Saline Coastal Soils Through Halophyte Plant Species

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Halophytes are generally defined as rooted seed-bearing plants that grow in a wide variety of saline habitats from coastal sand dunes, salt marshes and mudflats to inland deserts, salt flats and steppes. These highly adaptable plants, which can accrue relatively large amounts of salts.

Pot experiments were conducted with six levels of salinity i.e. 2.5, 7.5, 15, 20, 25 and 35 dSm-1 to monitor the effect of halophytes Savladora oleoides and Suaeda nudiflora in a pot experiment with 3 replications. Maximum 39.16 g and minimum 21.66 g fresh weight of shoot were recorded at 7.5 dSm-1 and 15 dSm-1, respectively. Salinity also affects the plant growth parameters like number of branches, shoot height and root height. In S. oleoides the maximum number of branches were observed to be 9 in treatment with 2.5 dSm-1 saline water and minimum no. of branches were 4.5 in 7.5 dSm-1 treatment. Maximum shoot height was 77.85 cm and minimum shoot height was 70.7 cm in 7.5 dSm-1 and 35 dSm-1 treatments, respectively. Fifty per cent reductions in root lengths were observed when salinity was raised from treatment 2.5 dSm-1 to 35 dSm-1. Sodium content of leaves in S. oleoides were increased up to 40% when salinity raised from 2.5 dSm-1 to 20 dSm-1, after that salinity was further raised, fall in sodium content of leaves was noted. In shoot, up to 32% increase in sodium content were recorded at salinity level of 35 dSm-1 in comparison of plants treated with 2.5 dSm-1 water. Similarly, 37% increase in root were observed salinity level 35 dSm-1 in comparison of salinity level 2.5 dSm-1. Thus increase in salinity level causes accumulation of sodium ion in leaves, shoots and roots.

Potassium content of leaves in S. oleoides was increased from 51983 ppm at salinity level of 2.5 dSm-1 to 71626 ppm 35 dSm-1 treatments. In shoots 9% rise in potassium content were observed in 35 dSm-1 treatment over treatment of 2.5 dSm-1 salinity level. 23% fall in potassium content was measured in roots of S. oleoides. Proline content of fresh leaves was increasing from 90 µg/g to 340 µg/g when salinity increased from 2.5 to 35 dSm-1. Thus under saline stress the proline content observes to be increased.

In case of S. nudiflora, root, fresh weight was increased from 0.935 g to 3.2 g up to salinity level of 25dSm-1. Maximum numbers of branches were found in 7.5 dSm-1 . On 90 days after transplanting (DAT), the increase in number of branches from 27 to 52 were recorded, when salinity was increased from 2.5 dSm-1 to 35 dSm-1. Shoot height increased up to 57.8 cm up to salinity treatment of 15 dSm-1. There was increase in root length from 8.2 cm to 23.5 cm when salinity level was raised from 2.5 dSm-1 to 15 dSm-1, but further increase in salinity ceased the growth of roots in S. nudiflora. Salinity raises sodium content in leaves, shoots and roots of plants. There was 52% rise in sodium content of leaves when salinity increased from 2.5 dSm-1 to 30 dSm-1 on 60 DAT. In shoot, 14 % increase in sodium content of shoot was recorded, by increasing salinity level from 2.5 dSm-1 to 30 dSm-1 on 60 DAT. Proline content of fresh leaves was minimum 440 µg/g at lower salinity level and maximum was 840 µg/g at highest salinity level. Thus, salinity enhanced proline synthesis in leaves of Suaeda nudiflora. The population of rhizosphere bacteria increases up to 32 *105 at salinity level of 15 dSm-1, further salinity resulted in decrease in number of bacteria (7*105) at 35 dSm-1 salinity level.

The halophyte plant species shows potential to remove salt from soil environment that could prove to be helpful in remediation of saline soils that are dominant in coastal and inland areas of Gujarat and other parts of nation. This can result in optimizing crop yield under salinity stress conditions.

Keywords: *halophytes, saline soil, reclamation, salt removal*

P1-497

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Soil Salinization in Southern Afghanistan

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The demise of many civilizations has been attributed to soil salinization, most notably the land area known as "The Fertile Crescent" which contributed to the rise of Mesopotamia but is now characterized by vast areas of desert. Salt-affected soils now threaten the productivity of 350 million hectares globally.

Soil salinization is an increasingly important challenge to consider on a global scale, especially in arid climates. With ever-increasing global populations, one of the primary interests in agricultural production systems is to increase yield per land unit area. This directive is secondary to increasing arable land area; however both edicts of food security consider soil quality and hence involve the mitigation of soil salinization. In climates where the P:E ratio (precipitation:evaporation) is less than 0.75, soil salinization is considered a potential hazard, especially in low flat areas subject to seepage from higher elevations.

The productivity of soils in southern Afghanistan is of great interest to many stakeholders in efforts to gain food security, resiliency from civil strife, and independence from strong-armed warlords and militias such as the Taliban. Soil salinization will thwart those efforts, and exacerbate conditions which are already characterized as futile and dismal.

War-torn and besieged by civil strife for three decades, Afghanistan's environment, infrastructure, economy, institutions, agriculture, and service sectors have been devastated. The nexus of donor aid, food security in Afghanistan has reached an undeniably colossal level of global interest. Improved yield and increased arable land has been the focus of many agricultural experts deployed to assist the Afghan populace, 80% of which are directly involved in farming. With the agrarian society dominated by small-scale landholders and sharecropping farmers, the sustainability of agricultural production is much less regarded than the far greater and more immediate concern of putting food on the table.

In southern Afghanistan, water scarcity is one of the primary concerns with which farmers contend. Resultantly, when the availability of water exists farmers tend to use as much as they can; and over-irrigation leads to deleterious conditions, starting with anoxic root-zones and progressing towards soil salinization.

Our team, headquartered in Zhari District of Kandahar Province in southern Afghanistan, began investigations in November 2012 after noting the presence of salt-crusting on the soil surface of a freshly planted plot of saffron (Crocus sativa). Preliminary research revealed that the seminal plot was conducive to soil salinization: a hot, arid, windy climate, resulting in a P:E of 0.15, and a low, flat topography, subject to seepage from higher elevations.Analysis of surface soils and irrigation waters were conducted using a handheld EC meter (Hanna 991301), procured by advocacy with US Army Corps of Engineers (USACE). Samples were gathered via integrated civilian-military interagency co-operation. The salinity of irrigation water (ECW) ranged from moderately saline to severely saline (0.75-3.00 dS/m). The salinity of surface soils ranged from moderately saline to severely saline (2.0-16.0 dS/m). These data were reported to USACE in order to augment the regional database, which has been utilized for salinity mapping. The implications of this study revealed that these agricultural production systems are subject to exacerbating degrees of soil salinization, and provided a baseline to address the challenges to keep these soils in production. The Directorate of Agriculture Irrigation and Livestock (DAIL) has been presented with this information as well as recommendations on methods of mitigating its effect. These guidelines involve irrigation management, crop management, and soil management.

Keywords：*food security, soil salinization, mitigation, desertification*

P1-498

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effectiveness of Subsurface Drainage System at Coarse-Textured Reclaimed Tidal Land

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Subsurface drainage system is recognized as a powerful tool for the process of desalinization in saline soil. However, little information was revealed the effect of subsurface drainage system at reclaimed tidal saline soil. The objectives of this study were to evaluate the efficiency of subsurface drainage on soil salinity and changes of soil physical properties at reclaimed tidal saline soil. Field experiment was conducted at coarse-textured Saemangeum reclaimed tidal land (35°46′N, 126°37′E) in Korea. The dominant soil at this experimental site had sandy loam texture. Drainpipes of 150 mm diameter were installed with 5 m spacing at 0.8 m soil depth. Soil samples were collected at four depths with 0.5 m lateral intervals from drainpipes. Soil water content within 1 m distance from drainpipes was significantly lower, which was increased with increasing distance from drainpipes. Although soil pH at surface layer (0-20 cm) was significantly lower than sub-surface layer, soil pH was not statistically influenced by sub-surface drainage system. Soil salinity levels were dramatically lower in areas above the drainpipe due to the lower soluble salt contents. Average salinity level in areas above drainpipe was about 70% lower than the areas between drainpipes and soil salinity was significantly increased with increasing the distance from the drainpipes. The effect of drainage system was varied with soil salinity levels and salt types. Sub-surface drainage system also influenced on soil physical properties such as porosity, soil hardness and hydraulic conductivities. In conclusion, the efficiency of drainage system was maximized in areas within 1 m from drainpipe and it was diminished as distance increases. The result of this study showed that sub-surface drainage system was effective on salt leaching through the soil profile in areas near the drainpipe lines at coarse-textured reclaimed tidal land, which indicating that soil needs to be reclaimed to increase the efficiency of subsurface drainage systems at Saemangeum reclaimed tidal saline soil.

Keywords：*Reclaimed tidal land, saline soil, subsurface drainage, salinity*

P1-499

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effect Of Green Manure Crops on Soil Aggregate Stability under Different Soil Salinity Levels at Saemangeum Reclaimed Tidal Land

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Soil aggregate stability is widely used to evaluate the quality of soil physical properties. The objective of this study was to evaluate the effect of green manure crops on soil aggregate stability under different soil salinity levels at reclaimed tidal land. Field experiment was conducted at Saemangeum reclaimed tidal land (35°46′N, 126°37′E) in Korea and the dominant soil series at this experimental site was Munpo series (coarse loamy, mixed, nonacid, Mesic, Typic, Fluvaquents). Four different crops including sesbanina (Sesbania sesban), sorghum-sudangrass hybrid (Sorghum bicolor), rice (Oryza sativa), and rice-barley (Hordeum vulgare) rotation were cultivated at 0.1 and 0.3% soil salinity levels and water stable aggregates were measured on size distribution from 2.0 to 0.1mm. Types of Crop significantly changed on soil aggregate stability and average soil aggregate stability was significantly higher at 0.1% soil salinity level compared to 0.3% level. Cultivation of green manure crops had greater (3.2% vs. 2.0%) aggregate stability than the control, but it had lower values compared to rice (4.0%) and rice-barley rotation treatment (5.2%). There was no significant different on aggregate stability between sesbania and sorghum-sudangrass hybrid, but soil salinity levels were influenced (F-value=5.112, p-value= 0.0253) by the crop types. Rice cultivation was significantly increased the average soil aggregate stability, but the cultivation of barley during the winter season did not influenced on soil aggregate stability at Saemangeum reclaimed tidal soil, regardless of soil salinity levels. Our results indicated that green manure crop is the one of the best managements to improve soil physical and chemical properties, but soil aggregate stability was not improved by green manure crops and rice cultivation should be considered to improve soil aggregate stability at Saemangeum reclaimed tidal land.

Keywords：*Reclaimed tidal land, green manure crop, aggregate stability, soil salinity*

P1-500

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effect of Soil EC on N Mineralization of Livestock Manure Compost in Sea-Reclaimed Soils of Korea

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Korea has made efforts to expand its limited arable land by building dams in low water level seas to reclaim them. Soils made from such effort are affected by sea salt to have sodic or saline-sodic characteristics unsuitable for crop growth. Application of organic materials is recommended as one way to improve the saline-sodic soil. Livestock manure compost (LMC) is popular source for organic material in Korea. Unlike other organic materials, it supplies not only organic matter but also nutrients due to its own abundant contents.

This experiment aimed to understand the effect of soil EC on N mineralization of LMC. It was carried out under short-term laboratory incubation. Two sandy loam soils were collected in one field at West Sea in Korea, differing EC level (High EC: 12.2 dS/m, Low EC: 3.5dS/m). The other two clay loam soils were collected in one field at South Sea, differing EC level (High EC: 9.0 dS/m, Low EC: 3.4dS/m). Four sets of soil sample were treated with LMC of 0, 1, 2, and 3% (w/w). Sandy loam soils and clay loam soils were controlled to 50% and 70% of field water capacity, respectively. For six weeks under constant 25℃, inorganic N, dehydrogenase, and biomass C of the samples were analyzed weekly.

Inorganic N (NH4+-N+ NO3--N) contents increased with the increase of LMC application rates. Soil EC did not affect N mineralization of sandy loam soils from West Sea, however, clay loam soils from South Sea showed higher N mineralization amounts at low EC soil than those at high EC soil. Dehydrogenase and biomass C also increased as the amount of LMC treatment increased. The effect of soil EC on dehydrogenase and biomass C showed similar trend as the effect towards N mineralization. However, there was difference that the case of inorganic N contents reduced significantly after three to four weeks while dehydrogenase and biomass C maintained similar or even increasing levels. It can be explained by immobilization of inorganic N by microbes. NH4+-N contents showed low level from the beginning till the end of the incubation. It was believe to be due to ammonia volatilization, considering the high pH condition (pH 7.9-8.3) of the soils before experiment. Therefore, inorganic N contents can almost be seen as NO3--N, and soil EC does not affect nitrification.

Cinsidering that there was no consistant effect of soil EC on N mineralization of LMC between West Sea soils and South Sea soils, it can be concluded that soil EC was not the principal factor on N mineralization of LMC up to the level of 12 dS/m which is the range of this experiment.

Keywords：*saline-sodic, nitrogen mineralization, EC, ammonia volatilization, nitrification, dehydrogenase*

P1-501

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effect of Subsurface Drainage Systems on Soil Salinity and Crop Development in Saemangeum Reclaimed Tidal Land

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Soil salinity is the main limiting factor in the productivity of reclaimed tidal land in Korea. The objective of this study was to evaluate the effect of subsurface drainage systems on soil salinity and corn (Zea mays) growth at reclaimed tidal land. Field experiment was conducted at Saemangeum reclaimed tidal land (35°46′N, 126°37′E) in Korea and the dominant soil series at this experimental site was Munpo series (coarse loamy, mixed, nonacid, Mesic, Typic, Fluvaquents). The study field was treated with four subsurface drainage systems: (1) untreated (Control), (2) subsurface drainage with 10 meter intervals (S10), (3) subsurface drainage with 5 m intervals (S5), and (4) double-layer drainage combined with 10m and 5m intervals (DL). Soil water contents were increased with increasing soil depth and the effect of drainage system was significant at lower depth. Soil salinity was statistically significant at surface layer and the effect was diminished with increasing soil depth. Groundwater level at S5 was significantly lower compared to S10. Soluble sodium content was ranged from 2.3 to 13.5 cmol kg-1 during the growing season and it was significantly lower at S5. Corn growth was significantly greater at S5 and DL at V5 and harvesting stage. Nutrient contents in corn stover were not statistically influenced by subsurface drainage systems, but Sodium contents were significantly lower at DL and S5 compared to the Control. Our results indicated that subsurface drainage system was significantly influenced on soil water content and soil salinity, which was also significantly influenced on corn growth in Saemangeum reclaimed tidal land.

Keywords：*Reclaimed tidal land, soil salinity, sub-surface drainage, double-layer, corn*

P1-502

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Seasonal Variations in Soil Salinity of Paddy Soil and Yield Potential in Rice(oryza Sativa. L.) Cultivated in Newly Reclaimed Tidal Lands

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It is known that the soil salinity in newly reclaimed tidal land is too high to cultivate any other crops. Nevertheless, some researchers revealed that rice cultivation was not only possible to adapt, but also helpful to desalinize typical salt-affected soil. In this study, We assessed whether consecutive rice cultivation was helpful for desalinization. A field experiment was conducted through 2010~2013 in newly reclaimed tidal land of Saemangeum with a view to determining the contribution of rice cultivation to desalinization of salt-affected land by monitoring seasonal variations of soil salinity and yield of rice. The initial salt level was so high after reclamation that flooding was recommended to desalinize before first rice cultivation. The salt level decreased to 0.34% after first rice cultivation. The desalinization was accelerated year on year. In the fourth year, the salt level reached 0.02% after three consecutive cropping. The rice cultivation changed the soil chemical properties. The soil pH and Ex. Na. decreased markedly. Soil organic matter and Ex. Ca. increased dramatically by four-year rice cultivation. In addition, It was found that soil salinity had little effect on the growth parameters and yield of rice during four growing seasons. The yield of rice through 2010-2013 was 518~579kg on average. In conclusion, it is suggested that desalinization strategy such as flooding of rice cultivation may be a useful tool to control initial soil salinity in reclamation area. Consecutive rice cultivations will be helpful for lowering soil salinity and enhancing soil fertility in a newly reclaimed area.

Keywords：*Reclaimed tidal land, soil salinity, desalinization, rice, paddy field*

P1-503

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

A Detailed Soil Survey on Reclaimed Land in the Westen and Southen Costal Area of the Korea Peninsula

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In general, reclaimed soil has poor basic fertility and high salinity. In addition, it has a high groundwater level with weak soil structure. After all, it has physicochemical characteristics which are disadvantageous for crop farms. With these reasons, reclaimed lands in Korea have been primarily used as a rice farm. Due to recent decrease in rice consumption and great changes in agricultural conditions, however, there has been a rising demand for the use of reclaimed lands for diverse purposes. Despite this kind of need, there has been no systematic study on the reclaimed soil. Therefore, this study has conducted a detailed soil survey on five areas (Seokmun, Sihwa, Gunnae, Bojeon and Samsan) in order to enhance the usefulness of reclaimed agriculture land in the South and West Sea and select a suitable place for crop cultivation. The detailed soil survey on the reclaimed land was carried out from March to August in 2013. The size of the land examined by area were as follows; Seokmun (Dangjin, Chungnam)-1,968ha, Gunnae (Jindo, Jeonnam)-464ha, Bojeon (Jindo, Jeonnam)-213ha, Sihwa (Hwaseong, Gyeonggi) and Samsan (Jangheung, Jeonnam)-283ha. In terms of a survey method, after soil classification, one target spot per 20ha was selected in five areas. Then, surface soil (0-30cm) and subsurface soil (30-60cm) were sampled, and pH, ECe, soil texture, available phosphorus, organic matters, chlorine and water-soluble cations (Ca, Mg and Na) were analyzed. In terms of pH, all five areas showed alkaline soil. In terms of soil texture, silt loam was mostly found. However, Seokmun Area soil was classified into loam, sandy loam and silt loam. The organic matter contents were about 1%, less than the general paddy field level (2.5%). In case of Sihwa Area which is on going development, in particular, the organic matter contents were about 0.4% which is close to the level of salty paddy field. In terms of available phosphorus, all five areas were much less than the general rice field level (80-120mg/kg). In particular, Gunnae and Bojeon Areas were as low as 7mg/kg, even lower than the salty paddy field (20mg/kg). In terms of soil salinity, subsurface soil was higher than surface one by over 40% in all five areas. When average salinity was compared based on general plow layer (30cm), Sihwa (15.0dS/m) was the highest, followed by Samsan (10.1dS/m), Gunnae (6.4dS/m), Bojeon (5.7dS/m) and Seokmun (4.0dS/m). In case of Seokmun Area, salinity was relative low compared to other areas which are pretty same in terms of date of the reclaimed land development project completed because Seokmun Area has high sand contents such as loam and sandy loam. In case of Sihwa Area which is under development, on the contrary, sand content was low, but freshwater lake salinity was very high with 3.6dS/m. In terms of Sodium Absorption Ratio (SAR), it was close to salinity. Based on surface soil, Sihwa (15.0) was the highest, followed by Samsan (10.1), Gunnae (6.4) and Seokmun (4.0). When salt-affected soil was classified considering pH, salinity and SAR, surface soil and subsurface soil were categorized as saline soil and saline-sodic soil respectively in Seokmun, Gunnae and Bojeon Areas. In Sihwa and Samsan Areas, on the contrary, both surface and subsurface soils were categorized as saline-sodic soil. In Sihwa Area, in particular, SAR was very high with 29 in surface soil and 34 in subsurface soil. As the reclaimed land was developed earlier, soil salinity was lower. In the lands which were developed during the pretty same period, desalinized conditions varied depending on soil texture. To make use of the reclaimed in the westen and southen costal area more effectively, it would be necessary to perform a further study on the selection of a suitable spot for cultivation and water quality of freshwater lake which has been used as agricultural water in addition to rice field based on the results of the soil survey.

Keywords：*Reclaimed Land in the Westen and Southen Costal Area of the Korean Peninsula, Reclaimed Soil, Salinity, Salt-affected Soil*

P1-504

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

The Effect of Soil Improvement on Soil Chemical Properties and Seedling Growth on the Undersea Dredged Soil Slope

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This study was conducted to determine the changes in the soil chemical properties and the growth of seedling by different soil improving methods at slope of Saemangeum sea dike infilled with undersea dredged soil. Undersea dredged soil was improved by five different methods with the soil conditioner and forest soil in 2009. Seedlings of *Ulmus davidiana* var. *japonica*, *Chionanthus retusa*,*Celtis sinensis*, and *Pinus thunbergii* were planted after 9 month of experience site installation, then the soil pH, NaCl concentration in soil, the soil organic matter (SOM), and the survival rate and height of seedling was measured. The initial soil pH and NaCl in the control plot was highest among those in the other plots. The SOM in the soil improving plots was higher than that in the control plot during the study period. The survival rate after 36 months after planting of *U. davidianaca*, *C. retusa*, *C. sinensis*, and *P. thunbergii* was 75-92%, 8-83%, 83-92%, 97-100%, respectively. The tree height in the soil improving plots was relatively higher than that of the control plot (*U. davidiana*: 2.2-2.7 times, *C. sinensis*: 2.1-3.5 times, *P. thunbergii*: 1.2-1.3 times). The growth of *U. davidiana* and *C. sinensis* was correlated with the initial soil pH and NaCl. However, *P. thunbergii* was not correlated with the initial soil chemical properties. The following conclusions were obtained by this study. 1) Improving of dredged soil was required to create the vegetation growth base quickly, 2) and it was also required to create *U. davidiana* or *C. sinensis* forest because they were correlated with the initial soil chemical condition. 3) Creation forest with *P. thunbergii* might be a cost effective afforestation in coastal reclaimed land since it rarely needs additional improvement of dredged soil.

Keywords：*soil improvement, dredged soil, Pinus thunbergii*

P1-505

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Assessment of Soil Chemical Properties of Typical Salt-Affected Land in Reclamation Areas in Korea

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The need for understanding and assessing soil quality is getting increasingly of importance due to growing public interest in determining the effect of management practices on the sustainability of soil resource base. The research objectives were to investigate the effect of land management on potential soil characteristics of typical salt-affected farm land in reclamation area compared with native soils. The farm land management of reclamation area in Korea has been rice crop cultivation for the purpose of staple food production since the initial reclamation. The survey was carried out in 11 state-owned reclamation areas nationwide. According to the type of land management, the 85 sampling sites were classified into rice cultivation and native soils (60 rice cultivation and 25 native soils). A group of ten measured variables representing soil chemical properties at 0-20 cm soil layer were used. Soil pH under rice cultivation (7.29) were lower ($p \leq 0.020$) than that under native soils (7.80). Similarly, soil EC (1:5) (6.36 dS/m) under rice cultivation was lower than ($p \leq 0.027$) that under native soils (12.95 dS/m). Soil organic matter under rice cultivation (11.52 g/kg) was greater ($p \leq 0.001$) than that under native soils (5.54 g/kg). Available SiO2 from rice cultivation (177.0 mg/kg) was not different from that under native soils (172.2 mg/kg). Available P2O5 under rice cultivation (37 mg/kg) was not different from that under native soils (31 mg/kg). Exchangeable K and Mg under rice cultivation were not different between land management. Exchangeable Ca (5.3 cmolC/kg) under rice cultivation was significantly higher ($p \leq 0.007$) than that under native soils (3.1 cmolC /kg). Similarly, Exchangeable Na (5.3 cmolC/kg) under rice cultivation was significantly lower ($p \leq 0.040$) than that under native soils (11.4cmolC /kg). SAR (1:5) under rice cultivation (2.28) was significantly different ($p \leq 0.009$) from that under native soils (4.93). In conclusion, it was found that land management influenced the soil chemical properties. Especially, the content of soil organic matter under rice cultivation markedly was higher than that under native soil due to continuous input of crop residues such as stubble and straw. Soil EC and Exchangeable. Na was lower in paddy soils, which means long-term flooding during growing season played an vital role in controlling the soil salinity factors such EC and Exchangeable Na.

Keywords：*Reclamation area, Saline soil, land management, soil chemical properties. Soil assessment*

P1-506

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effect of Compost and Gypsum on Production of Chinese Cabbage in Reclaimed Land

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To alleviate food shortage from increasing population and limited agricultural land resources, there have been needs for reclamation of coastal tidelands in Korea. Reclaimed lands are generally unfavorable for upland crops not only due to high salinity and sodicity of soils but also to low organic matter. Compost and gypsum can be used as a soil ameliorator to supply organic matter and calcium, respectively. To investigate the effect of compost and gypsum on production of Chinese cabbage in reclaimed land, we conducted a pot experiment of growing cabbages in a soil which was high in both soil ECe (electrical conductivity of saturated soil extract, 40 dS m-1) and exchangeable-sodium concentration (10.1 cmolc kg-1) and low in soil organic matter content (2.2 g kg-1). Compared with conventional fertilization of applying both chemical fertilizer and compost, additional compost amendment (30 Mg ha-1) did not increase dry-mass yield of Chinese cabbage. However, additional gypsum input (5.0 Mg ha-1) significantly ($P > 0.05$) increased dry-mass yield of cabbage which was three times as much as those of conventional fertilization. Gypsum amendment significantly ($P < 0.05$) increased soil salinity (48 dS m-1) compared to conventional fertilization (39 dS m-1), decreased little exchangeable-sodium concentration in soil, and significantly ($P < 0.05$) increased saturated hydraulic conductivity of soil. However, compost amendment slightly ($P > 0.05$) decreased soil salinity (36 dS m-1) and exchangeable-sodium concentration. Compost also significantly increased saturated hydraulic conductivity of soil, but the increase (15%) was less than that of soil amended with gypsum (29%). Therefore, it was suggested that the cabbage-yield enhancement in gypsum-amended soil reflected the effect of gypsum on an increase in saturated hydraulic conductivity of soil rather than that on ameliorating the high salinity and exchangeable sodium in soil.

Keywords：*compost, gypsum, saline soil, saturated hydraulic conductivity, sodic soil*

P1-507

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Effect of a Combination of Rice Straw and Gypsum on Soil Salinity and Yield of Potato in Newly Reclaimed Tidal Lands

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Higher soil salinity and low soil fertility in a typical salt-affected soil of reclamation area have a detrimental effect on the establishment of favorable condition to cultivate. Both soil desalinization and fertility should be considered to establish suitable crop production base. So far, the effect of organic amendment and gypsum on soil properties under a salt-affected upland was not evaluated. In this study, the effect of a combination of rice straw and gypsum on soil salinity and yield of potato was evaluated in a field experiment at a newly reclaimed tidal land of Saemangeum. The soil was sandy loam texture. The application rate of rice straw application was 5, 10, 20 Mg/ha and gypsum treatment was 2, 4 Mg/ha. The experimental design was split-plot design (main: rice straw, sub: gypsum). No rice straw and gypsum was used as control. The yield of potato improved following rice straw incorporation (18.1~24.0 ton/ha) compared with control (13.1 ton/ha). However yield of potato were decreased with rice straw application increasing. Interaction between rice straw and gypsum was effective significantly in a combination of 5.0 Mg/ha of rice straw + 2.0 Mg/ha of gypsum. The marketable yield was 26.3 ton/ha. Especially, combination treatments influenced the growth of Potato positively. N and Na content of shoot and tuber in the plot of control was higher compared with combination plots, which indicates that salt stress resulted in lasting vegetative growth and slower tuber growth. A combination of rice straw and gypsum was variable under a salt-affected upland. Application of gypsum without rice straw was not effective for lowering the soil salinity level. The salinity level in combination plots was lower than that in control. Especially, with the rate of rice straw application increasing, the salinity levels at both surface (0-20cm) and sub-surface (20~40cm) were lower than those under different combination plots. Although increasing application of gypsum led to slightly higher salinity, its effect on soil salinity were totally different from salinity in control based on soil chemical analysis. In conclusion, increasing rate of rice straw application was the effective material to desalinize and to control the ever-changing movement of soluble salt. Addition of gypsum for accelerating desalinization was effective at lower rate of rice straw. A combination effect was less effective with the rate of rice straw increasing.

Keywords：*saline soil, rice straw, gypsum, soil salinity, potato*

P1-508

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Over Ground Biomass of Euphorbia Sp. in Shanjan Rangelands, East Azerbaijan, Iran

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Stem of plants can be used as animal grazing, wind erosion control, reduce water flow, increase evaporation and transpiration. In NW of Iran (East Azerbaijan Province), rangelands was Utilized with animal grazing and changed to agricultural land use; this vegetation is unsuitable vegetation coverage. We studied EUPHORBIA SP. to determine its stem biomass characteristics. Data were collected with accidental sampling method (1*1 m) in this area. In total of 6 plots were collected and 30 samples were studied in this research. Minimum, maximum and mean stem biomasses of this plant were 4.8, 10.7 and 7.5 gr, respectively

Keywords：*EUPHORBIA SP., stem Biomass, Rangeland, Iran*

P1-509

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Long-Term Repeated Intensive Prescribed Burning Decreases Soil Carbon and Nitrogen Pools in a Wet Sclerophyll Forest of Southeast Australia

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Prescribed fire is very important management practice, widely used all over the world. But how prescribed fire affects soil carbon is largely unknown, particularly over the long term. A long-term repeated fire experiment was used in this study to investigate how different fire frequency regimes affected surface soil carbon (C) and nitrogen (N) pools. This field experiment was established in 1972 in Southeast Queensland, with three burning frequencies never burnt (NB), burnt every 2 years (2yrB) and burnt every 4 years (4yrB). Various chemical extraction and incubation methods were used to determine soil labile, biologically active and recalcitrant C and N pools. Soil labile C and N pools were determined by KMnO4 oxidation and HCl hydrolization; biologically active C and N pools were determined by fumigation extraction and 35-days cumulative CO2-C evolved from the soils, while recalcitrant C and N pools were characterized by NaOCl oxidation and charcoal.

Results showed that fire significantly affected all soil C and N pools except charcoal N in recalcitrant pool. More frequent fire treatment (2yrB) significantly reduced soil total C (TC), total N (TN), and all labile, biologically active and recalcitrant C and N pools. Compared with the NB sites, 2yrB decreased soil TC by 44%, TN by 54%, labile organic C by 48-81% using both methods, chloroform released C by 42%, chloroform released N by 33%, cumulative CO2-C by 28%, recalcitrant C by 41% and recalcitrant N by 51%, and charcoal-C by 23%. All labile, biologically active and recalcitrant C and N pools were correlated positively with each other, and with moisture%, TC and TN ($r=0.61$-0.99; $P<0.05$), while correlated negatively with soil pH. The C:N ratios of different C and N pools were greater in the burning treatments than in the NB treatments. The 4yrB and NB treatments showed no differences for soil TC, TN, labile, biologically active, and recalcitrant C and N pools. The reason for these results may be that 4 year intervals between two prescribed fires allowed forest ecosystem to have enough time to recover, while 2 year intervals were too intensive to recover. Our findings indicated that prescribed burning every 4 years was a more sustainable forest management practice for maintaining and improving the original C and N pools, with reducing huge losses of C and N contents for this Australian Eucalypt forest ecosystems.

Keywords：*Fire, Forest,Soil, Carbon Pools*

P1-510

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Estimation of Soil Aggregate Stability in Forest`s Soils by Artificial Neural Networks

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Using artificial neural networks to predict the surrogate soil properties such as aggregate stability would reduce the time and cost needed for their direct measurement. In this research, 140 soil samples were collected from the forest soils of Guilan province. Organic matter, bulk density, equivalent carbonate calcium, particle density, porosity, soil mechanical resistance, clay, sand, silt, pH and electrical conductivity were measured as independent variables, Geometric mean diameter (GMD) was computed as dependent variable by appropriate methods. Samples were divided into two data subset randomly: 80 and 20 data for model calibration and for model test, respectively. For establishing ANNs we used Marquardt-Levenburg training algorithm and 3-layer perceptron structure with 6 neuron in one hidden layer. According to the results of correlation matrix between GMD as dependent variable and six groups of independent variables were selected, that these variables were used as input variables for artificial neural networks. According to coefficient's statistics of corrected explanation, root mean square error (RMSE) and relative improvement (RI) for determination of best model, model to input independent variables pH, particle density, silt and soil mechanical resistance were the best Model of artificial neural networks for estimation of GMD of forest train data.

Keywords：*Aggregate stability, Artificial neural networks, Geometric mean diameter (GMD)*

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[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Degradation Indicators and Sustainable Use of Soils

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Soil degradation is a serious global environmental problem. Under the last a few decades several land-use technics have degraded near 5 billion ha of World plant covered land. This land quality decrease results in reduced soil productive potential. The decline of arable land has been caused by a number of factors, many or most of which are tired to human development usually for agricultural, pastural, industrial or urban purposes. The most important causes are deforestation, overexploitation for fuelwood, overgrazing, agricultural activities, industrialization and mining activities. The major soil degradation indicators can be listed as i. Wind Erosion (WE), ii. Water Erosion (WE), iii. Gully Erosion (GE), iv. Sheet Erosion (SE), v. Compaction (COMP), vi. Laterization (L), vii. Hardsetting (H), viii. Depletion of Organic Matter (DOM), ix. Soil Acidification (SA), x. Depletion of Nutrients (DN), xi. Acid Sulfate Soils (ASS), xii. Salinity (S), xiii. Contaminations (CONT), xiv. Loss of Soil Biodiversity (LSB), and xv. Land Capability (LC). Soils are one of the fundamental natural resources. Maintaining and improving the condition of the land and soil resources by avoiding above soil degradation processes is crucial to sustainable use of soils for the future.

Keywords：*Soil, Degradation, Indicators, Sustainability*

P1-512

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Components of Soil Humic Substances in Larch Plantation of Northeast China and their Effect on Soil Acidity

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This study was done to illustrate component variation in humic substances and their effect on soil acidity in larch plantation of Northeast China. The results showed that for rhizosphere soil (RS) and non-rhizosphere soil (NRS), soil organic matter (SOM), carbon content (C) in humic acid (HA) and humin increased from young to near mature stand over stand ages, however, SOM, C in fulvic acid (FA) and humin decreased from near mature to mature stand. Humification degree (C in HA accounts for the percentage of total C) and the ratio of C in HA to C in FA acid were greater in secondary forests than in young and near mature stand. As compared with young stand in the first rotation, for RS, SOM, C in FA acid and humin decreased by 4.53%, 35.8% and 1.98% in young stand in the second rotation, respectively, but for NRS, SOM, C in HA, FA and humin increased by 46.44%, 43.69%, 47.45% and 49.5%, respectively. Correlation between humus components and soil acidity changed over ages. In RS, close correlation existed among humus components, active acidity (pH value), exchange and hydrolytic acidity at different development stages.

Keywords：*larch plantation; component of humic substances; humic acid; fulvic acid; humin; soil acidity*

P1-513

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Carbon Sequestration and Nutrient Removal by Some Tree Species in an Agroforestry System in Punjab, India

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Forestry related measures have got much interest to mitigate greenhouse gases from the atmosphere. The carbon dioxide used by trees in the photosynthesis process is ultimately accumulated in the woody biomass and the underneath soil. Carbon capture and sequestration through forests can play an important role in reducing atmospheric carbon dioxide concentration. It has been estimated that managing the world's vegetation could turn the terrestrial biosphere from a source of carbon (0.1-4.2 Pg C/year) to a carbon sink (1.3-3 Pg C/year). On the other hand, the fast growing trees may lead to considerable removal of nutrients from soil, thus requiring a balanced application of nutrients. Nutrients accumulated in the biomass components of the standing trees are removed from the site and some quantity is returned to soil through litterfall and roots of the trees. Therefore, an investigation was conducted to quantify the carbon and carbon dioxide storage in the tree biomass and the soil, nutrient content (N, P and K) and their removal by five tree species (5 x 4 m spacing) namely Toon (Toona ciliata), Maharukh (Ailanthus excelsa), Dek (Melia azedarach), Poplar (Populus deltoides) and Eucalyptus (Eucalyptus tereticornis) after seven years of growth in an agroforestry system (trees intercropped with pearlmillet in summer and wheat in winter) in Punjab, India. The mean tree technique was used for estimation of tree biomass and carbon content. Three trees of each tree species representing mean size of the plantation were cut at ground level after about 7 years of planting. Roots were extracted by excavating laterally and vertically around the tree stem. The fresh weights of aboveground (stem, branches and leaves) and belowground (roots) components were taken. Stem samples from lower, middle and upper part of tree; branches, leaves and root samples were transported to the laboratory for estimation of dry biomass. The samples were oven dried at 65 ± 2°C till a constant weight for dry weight estimation. Carbon and carbon dioxide content in the tree biomass, soil organic carbon and nutrient content (N, P and K) of different components of trees were estimated by standard methods.

Poplar and eucalyptus attained significantly higher diameter at breast height (24.8 and 24.2 cm, respectively) and height (22.3 and 25.8 m, respectively) than the other species. The carbon and carbon dioxide content and nutrient removal by various tree components differed significantly ($P<0.05$) among various tree species. The carbon content in the aboveground (stem, branches and leaves), belowground (roots) and in total biomass was the lowest (25.1, 5.7 and 30.8 Mg/ha, respectively) in toon and the highest in case of poplar (68.0, 16.9 and 84.9 Mg/ha, respectively). The carbon sequestration (in stem portion of trees) by poplar, eucalyptus, dek, maharukh and toon was 54.9, 48.0, 43.3, 20.8 and 19.1 Mg/ha, respectively. Similarly, the carbon dioxide storage (in stem portion of trees) by these species was 201, 176, 159, 77 and 70 Mg/ha, respectively. The increase in soil organic carbon stock of surface soil (0-15 cm) was the highest in poplar (21.2%) and the lowest in maharukh (9.1%) over its level at the planting time of trees (6.37 Mg/ha). The nutrient (N, P and K) content of different components of trees was the highest in stem portion of all tree species. The removal of N by different tree species was in the order of poplar (839 kg/ha)>eucalyptus>dek>maharukh>toon (365 kg/ha). Similarly, the removal of P and K from soil was the lowest (P: 30.3 kg/ha, K: 223 kg/ha) by toon and the highest (P: 107 kg/ha, K: 609 kg/ha) by poplar. It can be concluded that poplar, eucalyptus and dek have considerably better growth and higher potential of carbon and carbon dioxide sequestration than maharukh and toon. However, there is higher removal of N, P and K from the soil by these tree species than the others, but that is compensated by higher storage of carbon and carbon dioxide in the biomass and soil. Thus, in addition to fulfilling the demand of society for wood and wood products, tree plantations can enhance the environmental sustainability by sequestering atmospheric carbon in the biomass and the underneath soil.

Keywords：*Carbon sequestration, Growth parameters, Nutrient removal, Soil OC, Tree species*

P1-514

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Soil Organic Carbon (soc) in Soils along a Rainforest-Savannah Boundary in Central Guyana, South America

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Rainforest-savannah boundaries are dynamic interfaces continually changing under the influence of an intensifying hydrological cycle and anthropogenic disturbance. In central Guyana, seasonal fluctuations in the water table result in a patchy distribution of sub-environments at these boundaries. These sub-environments suggest temporal snapshots of the changing boundary position. Savannah grassland is divided by scattered trees and small clumps of wooded areas. Fingers of forests reach out across the grassland from the main rainforest body, and patches of peaty savannah swamps echo a potential remnant of forest swamps. At the interface, scrubland growth post-fire suggests forest reclamation. Within the rainforest, flat areas of mixed tree species are broken up by depressions of swamp forest and hills of gravelly laterite, on which these mixed species are still able to colonize.

These sub-environments were sampled in central Guyana in order to investigate the underlying mechanisms of soil organic carbon (SOC) dynamics which influence the changing position of the boundary. The same geochemical analyses (py-GC MS) were performed for each sub-environment; these investigated the importance of plant-derived polyphenols in soils in relation to carbon storage at the landscape scale. Polyphenols constitute a high proportion of SOC and can play an important role in regulating C cycles (Freeman et al., 2004; Sinsabaugh, 2010) which may then affect the vegetation distribution at the boundary. This study also considers environmental variables such as horizon depth, water table depth, soil moisture content, bedrock depth, pH, texture, mineralogy and sunlight exposure. These variables were measured in order to assess their influence upon SOC and polyphenol characteristics.

An interesting observation was that surprisingly, a non-linear response was found between SOC storage and environmental variables. This shows that such short- term measurements do not reflect the inherent long-term signature of the environment and that SOC is unaffected by short-term fluctuations. Another observation is that SOC storage within surface soils of a swamp forest was found to be greater than at other sites, potentially acting to aid stability of the rainforest against savannah encroachment at these boundaries. Savannah swamp SOC storage showed intermediate figures between swamp forest and savannah grassland, suggesting this may be a snapshot of a once forested area and may be progressively converting to savannah grass or woodland. Although not as great a carbon store as the forest swamp, the savannah swamp surface soil still stores c. 12% of carbon from all the sites sampled; a potentially valuable carbon reserve in this region. A greater understanding of how stable these savannah swamp areas are in progressively warming climates is needed.

Correlations between polyphenolic data of surface soils and carbon storage also reveal a non-linear response across sites, showing that these compounds may not be significant in regulating C cycles. Proxies calculated to show the degradation states of polyphenols (lambda, S/G ratio, C/G ratio and Ad/Als) potentially reflect the inherent long-term environmental signature of the

region. They may also provide clues to past changes in vegetation further down the soil profile. This may offer some insight into boundary tipping points at which environment and vegetation alter.

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Keywords：*soil organic carbon, polyphenols, rainforest-savannah boundary*

P1-515

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Effects of Logging Activities on Soil Hydraulic Properties in a Hardwood Forest

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Previous studies have shown that once compacted, forest soils often recover slowly (over many decades) to pre-disturbed levels for soil properties such as bulk density or penetrometer resistance. Soil compaction has been shown to significantly increase runoff and soil erosion from forest lands. Increased carbon sequestration is expected from land under forest management; however, increased runoff and erosion will negatively affect carbon sequestration in the soil. With climate change, more intense rainfall may occur which will create challenges with runoff and erosion from compacted sites. This study was conducted to evaluate the effects of selected harvesting techniques on soil physical and hydraulic properties which affect runoff and erosion. The effects of logging roads, log landing areas, and logged areas on water retention, saturated hydraulic conductivity (Ksat), and bulk density were investigated on harvested sites within the Mark Twain National Forest in Callaway County, Missouri, USA on a moderately well-drained Keswick soil (fine, smectitic, mesic Aquertic Chromic Hapludalfs). Soil cores (7.6 cm by 7.6 cm) were removed in four 10-cm depth increments and were evaluated for saturated hydraulic conductivity, soil water retention, pore-size distributions, and bulk density. Saturated hydraulic conductivity was measured for each core sample using a constant head permeameter, or the falling head method for samples with low values. For water retention measurements, soil cores were saturated and water retention measurements were recorded for 0.0, -0.4, -1.0, -2.5, -5.0, -10.0 and -20.0 kPa soil water pressures. Soil aggregates were used for the -33 and -100 kPa water retention readings and samples passed through a 2.0 mm sieve were used for the -1,500 kPa water retention reading. The soil bulk density was also determined for the soil core samples. Pore size distributions were estimated using the water retention data from each sample. Bulk density was significantly higher ($P<0.01$) for the logging road and log landing areas compared to the logged areas. This effect was attributed to higher levels of soil compaction in the more trafficked areas of the site. Significant interactions ($P<0.01$) for bulk density between treatments and soil depth occurred; density in logged areas increased with soil depth while values in the logging road and log landing areas remained fairly constant with depth. No statistical differences in bulk density were observed at the deepest sampling depth (30 to 40 cm). Saturated hydraulic conductivity was also significantly lower ($P<0.01$) for the logging road and log landing areas compared to the logged areas. These values were also affected by soil compaction. Values for Ksat in the surface soil were 33 times greater for the logged areas compared to the logging road and log landing areas. No statistical differences in Ksat values among treatments occurred at the deepest sampling depth (30 to 40 cm). For the 0 and -0.4 kPa soil water pressures, water retention was 11% higher and 7% higher for the logged areas versus logging road and log landing areas averaged across all soil depths, respectively. Soil water retention was significantly affected ($P<0.01$) by soil depth for all pressures; soil water retention increased with increasing soil depth due to increases in clay content. In addition, significant interactions with soil water retention occurred among treatments and soil depth; retention decreased more with depth for logged areas compared to log landing and logging road treatments. For the macropores (>1000 micrometer diameter) and coarse mesopores (60 to 1000 micrometer diameter) combined, values were 95% higher for the logged areas compared to logging road and log landing areas within the 0 to 10 cm depth. Pores decreased with soil depth for coarse mesopores and fine mesopores (10 to 60 micrometer diameter), but increased with depth for the micropores (< 10 micrometer diameter), The water retention and porosity values were affected by increasing soil bulk density due to differences in soil compaction. Soil hydraulic properties which included soil hydraulic conductivity, water retention and pore size distributions were significantly affected by forest harvesting treatments. From this study, the methods used in logged areas appear to have caused less change in soil physical and hydraulic properties; however, significant changes occurred with these properties for logging road and log landing areas. Efforts to reduce compaction should be concentrated in areas with logging roads and log landings.

Keywords：*saturated hydraulic conductivity, water retention, pore size distribution, bulk density*

P1-516

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Spatially Explicit Large Area Net Soil Moisture Dynamics of Different Tree Species in Tropical Wildlife Reserve Using Geospatial Strategy

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Soil moisture constitutes the largest terrestrial pool of plant species playing important role in the global cycle. Soil moisture depletion includes the quantity of water used for evaporation, transpiration, and deep percolation losses. The moisture availability under the tree is important for growing of crops and grasses. Remote Sensing in conjunction with Geographic Information System are now providing new tools for advanced ecosystem management facilitating the synoptic analysis of Earth system function, patterning and change at local, regional and global scales over time. The present study addresses the estimation of soil mositure dynamics of Tropical Wildlife Reserve. Geospatial and various forest inventory approaches were used on IRS LISS III data acquired on October 2012, to find the precise estimation of soil moisture dynamics. The present soil moisture dynamics study of different tree species in Anogeissus pendula edgew., Acacia nilotica willd., Dendrocalamus strictus roxb., mixed Anogeissus butea and Riverine forest at 3 meter distance from tree trunk was carried out. It was observed that the depth wise soil moisture distribution and profile moisture status were maximum under control and closely followed by Riverine forest, as compared to other tree species. Soil moisture extraction and moisture extraction rate was maximum in Anogeissus pendula edgew. and minimum in Riverine forest.

Keywords：*Anogeissus pendula edgew., Extraction rate, Geospatial technology, Soil moisture*

P1-517

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Root Biomass under Stem Bases and at Different Distances from Trees in the Brazilian Caatinga

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Determining forest biomass is an important issue due to its role in CO2 balance, soil organic matter accumulation and nutrient cycling as well as for vegetation management and wood production. However, few determinations in tropical dry forest have been carried out and even fewer of root biomass. Collecting roots is a difficult task and most determinations ignore the root biomass under the stem bases of the trees, which may underestimate total root biomass values if more roots concentrate under the stem bases than outside the bases.

Aboveground and root biomasses and the root: shoot ratio were determined in six areas of Caatinga, the Brazilian dry forest. The aboveground biomass of selected trees was weighed after cutting and the aboveground biomass of all other trees in surrounding 20 × 20 m2plots was estimated by allometric equation. The root biomass was collected from 0.5 x 0.5 m2trenches, opened under the stem bases of the selected and cut trees and in areas away of the stem bases at several predetermined distances from the bases. The roots were collected in 20 cm deep layers down to 1 m or until an impermeable layer was reached and separated into five diameter classes: <2 mm; 2.1 to 5 mm; 5.1 mm to 10 mm; 10.1 to 20.0 mm; and>20.1mm. The root: shoot ratio was determined dividing the root by the aboveground dry biomass.

The average aboveground biomass was 46.5 Mg ha-1. The average root biomass in the trenches under the stem base (15.7 kg m-2) was ten times higher than in those outside the stem bases (1.65 kg m-2), which did not significantly differ according to their distance from a stem base.The area equivalent to the stem bases of all the trees in the plot (average of 141 trees in a 400 m2 plot), considering that each one corresponded to a trench of 0.5 x 0.5 m2, was 35.3 m2, about one eleventh of the area of the plot. Therefore, the root biomass under the bases was 41% of the total root biomass (10.6 and 25.6 Mg ha-1, respectively). The same value was found in a literature review of world forests in general. The root: shoot ratio ranged from 42 to 66%. The highest proportion of roots was in the upper soil layer and most of them were coarse roots (>20.1 mm).

The shoot biomass was slightly higher than the estimated average shoot biomass of Caatinga (about 40Mg ha-1), based on several measurements in different areas, but the root biomass was much higher than the estimated one (7 Mg ha-1) which was based on root:shoot ratios available for tropical forests, in the absence of existing measurements. The much higher ratio in Caatinga indicates that other dry forests may follow the same pattern, confirmed by some but not all of the few measurements in other countries and explained by the higher relative growth limitation of shoots than of roots under water stress.

Supposing that biomass under the stem bases had not been measured and the root biomass of the whole area was the same as that outside the bases (1.65 kg m-2), the total root biomass (16.5 Mg ha-1) would have been underestimated in about 64% of the real value (25.6 Mg ha-1). Therefore, it is essential to consider the root biomass under the stem base to obtain a proper estimation of the root biomass.

Keywords：*root: shoot ratio, root biomass, root distribution, dry forest, semiarid*

P1-518

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Spatial Distribution of Soil P and its Correlation with Soil Acidity in Mountain Meadow of Wugong Mountain

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Phosphorus is one of the essential elements for the plants growth. According different altitudes (the altitude range from 1600-1900metres) and different soil depths in mountain meadow of WuGong Mountain in JiangXi province to set the sites, analysed the spatial distribution of soil total P content and the available P content, and the correlation between soil P and soil acidity. The main research results were as follows: (1)Wugong Mountain the same soil layers of different elevation of soil available P content showed the vertical distribution of the law. With the elevation gradually increased, the total P content and available P content increased gradually, showing a clear upward trend, the range of variation in soil total P and available P were 3.71-17.78 mg?kg-1and 0.46-1.37 g?kg-1 respectively. Available P content have spatial correlation with total P content ;(2) There were no significant difference in pH along the altitudes and soil depths. The soil total hydrolytic acidity and soil exchangeable acidity depths have significant difference along altitudes; (3) there were significantly positive correlations between soil available P and soil total hydrolytic acidity and soil exchangeable acidity. This research can reveal the spatial distribution of soil P and the correlation between available P and soil acidity, as well as for a guidance of vegetation restoration in mountain meadow ecosystem.

Acknowledgement

The work reported here has been funded by The National Natural Science Funds (31360177)，(31260194），(30960312) and IPNI (Jiangxi-29); National Key Technology R&D Program of the Ministry of Science and Technology (2012BAC11B006); Department of Education Science and technology project in Jiangxi Province (GJJ10107); The environmental protection department science and technology project in Jiangxi Province (JXHBKJ2012-7) and The young teacher development plan of visiting scholars in Universities in the special fund.The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Mountain meadow; soil available phosphorus; total hydrolytic acidity; exchangeable acidity ; Active a*

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[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

The Effect of Robinia Pseudoacacia Short Rotation Coppice on Soil Physical Properties

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Land use, soil management and soil cover have a significant influence on soil physical properties. Several studies highlighted these influences (Kodesova et al., 2011; Bagarello et al., 2011; Yuksek et al.). Comparing to other land use, agricultural activities can lead to a degradation of soil physical properties. Agricultural machinery traffic across the fields can induce the development of compacted areas at the wheel tracks (Coutadeur et al., 2002). It leads to soil compaction from the surface to the bottom which causes a decrease in porosity and a new distribution of different classes of pores (Richard et al., 1999). This change results in a decrease of the hydraulic conductivity (Stepniewski et al., 1994), and therefore, prevents water infiltration and promotes surface runoff (Quiquerez et al., 2008). In the arable land, surface runoff and soil erosion are enhanced due to the absence of soil cover for part of the year (Ruiz-Colmenero et al., 2013) and by the decrease of aggregate stability related to soil organic matter decline (Haynes and Swift., 1990).

In that context, few studies focused on the conversion of an arable land in a short or very short rotation coppice. This study aims to determine the influence of a Robinia pseudoacacia short rotation coppice (SRC) established on a arable land on soil physical properties.

Five years ago, an arable land located near the experimental farm of Grignon, (30km West of Paris, France) was converted to SRC. Robinia pseudoacacia was planted at two density of plantation i.e. 2500 stems ha-1 and 5000 stems Ha-1. On the same soil type and less than 500 m of the Robinia establishment, grassland, arable land and forest were used as comparison. Therefore to measure the effect of land use on soil physical properties, measurements of i) soil water retention on a pressure plate apparatus for 7 water potential between 0 and 1500 kPa, ii) aggregate stability using the method described in Le Bissonnais (1996), iii) bulk density using the method for gravelly and rocky soil recommended by the USDA (USDA, 2001), iv) soil hydraulic conductivity using a single ring infiltrometer and v) nitrogen mineralization dynamics were performedon the different land uses.

Measurements are underway. They will be analyzed and presented to Congress.

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Keywords：*soil water retention, Hydraulic conductivity, Aggregate stability, Bulk density, nitrogen mineralization, land use*

P1-520

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

The Morphological Features of Mica And Chlorite Minerals in Fine Sand Fraction in Some Forest Soils of Kurdistan Iraq

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This study was conducted to investigate the morphological features of mica and chlorite minerals in fine sand fraction in some forest soils. Soil profiles were taken from seven different sites of forest soils. Which include Xalakan-Pine, Dukan-Oak, Baxy-baxteyare-Pine, Goizha- Cypress and Goizha-Olive. Near each above sites, a reference site of soil was dug and they had the same above properties, but are abandoned soils. Soil samples were analyzed for some physical, chemical and mineralogical properties in the soils. The following results were obtained and can be summarized as follows: Results of chemical analysis were exhibited that the pH values for studied soils were ranged between moderate slightly acidic to alkali (6.62-8.36). The results of electrical conductivity (EC) indicated that all studied soils were non-saline, and the value ranged between (0.13-2.07 dS.m-1). Amount of calcium carbonate equivalent indicated that the studied soils were calcareous to extremely calcareous soils and the amounts of total and active CaCO3 were ranged between (50-495 g.kg-1) and (10-225 g.kg-1) respectively. As well as the results showed a decrease in content of organic matters with depth in all studied soils. The results of four forms of K in soils: soluble, exchangeable, Non-exchangeable, and mineral were (0.0014-0.0595), (0.40?1.51), (0.02?1.66), and (17.83?38.72) Cmol kg-1 respectively. The change in morphological features of fine sand fraction due to weathering by using optical microscope was investigated and the results showed that the grains of these minerals from individual soil horizons had different colors, those from the surface horizons were have a dark brownish spots, presumable due to staining by organic matter, those from (B) horizon have a yellowish grey-to yellowish brown spots, and those from the (C) horizon were sometimes grey, similar to the parent rocks. In general, almost the grains of chlorite were kept up their green color with depth in all studied pedons, while the surface of these grains in top soil were stained by dark brownish to dark spots, due to partial oxidation of chlorite minerals at the surface soil horizons. The optical microscope examination indicated that mica grains generally occurred as thick particles with different stages of layer separation. They were weathered with layer separations and bending at their edges. However, in control pedons, weak layer separation at the edge was observed.

Keywords：*forest soil, clay mineralogy*

P1-521

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

The Effects of Inceptisols and Ultisols on Composition of Solution Ions in Fushan Natural Hardwood Forest Ecosystem in Taiwan

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The biological and chemical processes in a soil environment are affected mainly by the chemical composition changes of soil solutions. An intensive effect of atmospheric chemical input on soil solution properties could be found since the atmospheric precipitation can be much different among landscapes. Moreover, the soil properties can strongly affect solution properties as well. In Fushan natural hardwood forest ecosystem in Taiwan, two plots was selected according to their different soil properties with similar atmospheric input and forest instruction to study the increasing/buffering effects of soils on the composition of solution ions. The study site is located at 24 45'40" N, 121 33'28" E and is constructed by complicated topographic components at elevations ranged from 600 to 733 m above sea level. The bedrock in the studied area is a metamorphosed sedimentary rock from the Oligocene and Miocene, containing argillite and slate. The climate is strongly influenced by northeastern monsoon in winter and by typhoon in summer with an average temperature of 18.2℃, a mean annual precipitation of 4270 mm, and a mean relative humidity of 95%. Two plots were selected according to their soil classification results including an Inceptisol plot at a steep slope and an Ultisol plot at a gentle slope. Three soil profiles of each plot were used in this study. The throughfall, runoff and soil solutions leached from A and B horizon were collected monthly from January 2008 to February 2009. The water volume of each collection was recorded and the subsamples were then filtered with Whatman No. 42 filter paper followed by the analyses of pH and EC. Furthermore, the concentrations of dissolved organic carbon (DOC) were determined using a total organic carbon analyzer (Aurora Model 1030W), the concentrations of Ca, Mg, K, Na, Fe, Al, Mn and Si were determined by Inductively Coupled Plasma with Atomic Emission Spectroscopy (ICP-AES Perkin-Elmer 2000 DV), and the concentrations of NO3, PO4, SO4 and Cl anions were determined using ion chromatography (Metrohm 792 Basic IC).

Our results showed that the volume and the chemical composition of throughfall were similar from one plot to the other with the exception of pH which was higher in the throughfall collected from Ultisol plot than from Inceptisol plot. Although the slopes were different, both plots showed a loading of water from higher land either through surface runoff or through lateral drainage, which indicates the complexity of element budge assessment. The surface A horizon did not retain the concerning ions in throughfall water to decrease their concentrations in runoff water. Conversely, K, Mg, Fe, Al and DOC were released into the runoff water. All soil profiles showed pH buffering effects comparing throughfall with leaching solutions. The soil solums buffered the input of K and DOC from throughfall which resulted in the lower concentrations in leaching solutions. In contrary, the leaching solutions contented higher Mg, Fe, Al, Si, and NO3 and much higher Ca then the throughfall water. Compared to Inceptisol, the increasing ability for the concentrations of Fe and Al was higher and that of Ca was lower in Ultisol plot.

In the two plots, the topography variation did not cause large differences in water and chemical loading. In addition, the climate, forest construction and parent material were similar. Supposing that the weathering intensity in the Ultisol plot was not largely differ from that in the Inceptisol plot, time of pedogenesis might be a critical factor on the soil formation. This implicates that the Inceptisol plot might be a younger colluvial/truncated soil whereas the Ultisol plot might be an older in-situ-formed soil, which needs to be further studied. The ion input/output budget assessment showed that both soils had the net outputs of Si and Ca (2.7-2.9 and 27-59 kg/ha, respectively) and the net inputs of ions K (44-88 kg/ha), Na (34-43 kg/ha), Mg (1.4-18 kg/ha), Cl (100-170 kg/ha), and SO_4 (50-72 kg/ha) while the net outputs of Fe (1.3 kg/ha) and NO_3 (49 kg/ha) was obvious only in Ultisol and Inceptisol, respectively. Charge balance calculations showed significant deficits of anions in leaching solutions from both A and B horizons and thus, DOC might play an important role on the mobility of cations.

Keywords：*Forest, Throughfall, Runoff, Leaching, Inceptisol, Ultisol*

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[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

The Effect of Prescribed Burning on Soil Microbial Properties in a Suburban Native Forest of South-East Queensland

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Carbon (C) and nutrient (particularly nitrogen (N)) cycling are key ecosystem processes, which can be affected by prescribed burning - an important tool in forest management systems around the world. However, changes in soil C and N pools and their dynamics in response to the fires may be site-specific and need to be investigated for periods from short to long term. The present study was undertaken to investigate surface (0-5 cm) soil labile C and N pools before and in the first 18 months after the prescribed burning. The experimental site was located within a suburban Toohey Forest of south-east Queensland, Australia (27°30′S, 135°E). The soil samples were collected before the burning and monthly in the first six months after the burning, then every second month in the following six months, and every three months in the last six months of the experiment. Within the labile C and N variables measured, only hot water-extractable total organic C (HWTOC) and hot water-extractable total N (HWTN) were significantly influenced by the fire during the 18-month period. Both HWTOC and HWTN significantly increased after the fire. These changes can be attributed to the releases of carbohydrates due to microbial lysis as well as heat-induced alterations of organic compounds. The low intensity of the fire might account for the lack of a significant effect on the other variables of labile C and N. We will also present both medium- and long-term changes in soil labile C and N pools after the fires.

Keywords: Prescribed burning, Carbon and nitrogen cycling,labile C, soil microbial properties

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[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

The Impact of Biodiversity on Initial Soil Erosion Processes and Nutrient Fluxes in Subtropical Forest Ecosystems

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In soil erosion research it is widely accepted that vegetation is a key factor for the type and intensity of erosion. Thus, scientists have long recognized the importance of forests for erosion control and afforestation is a common measure of soil protection. However, the mechanisms how forests protect the soil remain debated and especially the role of biodiversity is unclear.

In the framework of the "Biodiversity and Ecosystem Functioning (BEF) China" project (funded by the German Research Foundation) several experiments have been carried out in subtropical China to investigate the role of biodiversity for soil erosion control. In this study, we present results of an experiment on the influence of tree diversity on initial soil erosion focusing on sediment discharge, runoff volume and nutrient as well as carbon fluxes.

The initial soil erosion has been quantified in the field using small scale runoff plots (MiniROPs, 40 cm x 40 cm). Within the BEF China project, 70 study plots have been equipped with 5 ROPs each (350 MiniROPs in total). The study plots represent different levels of biodiversity ranging from 0 (bare plots) to 24 tree species mixtures. The measurements took place during the rainy season from May to July 2013 with rainfall events showing intensities up to 85 mm h-1. We measured sediment discharge, runoff volume, soil surface cover and leaf cover in the field. In addition organic carbon, nitrogen and phosphorous contents were analyzed in the lab.

The results show soil loss rates of 55 t ha-1 year-1. Compared to other studies from subtropical regions they are in the same range. This confirms that our MiniROPs are well suitable to measure initial soil loss and runoff in subtropical ecosystems. According to their small size, they are easy to handle in the field and a large number of replications can be applied. First analyses of runoff and sediment discharge data indicate a significant influence of tree diversity on initial soil erosion. Since our experimental forest is still young with 3 and 4 years old trees, not only LAI but also the size of the gap fraction controls soil loss greatly. Another important component in such initial forest ecosystems is biological soil crust (BSC) cover. We observed different BSC (mosses, lichen, algae and cyanobacteria) covering up to 55 % of the ground. In general, it can be shown that such BSC increase runoff. Regarding sediment discharge, runoff plots with high BSC cover show lower sediment loss. We assume that CNP fluxes follow the same pattern. These preliminary findings will now undergo a detailed statistical analysis to better understand the processes involved and to quantify the relationships between tree diversity and soil erosion and will be presented at the 20th WCSS in Jeju.

Keywords：*soil erosion, biodiversity, forest ecosystems, sediment discharge, runoff*

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[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Nitrogen Fluxes in the Soil Profile of Tropical Seasonal Forests in Cameroon

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Introduction

Nitrogen (N) is considered to be one of the essential elements limiting net primary production in tropical forest ecosystems. Many studies on N fluxes in tropical forests have been conducted to elucidate N use efficiency under the infertile soils on which most tropical forests exist. However, most of these studies have not focused on the soil conditions and have just described the soils as 'infertile' or 'highly weathered' so it is still unclear what kind of soil properties (e.g., pH, soil texture and etc.) causes different N dynamics in forests. In strongly acid soils for example, it is well known that Al-toxicity and inhibition of nitrification occurs, possibly resulting in the different N dynamics of moderately acidic soil. For sustainable production in Central Africa, which has tropical forests on both strongly and moderately acidic soils, it is essential to reveal the difference in soil N dynamics in forests for each soil condition. Therefore, the objective of this study was to compare the soil N dynamics of tropical seasonal forests under different soil pH conditions in Cameroon thorough analysis of in situ soil solutions within the soil profile.

Materials and Methods

This study was carried out in forested sites in eastern (A) (A horizon pH is 4.2, Typic Kandiudox) and southern (E) (A horizon pH is 3.5, Typic Paleudults) Cameroon. Sites were 400 km apart. Soil solutions by tension-free lysimeters at 0.3 m depth and litter leachate (beneath O horizon) in five replications were collected monthly between April 2010 and April 2011. Throughfall was also collected using a precipitation collector. The volumetric water content in soils at 0–15 and 15–30 cm were monitored half-hourly. The concentration of dissolved N was measured for all samples and the annual flux was calculated. The water fluxes of throughfall were measured using a precipitation collector, while the half-hourly fluxes of soil water percolating from 30 cm were calculated using HYDRUS-1D. Litterfall was also collected monthly and the annual input of N and carbon was calculated. Fine root biomass in the O horizon was also measured.

Results and Discussion

The amount of annual rainfall during the experimental period at site A was 1,325 mm and was 1,460 mm at site E, showing no clear differences in climate condition between two sites. Nitrate fluxes (dissolved N fluxes consisting mostly of nitrate-N) in the O horizon at site A (118.9 kg-N ha^{-1} yr^{-1}) were six times as high as those in throughfall (19.2 kg-N ha^{-1} yr^{-1}), while no difference

was detected at site E (11.8–12.0 kg-N ha^{-1} yr^{-1}). Conversely, nitrate fluxes in soil solution at 30 cm from both sites were substantially low (11.5 kg-N ha^{-1} yr^{-1} at site A, 4.9 kg-N ha^{-1} yr^{-1} at site E) compared with each O horizon. The litter leachate pH value was significantly lower in site E (5.3) than in site A (6.8), corresponding with the soil pH relationship. The fine root biomass in the O horizon at site E (2.2±0.5 Mg ha^{-1}) was significantly higher than that at site A (0.9±0.4 Mg ha^{-1}), as a thick root mat was observed at site E. Thus, the results indicate that N is absorbed by plants at both the O horizon and mineral soil layer (0–30 cm) at forested sites with moderately acidic soil (A), whereas N is mostly absorbed within the O horizon with a thick root mat but not at mineral soil in a forested site with highly acidic soil (E). The C/N ratio of litterfall was also significantly lower at site A (19) than at site E (29). This indicates that at forested site A, N-rich litter is produced, resulting in immediate N mineralization and much N leaching to the mineral soil, while at forested site E, N-poor litter is produced, resulting in slow N mineralization and little N leaching. This litterfall quality result is consistent with the N fluxes through soil solutions. Therefore, the results suggest that soil pH caused the different soil-plant N dynamics in the tropical forests of Central Africa.

Keywords：*Soil solution, Tropical forest, Central Africa, Soil pH, Nitrogen dynamics, Oxisols, Ultisols*

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[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Novel Techniques for Expanding Our Understanding of Soil Disturbance Resulting from Stump Harvesting Operations

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This paper presents results of applying new methods to improve understanding of disturbance to forest soil resulting from stump harvesting.

For a number of countries there is interest in the application of stump harvesting as a source of forest fuel, but there is also a widely held concern about the soil disturbance that may result from it. In assessing the severity of disturbance there is a need to determine both its nature and extent. Published results differ in the degree and particularly the nature of stump harvesting disturbance, compounded by the lack of any uniform standard for measuring it.Two widely used measures employed in stump harvesting disturbance studies are visual assessment of disturbance extent and bulk density measures of the nature of disturbance. Each of these has limitations. Visual assessment requires no specialist skills, and is relatively quick. However it is limited to two dimensions, is subjective in its application and, in the absence of a commonly adopted method, difficult to compare results between different studies. Bulk density provides a relatively straightforward indirect measure of the soil response to implosive and explosive force, both of which are present in operational stump harvesting. But it does not provide any direct evidence of how these disturbance forces transform the soil structure and so impact the functional capability of the soil.

This study seeks to extend the insight into both the nature and extent of disturbance by the application of additional novel techniques by which means the physical disturbance effect of both stump harvesting and other forestry practices can be compared.

To overcome the two-dimensional and subjective nature of visual assessment, a radiometric approach was adopted, utilising residual Chernobyl 137Cs fallout to determine the degree of soil mixing. This provides a non-intrusive, objective field method for disturbance assessment, the results of which include a depth dimension. To this was added the in-ground deployment of innovative low-cost tracer devices which permitted monitoring of the actual movement of soil during stump extraction, providing data on the depth and lateral extent of the resulting soil disturbance.

To complement bulk density measurements, further insight into the nature of disturbance and its structural impact was gained by the micromorphological analysis of soil thin sections produced from samples collected under a range of field conditions, including both undisturbed and disturbed soil. This provided a direct view of resulting pore space outcomes.

Another facet of this study was close observation of operational process under field conditions. Stump harvesting involves a sequence of operations, each of which has disturbance potential, and these may at times act with opposing effect. It is therefore important to be able to understand and interpret the net outcome in the light of the operational process.

All of the above elements were applied to a stump harvesting operation carried out under current UK guidance at a UPM Tilhill managed site in south west Scotland. Through the field application of an enhanced toolkit of methods, issues relating to actual stump extraction could be identified, and distinguished from those which relate to wider operational or management considerations, allowing the range of outcomes from historic stump harvesting studies to be better understood. Insights were gained into the movement of soil following stump extraction. Observations on the areal and volumetric measures of disturbance facilitated comparison with the disturbance generated by ground preparation operations. The study indicated that under current UK management and operational practice, stump harvested and replanted landscapes are likely to be subject to a net reduction in soil bulk density, rather than compaction as some historic studies have reported. This effect should be recognised in any discussion of future best practice.

This work was part-funded and actively supported by the UK Forestry Commission and UPM Tilhill.

Keywords：*Soil disturbance, Stump harvesting, Cs-137, Tracer tags*

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[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Effect of Forest Stands on the Subsurface Salt Accumulation and on the Watertable Level

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A systematic study is currently carried out for the characterization of the influence of environmental factors on the solute accumulation under forested vs not forested plots in the Great Hungarian Plain.

Data of pairs of control vs. forested plots showed the importance of both biotic (tree species, age) and abiotic (texture, watertable depth and solute content) factors. The study reported was carried out in dominantly sandy areas with shallow water table. On each site, temporal change of watertable level was observed to get information about watertable fluctuation/water table depression under forest stands of different tree species and age. Chemical parameters (EC, pH, pNa, pCl) of watertable and soil (particle size composition, EC, pH, pNa, pCl and CaCO3) was analysed and compared to the control plots (arable land or grassland) to observe accumulation processes under forest stands.

Results showed that the factors modifying clearly hypothetical results are assumed to be regional recharge/discharge systems and contrasting stand age of recently established forest stands older forest stands.

Vegetation has a strong influence on water and salt budget of the stands. Differences were seen between the effect of forest and control (arable or grassy) stands. Water uptake from the watertable by arable land was not so intensive, than by grass vegetation (pasture), due to buffer effect of interception. Data suggest that tree stands have taken up much more water, than the control stands, this way forming continuous water table depression.

Trees accumulate different kind of salts around the root zone, but in the studied cases, this process has not reached dangerous level. However, solute accumulation with Na-dominancy appeared in the watertable under one of the studied oak forest stands, which can damage some part of the forest in the long run. It can be claimed, that in mostly sandy areas, more than 140 years of continuous forest vegetation can negatively alter the chemical composition of watertable, and can contribute to an increased chance of soil sodification. Between these circumstances the process of solute accumulation is considered to be slow, perhaps can damage the next seedlings to be planted. This potential threat must be verified by further research.

The research was realized in the frame of OTKA NN 79835, TÁMOP-4.2.2.A-11/1/KONV-2012-0013 projects and the János Boyai Scholarship of the Hungarian Academy of Sciences

Keywords：*trees, water uptake, Watertable, solute accumulation*

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[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Hydropedological Interpretation of Ancient and Recent Soil Properties

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Hydrological modelling utilises flowpaths and storage mechanisms to develop conceptual hydrological models. Soil, a first order hydrological control, has signatures of these mechanisms developed by the soil water regime during soil formation. Changes in soil chemistry typically precede changes in morphology consequently soil chemistry is an indicator of the recent hydrology. Although hydrometric measurements do reveal the current hydrological regime, conceptual interpretations of these point scale data might be erroneous when applied to whole hillslopes. The transference value between soilscapes of the latter is also minimal. It is hypothesized that soil chemistry, a sensitive, equilibrated product of recent water/soil interactions can be used to (i) reveal the recent hydrological behaviour of a particular horizon in a hillslope and (ii) due to their relationships with horizon morphology can be extrapolated from point scale hydrometrical measurements to soilscape scale. The aim of is therefore to establish the relationship between ancient (morphological) and recent (chemistry) soil indicators of hillslope hydrology and to verify whether this relationship reflects the current hydrological regime using hydrometrical measurements.

Morphological and chemical properties are reported at 100 mm intervals. A Haplic Lixisol (Epidistric, Arenic) and an Alic Gleysol (Distric, Gleyic, Arenic) hydrological response was inferred using morphology. The chemical properties used to as indicators of processes where exchangeable Ca, Mg and S-value (sum of base cations); pHwater and CBD extractable Fe and Mn. The water regime is presented as drainable water, quantified as the degree of saturation exceeding 70% of porosity, in days per year (ADs>0.7), from long term soil water content measurements.

Soil morphology, an indicator of ancient soil water regime, correlated well with current duration of soil water contents approaching saturation. The high chroma of the Haplic Lixisol on the midslope seldom exceeds drained upper limit and serves as a recharge soil. This condition is indicative of a fast vertical flowpath and excess water recharging the underlying fractured rock. Slight increase in Ca, Mg, S-value and pHwater with depth in the subsoil and a decrease in the deep subsoil indicating that leaching is present and that cations are removed from the profile. Morphological indicators are therefore supported by a high degree of leaching confirming that water is moving vertically through the profile and exiting the profile. High ADs>0.7 (115 days of the year) of the topsoil can be related to the bleached colour of the horizon. The subsoil has drainable water for short periods increasing downwards (ADs>0.7 of 4, 8 and 50 days per year respectively) and a similar duration in the deep subsoil indicating a fractured rock water table and lateral water flow in the shallow fractured rock.

Alic Gleysol is a storage mechanism and a slow flowpath indicated by the gley morphology on the footslope. The high pH and base saturation in the gleyed horizon support the morphological deductions, but there are deviations in Ca, Mg, S-value and pHwater at the transition of surface and subsoil horizons suggesting the development of an Albic horizon and a flowpath not identified in the morphology. The decrease in chemical properties indicates a flowpath removing cations at the interface. Alic Gleysol is saturated for 203 days per year at the surface and saturated for nearly the entire year from the bottom of the topsoil and the transition to the gleyed horizon. Due to the slope (8%) saturated water will move laterally on the topsoil/subsoil interface confirming the flowpath inferred by the chemical properties.

Soil chemistry improved identification of hydrological processes currently active in the diagnostic horizons and soils and can therefore be used to verify trends in soil.

Keywords：*Morphology, Chemical Properties, Flowpath, Storage mechanism, hydrological response*

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[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Soil Contribution to Carbon Budget of Russian Forests

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Forests play an important role in the carbon cycle and carbon sequestration at both local and global scales. Boreal forest accumulate enormous amount of carbon, particularly in soil. More than half of Russian forests are growing on permafrost. The dynamics of soil carbon pool under climate change remain highly uncertain. The flux of CO2 from soil to the atmosphere ? soil respiration (RS) - is probably the least known component of the terrestrial carbon cycle. RS depends on many factors (like vegetation and soil type, decomposition conditions, etc.) and varies substantially in time and space. High uncertainty of RS flux causes a wide range of carbon budget estimates of Russian forests. We attempted to assess RS of Russian forests based on a comprehensive description of the country's ecosystems and landscapes presented in a form of an Integrated Land Information system and using the most comprehensive databases of in situ RS measurements with a focus on Northern Eurasia (3 500 records globally, including over 1 600 for the region). The RS model for Russian forests was elaborated based on in situ RS measurements, climate parameters, soil and land cover datasets, and accounting for ecosystems' disturbances. The spatial resolution of the model is 1 km^2.

Due to our estimation, Russian forest soil accumulated 144.5 Pg C in 1 m depth, including 8.3 Pg C in the most labile topsoil organic layer. Uncertainties of the total stock of organic carbon in soil of Russian forests is estimated at ± 10% (CI 0.9). The average soil carbon density received (17.6 kg C m^{-2}) is within the range of other estimates: from 9.6 kg C m^{-2} (Alexeyev and Birdsey 1998) to 20.3 kg C m^{-2} (Rozhkov et al. 1996). Some recent results are closer to ours, e.g. 15.9 kg C m^{-2} (Zamolodchikov et al. 2005), 16.2 kg C m^{-2} (Chestnych et al. 2004). Any uncertainties of the previous results were not reported.

Our average estimate of topsoil organic layer carbon density is 1.01 kg C m^{-2} and varies from 0.39-0.48 kg C m^{-2} (forested lands in semi-desert zone) to 1.26 kg C m^{-2} (soils of broad-leaved forests in the Far East). Other authors reported from 0.72 (Chestnych et al. 2007) to 1.80 kg C m^{-2} (Alexeyev and Birdsey 1998) for the topsoil organic layer. Major reasons of such variability are different information bases and methods of the estimation, considering or excluding disturbances.

The total heterotrophic soil respiration (RH) flux for the Russian forest is estimated at 1.7 Pg C yr^{-1} (207 g C m^{-2} yr^{-1}). Interannual variability or RH in 1997-2005 was around 5% for the whole country and up to 23% for individual regions with an average linear trend +0.2% per year.

Our estimate of RH is higher than other published results for Russian forests. For example Nilsson et al. (2000) reported 179 g C m^{-2} yr^{-1}, Kurganova (2003) ? 171 g C m^{-2} yr^{-1}, Golubyatnikov (2011) ? around 160 g C m^{-2} yr^{-1}.

Soil carbon pool makes about 75% of the total carbon stock in forests of the Russian territory. Mean annual heterotrophic respiration flux from Russian forests does not exceed 1.2% of the total carbon storage. Heterotrophic soil respiration makes up about 65% of Net Primary Production that substantially impacts the net ecosystem carbon balance estimated at 611 Tg C yr^{-1} (74 g C m^{-2} yr^{-1}).

Keywords：*Soil respiration, Organic carbon, Boresl forest, Russia*

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[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Grazing in Mountain Ecosystems; Results of Long-Term Experiments in Norway

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Livestock grazing is an important land-use in the north-Atlantic region of Europe and the dominant form of land use worldwide. In Norway, sheep are the most important large herbivores grazing in natural and semi-natural habitats and sheep grazing pressure in mountain areas has increased in the last decades. Grazing by large herbivores may have severe impacts on ecosystem structure through direct and indirect impacts on ecosystem processes and properties important for carbon (C) and nitrogen (N) cycling and hydrology. Direct impacts of herbivory include trampling, plant defoliation and nutrient return in form of urea and faces. In turn, this may affect soil properties (e.g. temperature, moisture, bulk density and infiltration rate), vegetation cover (e.g. species composition, biomass and nutritional status) as well as recycling and losses of C and N. So far, most studies on effects of grazing on aboveground (vegetation dynamics and water quality) and belowground (physical and chemical soil properties) processes and properties have been done in intensively managed, fertilized systems, whereas detailed investigations in non-fertilized semi-natural alpine areas are rare. Here we present results from a unique 11-year experiment on the ecological effects of sheep grazing in an alpine environment of moderate productivity in Hol, southern Norway. The experimental setup included enclosures with three replicated density levels of sheep (no sheep, 25 km^2 and 80 km^2) running from 1050 to 1320 m a.s.l. These densities are within the range of sheep stocking in similar alpine rangelands in Norway. The grazing pressure prior to start of the experiment in 2001 was around 10 sheep km^2. The high sheep density and the ungrazed treatments thus represented an increase and decrease in grazing pressure, respectively. Results on recruitment and survival of birch (Betula pubescens tortuosa) along an altitudinal gradient clearly showed that herbivores limit the treeline below its climatic potential. Birch recruited within the whole altitudinal range of ungrazed enclosures, but recruitment was smaller at low sheep density and largely limited to within the treeline at high sheep density. Aboveground plant biomass of vascular plants decreased after five years at high sheep density, whereas a marginal increase was found at low sheep density. The ungrazed treatment was found to be intermediate suggesting a non-linear effect of increased grazing on plant productivity. In accordance with the results on plant biomass production, seven years of grazing at greatest sheep density reduced soil organic C concentration and C-stocks at equivalent soil mass as compared with the ungrazed treatments. By contrast, low sheep density caused no change or a slight increase. The form of SOM, expressed as the ratio of particulate organic C to soil organic C, showed a small decrease and moderate increase at high sheep density and low sheep density, respectively. In general, rates of soil N mineralization in the alpine systems at Hol are small and although, potential N mineralization rates were found to increase due to high sheep density, we found no evidence for increased N runoff, neither as ammonium nor nitrate. Infiltration rates were significantly reduced and bulk density significantly increased, due to high grazing density, causing increased runoff of coliform bacteria. In the initial 11 years of the experiment there was a stronger influence on aboveground than belowground compartments.

Keywords：*Grazing, mountain, soil, water, nutrients, carbon, vegetation*

P1-530

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Effect of Stand Factors and Tree Species Composition on the Content of Potentially Toxic Elements in Forest Soils

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When present in excessive concentrations, potentially toxic elements (PTE) exhibit a range of effects which are detrimental to the growth and reproduction of plants, and have a negative effect on the activity of microorganisms, influencing thus the whole ecosystem baheviour. Additionally, studies have shown that high metal concentrations alter litter decomposition due to impaired biological functions and the distribution of metals is dependent on litter turnover mostly due to the binding affinity between metals and humified substances. In spite of these facts, rather low attention has been paid so far to the pollution of forest soils compared with agricultural soils. In the Czech Republic, there are no guidelines or limit values set up for the forest soils.

This contribution presents preliminary results of a project aiming in setting up some reference (background) values of soil pollution for forest soils. The main aim of this contribution is to determine the level of PTE (As, Hg, Cd, Mn, Pb, and Zn) pollution in soils from various regions of the Czech Republic and to assess the effect of principal factors that can influence the PTE content, namely altitudinal zone and tree species composition (coniferous versus broad-leaved species and mixed forest). The difference between various depths was also assessed. The most polluted hot spots in industrial areas and in the vicinity of main sources of pollution were intentionally avoided.

The results showed that most PTE have significantly higher contents in the surface organic horizons (forest floor). It indicates their prevailing anthropogenic origin. Manganese is an exception; it shows, similarly to iron, increasing content towards the depth. It reflects its prevailing geogenic origin. Vegetation zones (altitudes) significantly influence the content of Pb and As content: with increasing altitude the content of these elements generally increases. It probably reflects higher amount of precipitation bringing to soil also higher deposition. Tree species showed significant effect on the content of Cd, Zn and Mn in soil: lower content was generally found under coniferous (mainly spruce) forest compared to broad-leaved and mixed forests. This can be a result of different soil pH. Under coniferous forests the pH is lower which could lead to stronger leaching of these elements, while higher pH under the other forest types allowed stronger persistence of the elements in soil. A different situation is in case of Pb which has strong affinity to organic matter and therefore is retained strongly also in the acid soils. A different situation is also in case of As due to its opposite behaviour in various pH ranges, when the mobility is decreased in acid conditions.

It can be concluded that all the studied factors have some effect on the distribution of PTE in forest soils; however, behaviour of each element is specific. Setting up of any reference values must respect the specificity of each particular PTE and the stand types. Further attention should be focused on the mobile and consequently more dangerous forms of the potentially risk elements.

Keywords：*forest soils, stand factors, soil pollution, stand factors, reference values*

P1-531

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

The Brownfield of the Eiffel Tower Steel Mill: A Highly Contaminated but Well-Functioning Ecosystem

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The iron and steel mill, which produced the iron used for the construction of the Eiffel tower, left an abandoned brownfield in Northeast France. In spite of extremely high concentrations of heavy metals in soil well above toxic levels (e.g. Cadmium (Cd), lead (Pb) and zinc (Zn) up to 175 mg kg-1, 49,600 mg kg-1 and 56,500 mg kg-1, respectively), this brownfield is presently colonized by a seemingly healthy forest. We examined whether soil contamination has impaired ecosystem functioning using plant litter decomposition as functional indicators. Organic matter decomposition is a fundamental ecological process that determines important soil properties and fuels inorganic nutrients pool available for plants. We hypothesized that heavy metal contamination may affect the rate of leaf litter decomposition through (i) bottom-up (i.e. changes in leaf litter quality owing to plant physiological response to environmental stress) and (ii) top-down (i.e. impact of heavy metals on leaf litter consumers) effects. To test these hypotheses and to determine the relative importance of each mechanism, the contaminated site was compared with three sites that had not been directly impacted by past industrial activities. We assessed effects of leaf litter origin and decomposition environment on leaf litter decomposition rate and soil biota (microorganism and macrofauna). Abscised leaves from Populus tremula were collected at each site to assess differences in leaf litter chemistry and degradability. Decomposition rates of leaf litter from the different origins were determined in all sites using coarse-mesh (5 mm) incubated for 283 days.

Leaf litter originating from the contaminated site (LOCS) contained significantly higher [Cd] and [Zn] reaching 41 µg Cd g-1 DM and 808 µg Zn g-1 DM, and marginally lower phenolic content compared to leaf litter from non-contaminated sites. However, site origin had no effect on other ecologically relevant traits (i.e., leaf mass per area, leaves tensile strength, and the contents of nutrients and fibers).

Irrespective of the incubation site and despites higher Cd and Zn contents, LOCS lost mass two times-faster than leaf litter from non-contaminated sites. These differences cannot be explained by the above measured parameters, but we assume that the slightly lower phenolic compounds content in LOCS and a putative higher content of an attractive compound for decomposers in LOCS could explain this result.

In contrast, independently of leaf litter origin site, leaf litter decomposition rate did not change significantly between site categories, suggesting that soil ecological functions were not impacted by direct toxic effects of heavy metals. Interestingly, we found detritivorous and phytophageous invertebrates to be more diverse and abundant in the contaminated site than in non-contaminated sites. Bacteria community also differed between soil types. We can therefore conclude that changes in decomposer communities observed on contaminated site, selected by contamination, allowed the leaf litter decomposition process to be maintained.

Besides challenging our mechanistic understanding of ecological effects of soil contamination, our findings raise questions of how to define and measure ecosystem health in the context of brownfield management. Actually, this study supports the use of a functioning based bio-indicator, providing additional information to classical community based bio-indicators.

Keywords: *bio-indicator, leaf litter decomposition, metal stress, brownfield management*

P1-532

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Effect of Landslide Deposition on Soil Properties in the Xitou Experiment Forest, Central Taiwan

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Landslide is the gravitational movement of earth material and causes significant disruption of the forest ecosystems in mountain regions. However, its effects on soil properties are not well understood in Taiwan and require more research especially due to more expectation under current changes of human activities and climate change. In this study, we conducted: (1) a series of sampling sites with varying degrees of landslide deposition effects, and (2) a data set that comparing a 1977 soil survey and present soil survey after the occurrence of landslide deposition, in the Xitou Experimental Forest to assess the landslide deposition effects on soil properties.

The results indicated that pH value, bulk density, inorganic carbon content, and base saturation increased following landslide deposition and that the greater severity of the landslide deposition was the greater these increases were. By contrast, soil organic carbon content, total nitrogen content, and cation-exchange capacity significantly decreased following a landslide, and the level of decrease declined as the extent of the landslide declined. However, the exchangeable potassium, calcium, magnesium, and available phosphorus contents were unaffected by landslides. Total soil P content were not altered by landslide deposition, but P speciation were greatly changed from organic P form dominated soils in un-deposited forest to inorganic P form dominated soils in landslide deposition areas.

These results clearly demonstrate that landslide plays an important role to alter soil properties and these changes in soil properties are expected to influence the functions of forest ecosystems.

Keywords：*Landslide, Soil properties, P speciation, XANES*

P1-533

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Effect of Silicon Application in Soil on Betula Pendula Roth. Growth under Water Deficiency Stress

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Silicon (Si) is a basic mineral formatting element. Silicon fertilization has been reported to result in increased soil exchange capacity, improved water and air regimes, transformation of P-containing minerals and formation of alumosilicates and heavy metal silicates. All these effects are caused by the change in soil mineral composition that results from silicate addition (Si fertilizers) and/or formation of new clay minerals, which are characterized by high biogeochemical activity. They have large surface area and are able to adsorb water, phosphates, potassium (K), nitrogen (N), aluminum (Al), and heavy metals (Matichenkov and Bocharnikova, 2001; Ma and Takahashi, 2002; Zaimenko et al., 2013; Gocke et al., 2013). Silicon is known to ameliorate the deleterious effects of drought on plant growth. Si incorporates within cells in cell walls, especially in epidermal, stomatal and leaf trichome cells, or deposited, together with other elements (Hossain et al., 2002; Melo et al., 2003). Silicon deposition in the tissues help to alleviate water stress by reducing transpiration rate, improve light interception characteristics by keeping the leaf erect, increase resistances diseases pets and lodging, remediate nutrient imbalanced, and there are other documented beneficial effects were observed (Ma et al., 2001; Hattori et al., 2005; Kvedaras et al., 2006; Hamayun et al., 2010).

The effect of Si (as mineral analcime (NaAlSi2O6?H2O)) application in soil on Betula pendula under water stress was studied in pot experiment. Two-year old birches grew in the 22-24°C temperature and 75-80% relative humidity. Soil humidity was maintained at 20, 40, 60, and 80% of the total water in soil. The aim of this study was to investigate the effect of analcime as natural mineral soil fertilizer on birches under drought stress.

Soil drought depressed the growth of shoot and root and decreased chlorophyll concentration. Addition of mg?kg-1 analcime in soil could improve the growth of shoots on 10 % (80 % soil humidity) ? 30% (20% soil humidity) and increase the leaf chlorophyll concentration of stressed plants on 5 ? 15 % respectively. Water stress may effect plasma membranes and cause oxidation of membrane bound unsaturated fatty acids. Si application caused decreasing of membrane lipid peroxidation in 1,5 (80 % soil humidity) - 2 (20% soil humidity) times. The results suggested that stress-induced membrane lipid peroxidation could be alleviated by added silicon.

Plants react not only with membrane lipids but may also interact non-specifically with other important compounds such as non-enzymatic compounds (carotenoids) and enzymes (catalase). Silicon soil application caused decreasing catalase activity in 1,3 (80% soil humidity) ? 3,7 (20% soil humidity) times. The proline concentration in the leaves was markedly increased under water stress, whereas added Si in soil reserved this in 1,3 times (all variants). Addition of silicon increased carotenoids content in 1,3 (80% soil humidity) -1,5 (20% soil humidity) times.

It was concluded that the inclusion of Si in birch soil nutrition under water stress are beneficial, as our study showed that Si application in soil improved growth attributes and effectively induced drought stress dependently of soil humidity. However, further studies are needed for a better understanding of drought effects on soil fertility and the physiological or biochemical roles of Si in higher plants and soil.

Keywords：*silicon, analcime, water stress, Betula pendula Roth., membrane lipid peroxidation, carotenoids, catalase, proline*

P1-534

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Effects of Slope Gradient and Planted Species on the State of Soil Organic Carbon Storage in a High Rainfall Forested Area of Shikoku Island, Southern Japan

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In Japan, Hinoki cypress (Chamaecyparis obtusa) is the dominant plantation species along with Japanese cedar (Cryptomeria japonica). Several researchers have previously measured surface soil movement due to raindrop impact in steep slope monoculture Hinoki cypress plantations. Surface soil movement is a concern because there is relatively little surface organic layer, as Hinoki cypress needle litter can easily break into small fragments after falling to the ground, directly enter the mineral soil (Tsukamoto 1991), and get washed away (Hattori et al. 1992). In addition, forest floor vegetation is not rich in Hinoki cypress plantations, especially in those of <40 years, because of the weak penetration of sunlight resulting from high stand density. In fact, Miura et al. (2002) reported that litter, surface soil movement (≤2 mm), and gravel movement on steep slopes in ten stands, including four Hinoki cypress stands, were mainly controlled by the status of forest floor cover and the amount of rainfall.

If the surface soil movement is large, as indicated by previous studies, significant cumulative changes in the soil in older steep slope Hinoki cypress plantations would be expected and study of these changes are important for future plantation management. To address this issue, we investigated the amount of organic layer and soil organic carbon storage at a depth of 0–30 cm as the indicator of the current state of surface soil in second-generation Hinoki cypress plantations (43 stands) and Japanese cedar plantations (19 stands) with various slope gradients and stand ages in Kochi Prefecture, Shikoku Island (with an annual precipitation of >2500 mm). Organic layers, composed of L and F layers, separately from H layer if any, were sampled from a 50-cm square area at three points on each site, after which the layers were oven-dried at 70 °C for 48 h and weighed in the laboratory. Soil pits (50 cm deep) were dug, and the soil layers were classified according to the Guidelines for Soil Description, 3rd Ed (FAO 1990). Soil samples for carbon content analysis and cylinder samples for measuring the bulk density were collected from each soil horizon. After that, we estimated soil carbon storage at a depth of 0–30 cm.

To show the results in brief, slope gradients and stand ages were classified in three groups: 0–20°, 20–35°, and >35° for slope gradients; 20–40 years, 40–60 years, and >60 years for stand ages.

In order of increasing stand age class, the average amount of surface organic layer was significantly smaller in Hinoki cypress stands (5.0, 7.6, and 7.5 t/ha for 19, 12, and 12 stands, respectively) than in Japanese cedar stands (15.4, 11.0, and 13.3 t/ha for 4, 7, and 8 stands, respectively). In Hinoki cypress stands, with increasing stand age class, the average soil carbon storage was 65.3, 78.5, and 93.7 t C/ha for 19, 12, and 12 stands, respectively; whereas, with increasing slope gradient class, the average soil carbon storage was 120.0, 82.1, and 67.9 t C/ha for 2, 20, and 21 stands, respectively. In Hinoki cypress stands, soil carbon storage increased with increasing stand age and decreased with increasing slope gradient. In contrast, in Japanese cedar stands, soil carbon storage did not increase or decrease with increasing stand age class (82.8, 75.5, and 77.7 t C/ha for 4, 7, and 8 stands, respectively) or with increasing slope gradient class (83.6, 77.0, and 76.7 t C/ha for 3, 9, and 7 stands, respectively).

As previous studies have shown, we confirmed that the amount of surface organic layer was small in Hinoki cypress stands. More importantly, our research shows that slope gradient affects the state of surface soil (depth, 0–30 cm) in Hinoki cypress stands, but no such effect was seen in Japanese cedar stands, indicating that the covering effect of an organic layer is retained over the long term in Japanese cedar stands. Thus, our results suggest that Japanese cedar as the tree species would provide a better conservation of surface soil in steep slope plantation areas.

Keywords：*Hinoki cypress, Japanese cedar, surface soil, carbon storage*

P1-535

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Aboveground and Belowground Patterns in Pyrogenic Boreal Aspen Ecosystems: What Governs Nutrient Availability?

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Background: Wildfire in forest ecosystems has a major influence on soil biogeochemical processes and the distribution of associated resources. Soil nutrients are an important resource for early-colonizing and competing vegetation in pyrogenic ecosystems, and exert a significant role in the structure of forests through development. Information on post-fire recovery of soil biogeochemical processes is required for the sustainable management of oil and gas rich ecosystems such as the boreal forests of northern Alberta, meaning a clear ecological understanding of the key mechanisms that regulate nutrient cycling and vegetation dynamics. We argue that this cannot be achieved by looking at nutrient supply rates, microbial properties and stand attributes in isolation. Rather a mechanistic understanding might be achieved by examining the spatial patterns created by the interaction of these properties. Spatial patterns in ecosystem processes are fingerprints that can generate meaningful insight about changes in forest development though time. Space can be used as a surrogate of unmeasured variables, and along with other measured variables, can be a powerful tool to tease apart relationships among ecosystem components. We hypothesized that fire would change the spatial variability in nutrient availability and associated biogeochemical properties, making them more uniform. Overtime, we believe that a fine scale spatial pattern might develop in these properties due to structural heterogeneity. In other words, we expected a strong belowground contribution to nutrient availability in the young stands and an increase in the aboveground control as forest structure develops in mature stands.

Approach: The objectives of this study were to 1) measure changes in the spatial structure of nutrient availability in upland boreal forest stands with time since last fire, and 2) quantify the spatially structured aboveground (tree distribution, forest floor depth, canopy cover, understory vegetation) and belowground (microbial biomass, respiration, extracellular enzyme activity, organic C and N) contributors to nutrient availability. To do this, we measured plant available macro- (N, P, S, Ca, Mg, K) and micronutrients (Fe, Mn, Zn, B), and the above mentioned key biogeochemical properties, along a fire chronosequence (1, 9 and 72 year) of boreal aspen stands in northern Alberta, using a cyclic spatial sampling protocol of 0.5 m resolution. A variogram-based geostatistical approach was used to quantify spatial variability. Spatial autoregressive models and principal coordinates of neighborhood matrices were used for decomposing pure spatial, environmental and biogeochemical contributions to nutrient availability.

Findings: Results showed that nutrient availability became patchy 9 years after stand replacing fire. No spatial structure was detected for N, P, Fe and Mn availability in the young aspen stand, with the exception of S availability (6 m range), confirming our hypothesis that wildfire creates uniformity in spatial pattern. Nitrogen availability had 16 m and 10 m spatial ranges in the 9 and 72 year old stands, respectively. Phosphorus and S availability showed a finer scale pattern (P - 2.8 m and S - 2.2 m) in the 9 year old stand than the mature stand (P – 8 m and S - 10 m). Spatial structure of Fe and Mn availability had not redeveloped in the 9 year

old stand. Aboveground properties and some belowground properties, such as dissolved organic C, microbial C and phosphatase activity also showed similar trend of increasing heterogeneity with stand age. Significant belowground and understory vegetation control was found on macronutrient availability in the young stand, whereas, a weaker belowground control was found in the 9 year old stand, followed by a stronger joint belowground and aboveground control in the mature stand. The aboveground, belowground and space components accounted for 9%, 35% and 19% variation in macronutrient availability in the young stand. Space here indicates the unmeasured variables such as micro-climatic factors, micro-topography and other important soil properties. In the mature stand this was 26%, 15% and 22%, respectively. The current findings suggest that post-fire nutrient availability in boreal aspen stands of northern Alberta might cycle through a belowground (heterotrophic) dominance to a synergistic aboveground and belowground control which supports our hypothesis.

Keywords：*Spatial variability, Aspen, Boreal forest, Belowground properties, Aboveground properties,, Enzyme activities, Spatial autoregressive models, Principal coordinates of neighborhood matrices.*

P1-536

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Assessment of Carbon Stock in Soil and Restored Deciduous Forest at Huai Hong Khrai Royal Development Study Center, Northern Thailand

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His Majesty King Bhumibol Adulyadej initiated the establishment of the Huai Hong Khrai Royal Development Study Centre on December 11, 1982 to be the area of experimentation and research for watershed area development and restore the fertile condition of the forests and the watershed areas, and enable the people to become self-reliant without having to destroy nature. The aims of this study were assess carbon storages in soil on difference forest communities in this area and the information will support the database of the country according to the UN-REDD. Assessment of plant communities were Forest Condition Index, Shannon-Wiener Index and Dominance. Above ground biomass, biomass of root and carbon stocks, soil carbon stock at 0-30 and 30-100 cm. in depth. Plant study plots, 40 x 40 m2 in size, were used for vegetation and soil sampling in 13 plots on difference forest communities, and soil type were also assessed. Dry deciduous forest (DDF) and mixed deciduous forest (MDF) were found in this area, the most dominat tree in DDF were Dipterocarpus Obtusifolius Teijsm.ex Miq. , Shorea obtusa Wall. ex Blume , Shorea siamensis Miq. and Dipterocarpus tuberculatus Roxb. The most dominant tree in MDF were Terminalia mucronata Craib & Hutch. , Tectona grandis Linn.f. and Lagerstroemia duperreanum Pierre ex Gagnep. Carbon storages in biomass and soil were highly in MDF on shale , DDF on volcanic rock , MDF sand stone, DDF volcanic and sandstone respectively. Biomass C and soil C stocks were highly correlated with the soils developed from different parent material or rock types.

Keywords：*soil carbon stocks, biomass carbon stocks*

P1-537

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Distribution of Organic Carbon and Nitrogen Associated with Aggregates in Semiarid Conifer Forest of the Loess Plateau, China

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Confiner species dominate the semiarid forest in the Loess Plateau of China. However, the distribution and turnover of organic carbon (OC) and nitrogen (N) associated with soil aggregates in conifer forest were not well understood, which are essential for assessing the behaviour of OC and N in semiarid forest soils. In this study, we collected soil samples from different conifer forests at 2 sites in the semi-arid Loess Plateau of China to investigate the distribution of OC and N associated with aggregate and to establish the relationships between aggregate associated OC and N and total OC and N in conifer forests. The species were Larix principis (LP), Pinus armandii (PA), Picea crassifolia (PC) and Pinus tabulaeformis (CP). Our results showed that macroaggregate and microaggergate dominated the distribution of soil aggregates, which varied with site. The OC and N associated with microaggregate size class accounted for 50% and 46% of the total O and N in soils. The OC and N concentrations associated with macroaggregate were relatively higher in the PC dominated forest, but lower in the PA dominated forest at the 0-20 cm depth. However, the OC and N stocks associated with macroaggregate size class were relatively higher in the LP and PA forests. Additionally, the proporation of macroaggregate associated OC and N to toal OC and N increased with the stand age. The results from this study indicate that macroaggregate associated OC and N dominated the distribution of OC and N in the semiarid conifer forest of the Loess Plateau. The tree species and stand age should be considered when assessing the distributions of soil OC and N in both bulk soils and aggregate size fractions in conifer forest.

Keywords：*Organic carbon, nitrogen, conifer forest, semiarid Loess Plateau, water stable aggregate*

P1-538

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Edaphological Characteristics of Selected Philippine Acid Upland Soils as Affected by Soil Amendments and Fertilizers

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The Philippine upland offers potential areas for crop production however the soils in these areas are inherently infertile and acidic which may limit crop growth and yield. The limitations of using these upland soils are often difficult to correct but with proper management can yield positive and profitable crop production. This study was conducted to characterize the physicochemical and mineralogical properties of selected acid upland soils in the Philippines, and assess the effect of various soil amendments and fertilizers in improving their edaphological characteristics.

The five (5) soil series selected for this study were Tigaon, Antipolo, Luisiana, Alaminos, and Bantay. These soils are generally clayey, very strongly acidic (pH 4.47 -5.40), low in available phosphorus (1.74 - 5.40 ppm), total nitrogen (0.06-0.14%) and organic matter content (1.07 ? 3.60%). Percentage base saturation (8.80 ? 34.84) is also generally low however exchangeable acidity (0.13?9.40 cmolc kg-1) and available iron (11.14 ? 125.13ppm) are high. Cation exchange capacity which ranged from 10 ? 27 cmolc kg-1 is reflective of the differences in their mineralogy, and clay and organic matter content. The low available soil P can be attributed to their phosphate retention which ranged from 19.12 ? 61.03%. The clay minerals present based on a single run XRD analysis of the soils were mainly quartz, kaolinite, metahalloysite and maghemite which are generally associated with later stages of weathering.

The use of soil amendments such as: Ca-rich zeolite (22tons/ha), biochar (2% w/w), vermicompost (5t/ha), chicken manure (5t/ha) and lime, and phosphate, were assessed as to their effectiveness in improving edaphological characteristics of acid upland soils by conducting an incubation experiment. The soils were analyzed on four incubation times: 14, 28, 56, and 84 days. Results of the incubation experiment showed that soil pH, phosphorus content, organic matter and CEC increased while exchangeable acidity, exchangeable aluminum and available iron of the soils decreased upon addition of Ca-rich zeolite and lime. Addition of phosphorus fertilizers increased soil P content only. Addition of biochar, vermicompost and chicken manure increased soil OM with minimal increase in soil pH.

Adequate knowledge of the physical and chemical constraints is vital for further development and sustainable utilization of these areas for future generations. The findings of this study showed that the soils have great variations in physicochemical and mineralogical properties due to differences in parent materials, sampling locations and soil types. Assessment of the behavior of soils showed that they behave distinctively against the different cultural interventions employed. In conclusion, the cultural interventions used in this study can improve the edaphological characteristics of the soils making them more suitable for crop production.

Keywords: *Philippine uplands, acid soils, red soils, liming, vermicompost, biochar, zeolite*

P1-539

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Functions and Complexities of a Reclaimed Mine Spoil: A Case Study of Kathara Coalmine Area of Jharkhand, India

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Human development processes over historical time have reduced the capacity of ecosystems to cope with through a combination of top-down and bottom-up impacts and has the scar in the form of habitat loss and generation of degraded and derelict ecosystems. The main concern for the managers of the biological systems is to contain the ecological footprints on the globe. Hence, it is pertinent to address the problem objectively. Present paper is an effort to measure stresses in the reclaimed mine spoils and has two sections - the first section deals with the experiments and results carried out between the year 2006-2011 and the second section has an ecological model to understand the stresses which is based on experiments. Experiments were carried out in the different chronosequences of the reclaimed mine spoils (RMS) with different stages of plantation (anthropogenic interventions). Soil arthropods were collected with physio-chemical parameters through standardised ecological tools and techniques at regular intervals for the purpose.

We observed that Shannon diversity index of younger RMS was higher than 15 to 30 years old RMS. RMS older than 30 years and forest had higher diversity than comparatively newer ones. Simpson's index was 0.0877, 0.889, 0.869 and 0.887 in four different chronosequences where as the older RMS and forest had 0.885 and 0.917 respectively.

Based on findings, regime status of the RMS was mapped and compared with the forest floor ecosystem. The inferences drawn were that the resilience and homeostatic process are in play in natural system but in the RMS it is the anthropogenic interventions, which supports ecesis and succession. The functional complexities of the soil compounded with anthropogenic activities have been converted into a model for the understanding of the natural processes, which will help in reducing the ecological footprint and ensure food security on the globe.

Keywords：*Reclaimed mine spoils, chronosequences,anthropogenic activities, ecesis, homeostasis, resilience,*

P1-540

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Establishing Relationships between Soil Fertility Indicators and Abaca Biomass Production in Central Philippines

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Decline in soil fertility due to crop removal is very eminent in most of the agro-ecosystems in the tropics specifically the underutilized and neglected crops grown in the degraded mountain soils. In understanding and assessing the changes in soil fertility, this particular endeavor was undertaken with the objective of establishing relationships among soil fertility indicators relative to the biomass as baseline data for soil fertility and quality assessment studies. This was conducted at the east-coast of the central Philippines under the different abaca-based agro-ecosystems. Samples were collected and analyzed based on the Minimum Soil Fertility Indicators (MSFI's) for assessment studies. Among the MSFI's, soil pH, available P, exchangeable K, exchangeable Ca, extractable Cu, Zn and Fe were selected. Variations among indicators were noted relative to the different sites and agro-ecosystems. Upper asymptotic sigmoid curve was observed for both P and K while mid-point-optima was noted for pH, Ca, Fe, Cu and Zn content of the soil. These relationships could be found useful for nutrient management and soil health assessment studies.

Keywords: *abaca, Musa textilis, soil fertility indicators, natural fiber, biomass*

P1-541

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Pollution Analysis of Soils in the Caves of Bukk -Mountains

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Cave-soils or cave sediments have been investigated in a four years study to identify the most common organic and inorganic pollutants of the cave systems. Cave sediments are important markers of any potential karst water quality problem. It captures some of the dissolved pollutants of the water on the colloid surfaces of the sediments. 41 samples from 16 caves have been analysed using ICP and GC-MS techniques. Out of the 12 metals and heavy metals, only the Cadmium reached relatively high level ? close to, and a little bit over the environmental threshold values. This result was not surprising, previous studies of the Cadmium content indicated high level of Cd in the surface soils of the Bukk region as well. The most important organic pollutant was the phthalate group, which occurred in almost all sediments, and three samples taken from one cave had measured concentration higher than the threshold.

Keywords：*cave soils, heavy metal contamination, Cadmiun*

P1-542

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

The Early Effect of Fertilization on Growth of Quercus Serrata Seedlings in Harvested Pinus Rigida Plantation, Korea

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Pinus rigida plantation occupies about 15% of coniferous forest in Korea. Although P. rigida as one of the major planting species were widely planted in Korea during 1960-1970s, this species has been a target for regeneration due to reduced growth. The objective of this study was to know the proper fertilizer amount for Quercus serrata seedlings planted in harvested P. rigida plantation, Korea. Study site was located in Pocheon-si, Gyeonggi-do, Korea. Q. serrata bare-root seedlings (1+1) were planted with the density of 3,000 seedlings ha-1 in April, 2011 after harvesting P. rigida plantation in 2010. Compound fertilizer (N:P:K=3:4:1) was yearly fertilized three treatments (control : no fertilization, F1: 180kg ha-1 and F2: 360kg ha-1) in May from 2011 to 2013. In each treatment, three plots (200m2 per plot) were established in April, 2011 and 30 seedlings per plot were randomly selected for measuring the root collar diameter (mm) and seedling height (cm). Soil samples to the depth of 20 cm were randomly collected by three samples per plot before and after fertilization (April, 2011 and 2012), to measure soil chemical properties such as soil pH, total nitrogen (TN), available P., organic matter (OM), cation exchange capacity (C.E.C), etc. Significant differences in root collar diameter and seedling height of seedling and soil chemical properties according to fertilization levels were performed using SAS 9.2 sofware. There was no difference on seedling growth from first to second years after planting. Despite all soil chemical properties such as TN, avail. P. and OM were higher at control plot than those at fertilizer treatment plots, root collar diameter in 2013 at fertilizer treatment plots (F2 : 40.1 and F1 : 37.4) were significant higher than those at control plot (34.3). The result of seedling height in 2013 (F2 : 241, F1 : 230 and control : 209) was the same tendency as root collar diameter. Although seedling growth at F2 treatment plot was significantly higher than that of other plots, we thought that the proper fertilization amount for Q. serrata seedling was F1 treatment plot. Because Q. serrata is not a species required to fertilization of large amounts during growth. Fertilization increases the stand's carrying capacity therefore, forest management such as fertilization can be used in these silvicultural practices to improve stand growth and to accelerate stand development. Therefore, we have to continue monitoring the changes in growth of Q. serrata seedlings and soil chemical properties after fertilization.

Keywords：*fertilization, forest soil, oak, pitch pine, regeneration, seedling growth, soil chemical properties*

P1-543

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

The Comparison of Seedling Growth of Zelkova Serrata According to Aspects at Harvested Pinus Rigida Plantation, Korea

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Pinus rigida as one of the major planting species were widely planted in Korea while 1960-1970s (P. rigida plantation area : 387,000ha, 2012). However, we have been concerned about candidate tree species for planting after harvesting P. rigida plantation because it has reached to the age of final cutting and regeneration. The objective of this study was to compare the seedling growth of Zelkova serrata and soil chemical properties according to aspects after harvesting P. rigida plantation, Korea. Study site was located in Pyeongtaek, Gyeongg-do, Korea. Bare-root seedling (1+1) of Z. serrata was planted at north and south aspects in April, 2010 and total planting area was 0.6ha. In each aspect, three plots (600m2 per plot) were established in April, 2010 and 50 seedlings per plot were randomly selected for measuring the root collar diameter and seedling height. Five soil samples to the depth of 20 cm were randomly collected within each plot in October, 2010 and 2011 and analyzed soil chemical properties such as soil pH, total nitrogen (TN), available P., organic matter (OM), cation exchange capacity (C.E.C), etc. T-test was performed to determine the differences in root collar diameter and seedling height of seedlings and soil chemical properties according to aspects using SAS 9.2 software. Soil exch. Ca2+ at south aspect was significantly higher than that at north aspect in 2010, and OM, exch. Ca2+ and K+ at south aspect were also significantly higher than those at north aspect in 2012. There was no significant difference on seedling growth by different aspect except root collar diameter in 2011. However, root collar diameter and seedling height at south aspect were higher than those at north aspect in every year. Therefore, we have to maintain monitoring about changes in seedling growth and soil chemical properties according to aspects because seedling growth of broadleaved trees planted in harvested P. rigida plantation can be slow due to insufficient available nutrients in the soil.

Keywords：*aspect, forest soil, pitch pine, regeneration, seedling growth, soil chemical properties, Zelkova serrata*

P1-544

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Regional Differences in Early Growth of Pinus Densiflora Seedlings at Harvested Pinus Rigida Plantations, Korea

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Pinus rigida as one of the major planting species during 1960-1970s occupies about 15% of coniferous forest in Korea. However, this species has been a target for regeneration due to reduced growth. Therefore, suitable selection for planting species and development of plantation management technique are very important especially in harvested P. rigida plantations. The objective of this study was to know the regional differences in early growth of Pinus densiflora seedlings at harvested P. rigida plantations, Korea. Study sites are located in Yeoju, Hoengseong and Muju, Korea. Annual mean air temperature (℃) and precipitation (mm) during 2011 to 2013 were 11.4 and 1,865 at Yeoju site, 10.7 and 1,459 at Hoengseong site, and 13.2 and 1,491 at Muju site. Two-years-old seedlings of P. densiflora were planted with the density of 3,000 seedlings ha-1 in April, 2011. In each site, three plots (400m2 per plot) were established in April, 2011 and 30 seedlings per plot were randomly selected for measuring the root collar diameter and seedling height. Five soil samples per plot to the depth of 20 cm were randomly collected at each site in April, 2011 and then, analyzed soil chemical properties such as soil pH, total nitrogen (TN), available P., organic matter (OM), cation exchange capacity (C.E.C), etc. All statistical analyses were carried out using ANOVA procedure. Duncan's multiple rage tests were used to determine if there was a significant difference in root collar diameter, seedling height and soil chemical properties. Soil pH at Yeoju was lower than that at other sites, and TN, OM, C.E.C, and Exch. K+ of soil at Hoengseong site was significantly higher than those at other sites. Annul root collar diameter at Yeoju site was significantly higher than that at other sites. Also, annual seedling height except 2013 at Muju site was significantly higher than that at other sites. Although soil chemical properties such as TN, OM, C.E.C, and Exch. K+ at Hoengseong site were higher than those at other sites, root collar diameter and H/D at Yeoju site were better than those at other sites. This result may be affected that because of P. densiflora grows even well in nutrient deficient environment and also, annual air temperature at Yeoju and Muju sites were higher than that at Hoengseong site.

Keywords：*forest soil, Pinus densiflora, pitch pine, regeneration, region, seedling growth, soil chemical properties*

P1-545

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Simultaneous Removal of Semi-Volatile Organic Compounds and Heavy Metals in Soil By Using Ultrasound-Assisted Soil Washing

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Many soils are often contaminated with both oil and heavy metals simultaneously. Soil washing combined with ultrasound irradiation was investigated in this study to evaluate the removal efficiency of organic compounds as well as heavy metals. The initial concentration of lead, copper and zinc in soil was 436, 312 and 342 mg/kg, respectively. Also, soil was artificially contaminated with n-tetradecane, n-hexadecane and phenanthrene. The laboratory experiments were conducted under various conditions (soil/liquid ratio, irradiation time, particle size, soil organic matter). The effects of these parameters on the removal efficiency of contaminants were examined as ultrasound irradiation was applied to soil washing. Also, organic acids and oxidants such as sodium persulfate and hydrogen peroxide were added into soil washing solution to investigate whether the removal efficiency can be increased. To compare the efficiency of ultrasound, conventional soil washing by mechanical mixing was also conducted.

Optimum soil/liquid ratio for the ultrasound-assisted soil washing was found to be 1/5. To enhance the removal efficiency of organic compounds in soil, sodium persulfate and hydrogen peroxide were used as the oxidant. However, enhancement was not negligible due to (a) scavenging of oxidant due to soil organic matter in soil, (b) low activation capacity of sodium persulfate by ultrasound, and (c) too slow dissolution of contaminants from soil. When organic acid was used in soil washing, higher desorption of heavy metals was observed. Additionally, enhanced oxidative degradation of organic compounds was obtained by the ultrasound-assisted soil washing with organic acid addition.

Keywords：*Remediation, Soil Washing, Ultrasound, Oxidation*

P1-546

[C4.1-1] Advances in Quantifying Forest Soil Processes and Functions

Comparison of Soil Properties of Two Elevations in the Mt. Makiling Forest Reserve, the Philippines

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Mt. Makiling Forest Reserve is located in the South Central Luzon Island, Philippines (14° 08' N and 121° 11' E). Most of original vegetation surrounding the mountain has been selectively logged during 1942-1944. The current vegetation belongs to the secondary tropical rain forests, and no specific disturbance has been reported since then. This area has two pronounced seasons: dry season from January to April and wet season from May to December. Mean annual temperature and mean annual rainfall are 26.5℃ and 2,397 mm, respectively. The forest reserve is composed of four vegetation types; the mossy forest zone (900-1109 m a.s.l.), the dipterocarp mid-montane forest zone (100-900 m a.s.l.), the grassland zone and the agroforestry zone. Of these vegetation types, experimental sites were situated at the dipterocarp mid-montane zone.

Two 1 ha permanent study sites were established in the study area. One was located at 400 m asl (above sea level), and the other was located at 700 m asl. The 400 m permanent plot was a secondary natural forest dominated by Magabuyo(sn) followed by Balobo (sn). The 700 m permanent plot was also a secondary natural forest dominated by Balobo followed by Apanang (sn), and Malak-malak (sn). Each permanent study site was divided into twenty five 20 m x 20 m subplots.

The soil temperature and the water contents were measured using HOBO (data logger) from February, 2009 to June, 2013. The soil temperature of 700 m plot was more fluctuating than in 400 m plot during wet season. The water content of 400 m secondary forest has gradually decreased from 2009 to 2011. The water content during dry season in 700 m secondary forest was significantly lower than the water content during wet season, while the water content in 400 m plot did not show significant difference between dry and wet season.

Keywords：*mid-montane zone, soil temperature, soil moisture*

P1-547

[C4.1-2] Environmental Management of Post-Epidemic Carcass Burial Sites

Practical Application of Novel Physical Ballast Washing System to Soil Remediation In Polluted Rail Yard

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Rail yards are apt to be polluted by petroleum or various kinds of heavy metal during the operation of rail cars. For this reason, many soil remediation projects are carried out, and the polluted ballast gravels should be remediated as well. Water washing method using detergent or chemical treatment using oxidant is conventionally used for the treatment of polluted ballast gravels. In this study, novel ballast gravel treatment method, dry washing method, was introduced for the field application. In dry washing method, chips made of alumina or melamine resin were blasted on the surface of polluted ballast gravels by using compressed air. The pollutants residing on the surface of the ballast gravels could be successfully removed while there was no significant damage on ballast gravels themselves. The treatment time was very short compared with that of water washing method, and the amount of secondary pollutants was also very small because no water is used. A pilot-scale treatment system was prepared. The maximum capacity of this system was 0.1 m3/h. This system was installed in a soil remediation sites, and the feasibility study on the treatment of polluted ballast gravels was carried out. This system could remediate the polluted ballast gravels efficiently and quickly. Treatment results of this system were presented in this study.

Keywords：*Soil remediation, Ballast gravel, Dry washing method, Total petroleum hydrocarbon, heavy metal*

P1-548

[C4.1-2] Environmental Management of Post-Epidemic Carcass Burial Sites

Needs of Biosecurity and Protocols for the Environmental Management of Carcasses Burial

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Avian influenza (AI) and foot and mouth disease (FMD) are two main contagious pathogenic viruses causing massive mortality burial, as burial is a primary measure to quaranteen the causative viruse(s). Biosecurity is a set of preventive measures designed to reduce the risk of propagation of infectious diseases. Main objectives of this paper were to discuss the needs of biosecurity and develop protocol outlines for environmental management of burial sites. Pathological characteristics of contagious viruses should be considered during environmental management practices. Current practice prescribes to minimize the potential for on-farm pollution and the spread of infectious diseases, policy makers should understand robust knowledge regarding biosecurity to make informed decisions on future legislation.

Keywords: *Biosecurity, Burial, Carcasses, Foot and mouth disease, Pathogen, Water quality*

P1-549

[C4.1-2] Environmental Management of Post-Epidemic Carcass Burial Sites

Detection of Foot-And-Mouth Disease Virus and Coxsakievirus in the Soil And Leachate of Modeled Carcass Burial Site

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Foot and mouth disease (FMD) is highly infectious disease of cloven-hoofed animals, particularly cattle, sheep, pigs and goats. Last outbreak reported in November, 2010 induced the enormous social and eco-nomical impacts. Culling of infected animals, movement control, and vaccination are the major control measures of FMD. The aim of this study was to detection foot-and-mouth disease virus (FMDV) in the soil and leachate from modeling burial for pig carcass as measured by real-time reverse transcriptase polymerase chain reaction (RT-PCR). FMDV and Coxsakievirus B1 (CVB1) were detected in soil by week 16 and Coxsakievirus B1 (CVB1) by weeks 12, respectively. FMDV and CVB1 also detected by weeks 8 in the leachate. Results from this study provides an evidence that FMDV could be inactivated for safe of pig carcasses infected with FMDV within 4 month in the carcass burial site.

Keywords：*Foot-and-mouth disease, Coxsakievirus, Modeled carcass burial site, Leachate*

P1-550

[C4.1-2] Environmental Management of Post-Epidemic Carcass Burial Sites

Cost Analysis for the Carcass Burial Construction

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A lot of burial sites for the disposal of the contagious livestock slaughtered by foot and mouth disease were constructed in a short time for preventing the rapid spread of the virus. More than 4,700 carcass burial sites were constructed in 2011. Approximately 7 million poultry and 3.5 million livestock including head of cattle and swine were buried in farm land. However, the available cost data for a burial site was not provided. This study was to performed in order to understand the economic issues related to carcass burial disposal. The data from a local government was analyzed and the assumption data web based was constructed to evaluate the cost for constructing a carcass burial. The results showed that the local government paid KRW 5,386 for the burial disposal of a mortality (swine). It was estimated that the cost could be reduced through an appropriate measures.

Keywords：*Animal carcass disposal, Cost analysis, Economic impact, Foot and mouth disease, On-farm burial*

P1-551

[C4.1-2] Environmental Management of Post-Epidemic Carcass Burial Sites

Survival of Escherichia Coli O157:h7 and Listeria Monocytogenes in Soil, Liquid Manure, and Liquid Manure Amended Soil

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The objective of this study was to investigate the survival of Escherichia coli O157:H7 and Listeria monocytogenes in loamy soil, liquid manure, and liquid manure amended soil. Loamy soil, liquid manure, and liquid manure amended soil were inoculated with E. coli O157:H7 and L. monocytogenes. Samples were incubated in consistent moisture content at 25℃. Samples had been collected during 105 days depending on the given conditions. E. coli O157:H7 survived for 105 days in liquid manure amended soil and over 105 days in loamy soil, respectively. L. monocytogenes survived for 105 days in liquid manure amended soil and loamy soil. E. coli O157:H7 and L. monocytogenes survived for up to 5 days in liquid manure. E. coli O157:H7 in loamy soil decreased by 0.5 to 1.0 log CFU g^(-1) for 105 days. E. coli O157:H7 in liquid manure amended soil decreased slowly for 21 days. However, E. coli O157:H7 sharply decreased after 21 days. L. monocytogenes in loamy soil increased by 0.5 to 1.0 log CFU g^(-1) for 7 days. During the following 14 days, L. monocytogenes in loamy soil decreased by 3.0 log CFU g^(-1). L. monocytogenes in liquid manure amended soil gradually decreased. The results indicate that E. coli O157:H7 survived longer than L. monocytogenes in loamy soil at 25℃. Increased knowledge of pathogen behavior in agricultural environments is a valuable part of future work on improving risk evaluations and, in a longer perspective, in providing data for guidelines regarding safe handling of pathogen-contaminated liquid manure and soil.

Keywords：*pathogenic bacteria, liquid manure, Survival*

P1-552

[C4.1-2] Environmental Management of Post-Epidemic Carcass Burial Sites

Microbial Community Analysis of Cattle and Pigs Carcass at Burial Sites

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Outbreak of contagious diseases to livestock animals is becoming prevalent worldwide and consequently, tremendous numbers of the infected or culled stocks are buried on the ground according to the most common disposal method. The buried animals can generate a wide range of detrimental components such as leachate, nutrient salts, and pathogenic bacteria, consequently resulting in the contamination of the surrounding soil and water environment 3). This study aimed at the comprehensive understanding of the community of microbes derived from the cattle and pig carcass at burial sites in Korea. Soil samples were collected in cattle and pig carcass from two disposal sites constructed in 2010. Bacterial compositions were estimated by cultivation dependent and independent methods: 16S rRNA gene sequence and pyrosequencing with GS-FLX titanium. By pyrosequencing of partial 16S rRNA genes directly extracted from the samples, a total of 32,035 reads were analyzed. Pyrosequencing analysis revealed 21 bacterial divisions and 20 candidate divisions. Proteobacteria was the most abundant division in the bacterial community, of which Gamma- and Beta-proteobacteria were appeared to be prevailing groups. The bacterial community structures estimated from the pyrosequencing analysis was similar at the phylum level. Genera Pseudomonas and Acinetobacter were dominated in both samples. In addition, pathogenic bacteria such as Acinetobacter baumannii, A. johnsonii, Bacillus cereus and Pseudomonas areroginosa were detected. In this study, two strains were found to be novel species, which were based on the comparative sequence similarity and phylogenetic analyses. This metagenomic analysis at the contaminated area will give insights to estimate the environmental remediation and sanitation.

Keywords：*Burial, Disease, Livestock animal, Metagenomic analysis*

P1-553

[C4.1-3] Soil Ecosystem under Climate Change

Soil Biochemical and Rhizsophere Properties of Pterocarpus Indicus Grown in Contrasting N Levels in Soil Exposed to Elevated Atmospheric Temperature and CO2

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The effects of elevated atmospheric temperature and carbon dioxide on the soil biochemical properties and rhizosphere induced responses of Pterocarpus indicus (L.) grown in soils with contrasting nitrogen levels were evaluated through a rhizobag experiment under an environmentally-controlled walk-in chamber. Seedlings of P. indicus (L.) were established at the central compartment of the rhizobag filled with forest soil and exposed to eight treatment combinations of two levels of CO_2 (400 and 800 μmol/mol CO_2), two levels of temperature (25°C and 30°C), and two levels of N fertilization (0 and 120 kg N/ha). Results showed an interaction effect of temperature x CO_2, x N levels in soil on the C and N distribution of P. indicus and soil properties of the rhizosphere. The pH and EC in soil solution was increased by elevated temperature and CO_2 and such increased was higher in N-fertilized soils. The concentration of dissolved sugar and organic carbon in soil solution and the C concentration and C/N in soil were increased by exposure to higher CO_2 but such increased was off-set by N fertilization. The N concentration in soil slightly increased with N fertilization especially in the rhizosphere soils. The microbial activity and soil enzyme activities were increased by elevated temperature and CO_2 especially at high N treatments. The microbial functional community structure based on Biolog EcoPlate of soils from the rhizosphere of P. indicus exposed to elevated temperature and carbon dioxide at different N levels differed distinctively from each other based on the bi-plot of principal component analysis. Overall, the results showed that the changes on plant growth and physiology of P. occidentalis due to exposure to elevated temperature and carbon dioxide at different N-fertility levels were extended to the soil biological properties via plant-induced changes in substrate quality and quantity in the rhizosphere. The study also demonstrated that elevated temperature and CO_2 as well as the inherent N fertility levels in soils can greatly affect microbial properties which are considered to be sensitive indicators of ecosystem responses to climate change parameters as indicated by differences in the potential functional diversity of microbial communities estimated by community-level physiological profile (CLPP) using Biolog Ecoplates.

Keywords：*carbon and nitrogen dynamics, interaction of temperature x CO2 and N levels, microbial functional st*

P1-554

[C4.1-3] Soil Ecosystem under Climate Change

Re-Evaluating the Biophysical and Technologically Attainable Potential of Topsoil Carbon Sequestration in China's Cropland

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To assess the topsoil carbon sequestration potential (CSP) of China's cropland, two different estimates were made: a) a biophysical potential (BP) using a saturation limit approach based on soil organic carbon (SOC) accumulation dynamics, and a storage restoration approach from the cultivation-induced SOC loss, and b) a technically attainable potential (TAP) with a scenario estimation approach using SOC increases under best management practices (BMPs) in agriculture. Thus, the BP is projected to be the gap in recent SOC storage to either the saturation capacity or to the SOC storage of uncultivated soil, while the TAP is the overall increase over the current SOC storage that could be achieved with the extension of BMPs. The recent mean SOC density of China's cropland was estimated to be 36.44 t ha^{-1}, with a BP estimate of 2.21 Pg C by a saturation approach, and 2.95 Pg C by the storage restoration method. An overall TAP of 0.62 Pg C and 0.98 Pg C was predicted for conservation tillage plus straw return, and recommended fertilizer applications, respectively. This TAP is comparable to 40%-60% of total CO_2 emissions from Chinese energy production in 2007. Therefore, carbon sequestration in China's cropland is recommended for enhancing China's mitigation capacity for climate change. However, priority should be given to the vast dry cropland areas of China, as the CSP of China is based predominantly on the dry cropland.

Keywords: *Carbon sequestration, Biophysical potential, Cropland, Soil organic carbon, Technically attainable potential, Climate change*

P1-555

[C4.1-3] Soil Ecosystem under Climate Change

Impact of Litter Addition on Gross Nitrogen Transformations in a Suburban Native Forest Under Repeated Prescribed Burning in South-East Queensland, Australia

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Nitrogen (N) cycling in forest ecosystems is essential for the sustainability of forests, especially in nutrient poor subtropical forests. Prescribed burning has been widely used as an effective tool for protecting both native and plantation forests from the risk of damaging wildfires in Australia. Prescribed burning can change soil functioning and affect the N status and net N transformation rates, but its effects on gross N transformations have not been well studied under field conditions in suburban subtropical forests. The present study was conducted to investigate the impacts of prescribed burning on soil N transformations in a subtropical forest. In situ ^{15}N pool dilution method was used to evaluate the effect of leaf litter addition on soil gross N transformations in a native subtropical forest. This study was conducted in Toohey Forest (27°30′S, 135°E), 10 km south of Brisbane in south-eastern Queensland, Australia. This forest occupies about 600 ha dominated by different eucalypt species and contains some 460 species of vascular plants. The climate is typically subtropical with hot, wet summers and cool, dry winters. Three sites were chosen in this study, which are 1 (B0), 4 (B3), and 6 (B5) years following prescribed burning. The soil at B0 and B5 was podzolic and at B3 site was lithosols. There were four plots at each site, which represented 4 replicates of each treatment. The in situ core incubation method was used in the field experiment. PVC cylinders (10 cm diameter and 15 cm height) were inserted into the 10 cm soil. Two treatments were compared: without any litter addition (removed the forest floor) and with litter addition (removed the forest floor then added leaf litters). Fresh eucalypt leaf litters were collected from the forest floor of each site. The amount of leaf litters applied represented the double average amount of leaf litter biomass on each forest floor. Leaf litters were applied on the surface soil within the cylinders, which were covered by high density nylon net to prevent fresh litter from falling into the cylinders. One month after the litter addition, 20 ml of $(^{15}NH_4)_2SO_4$ solution (10.0% ^{15}N excess ammonium sulphate 0.4631 g L^{-1}), $K^{15}NO_3$ solution (5% ^{15}N excess potassium nitrate 0.7086 g L^{-1}) or distilled water (as control in this experiment) were evenly sprinkled onto the surface of soil within the PVC cylinders using a syringe. One of the two paired cylinders of each treatment were removed immediately to provide baseline data, and the rest were left capped and remained in the field for 3 days, afterwards removed. Soil mineral N was extracted with 2 M KCl, thereafter micro-diffusion method was used to measure the ^{15}N isotopic composition of mineral N. Mineral N was measured using Discrete Chemistry Analyzer. The isotope ratio of mineral N and total N as well as N isotope composition ($\delta^{15}N$) were analysed using an isotope ratio mass spectrometer with a Eurovector Elemental Analyzer. The addition of leaf litters did not change soil mineral N and $\delta^{15}N$ significantly within one month after litter addition. However, the soils at both B3 and B5 sites had significantly higher $\delta^{15}N$ in nitrate N (NO_3^--N) than that of ammonium N (NH_4^+-N) in the control treatment, which might result from enhancing nitrate leaching by removing forest floor and weed control. After the addition of $^{15}NH_4^+$-N, the B3 site litters had significantly higher $\delta^{15}N$ at the end of 3-day incubation, while the B3 litter $\delta^{15}N$ decreased significantly after the addition of $^{15}NO_3^-$-N. Net N mineralization was consistently higher in the soils without litter addition than that with litter addition at all three sites. Gross ammonification and nitrification rates were decreased by the litter addition at both B0 and B3 site. However, gross ammonification rate was higher in the soil with litter addition at B5 site, while gross nitrification was significantly decreased by the litter addition in comparison to that of no litter treatment. The impact of 9-month litter addition on soil N transformations was also investigated thereafter, which could also provide some basic information to compare soil N transformations during dry (winter) and wet (summer) seasons.

Keywords： *Prescribed burning, gross N transformation, ^{15}N isotopic pool dilution, litter addition*

P1-556

[C4.1-3] Soil Ecosystem under Climate Change

Geospatial Approach for Carbon Sink in the Soil: An Investigation on Credible Strategy for Tropical Wildlife Reserve

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Carbon storage and biomass sequestration are the two important terms that come across when it is talked about our forest or plant ecosystem. It has been found that very little research had been conducted on the potential of carbon storage in trees and soil of the region having low rainfall. Here Remote Sensing can play a vital and useful role by its vast usage in ecological application as it is quick, accurate, cost-effective as well as a time effective method for estimation of carbon in soil as well as below ground biomass. In this study the objective was to quantify the below ground biomass accumulation and carbon storages in the species Anogeissus pendula, Boswellia serrata, mixed Anogeissus butea and mixed Acacia zizyphus found in Sariska Wildlife Reserve. For this purpose the satellite data of LISS III (2010) is used giving precise information of vegetation through reflectance value. For assessing the carbon sequestration potential of plantations, individual below ground biomass and soil models were developed and scaled to stand level. Thereafter the carbon content of the different layer of soil was assessed in sample plots. The result also showed that the carbon storage is higher in thorn as compared to the deciduous trees soil in the region of low rainfall.

Keywords：*Biomass, carbon, low rainfall regions, Anogeissus pendula*

P1-557

[C4.1-3] Soil Ecosystem under Climate Change

Experimental Warming Decreases Decomposition and Nutrient Release: Evidence from an Alpine Ecosystem

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Background

Litter decomposition is the main contributor to the soil nutrient cycle and is strongly influenced by climate. Surface air temperatures in South-Eastern Australia are expected to increase between 0.6 and 2.9 °C by 2050. In the Australian Alps, warming is expected to increase rates of decomposition that in turn may lead to significant ecosystem changes. While such warming effects in the Northern hemisphere alpine, arctic and tundra systems have been extensively studied, little is known about how elevated temperatures will influence Australian alpine ecosystems. This is particularly important because both the climate and soils of Australian alpine ecosystems are distinctly different to their Northern hemisphere counterparts and thus are likely to respond differently.

Method

The aim of this study was to determine whether experimental warming altered decomposition rates and subsequent nutrient release from a range of alpine litters (graminoid, forb and shrub) in the Bogong High Plains, Victoria, Australia. The experiment ran for 633 days and warming was simulated using open-top chambers (OTC). Nutrient release by decomposing litter was measured using ion-exchange membranes (IEM) over two time periods. This experiment is the first to use IEMs for in situ measurement of nutrient release from litters.

Results

Experimental warming increased ambient temperatures by 1.2 °C and decreased soil moisture by 0.01 (w/w) over the growing season. Forbs, having lower C:N ratios and higher initial nutrient contents, had greater mass losses (70%) compared to graminoids (48%) and shrubs (42%). Warming did not affect litter mass losses of forbs; however it decreased mass in graminoid and shrub litters. Warming decreased releases of P, K, Ca, Mg and Mn from litters in the first 50 days of decomposition. In the following 210 days, when soil moisture increased over the non-growing season, immobilization of NO_3 and releases of P and K were greater from litters in the OTC plots. Over the initial 260-day period, warming significantly decreased releases of K, Ca, Mg, Mn and increased immobilization of NO_3. Nutrient levels adsorbed on the IEMs correlated positively with initial ionic concentrations of litters and mass loss. Warming decreased total losses of C, N, P, S, Ca, Mg and Mn while the total losses of C, P, S, Ca and Mg from litters correlated significantly with mass loss.

Conclusion

These results suggest that the warming-induced soil drying negated the effects of warming on decomposition and limited the nutrient release of the alpine plant litters. Thus, over the short term, we expect that a warmer climate will decrease decomposition rates of the recalcitrant litters, and subsequently decrease net nutrient release.

Keywords：*Litter decomposition, climate change, Australian Alps, open-top chamber, ion-exchange membrane, nutrient release, ITEX*

P1-558

[C4.1-3] Soil Ecosystem under Climate Change

Microbial Fixation of Atmospheric CO_2 as Influenced by Organic Amendment Addition in Soil

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Although carbon dioxide (CO_2) emission from soil due to microbial respiration is a common process, atmospheric CO_2 fixation by soil microorganisms may also be an important process involved in controlling carbon (C) dynamics in soil. Application of organic amendments such as manures, composts and biosolids to soil may have an impact on microbial diversity and activity, thereby influencing CO_2 fixation in soil. Although a number of studies have examined the effect of various organic amendments on the release of CO_2 from soil, there have been only limited works on their effect on CO_2 fixation. In this study, our objective was to investigate the effect of a range of organic amendments on microbial CO_2 fixation in soil using a tracer experiment with $^{14}CO_2$.

Soil samples collected from a field experiment treated with various levels of biosolids, and an arable soil spiked with various organic amendments were used in this study. The field experiment was established at a landfill site in South Australia with 3 levels of biosolid addition (0, 25 And 50 Mg/ha) and two plant species (Brassica juncea L. and Helianthus annuus)). Organic amendments including green manure, poultry manure, sheep manure, horse manure, cow manure, pig manure, biosolid and biochar were spiked at a rate of 20 g C kg^{-1} to a surface soil (0-10 cm) collected from an arable field at Hart, South Australia. Both fumigated (three days in $CHCl_3$ vapour) and non-fumigated field and spiked soils were placed in air-tight 250 ml respiration jars sealed with rubber septum and the moisture content was maintained at field capacity. Two small vials were placed inside the respiration jar. One of the vials contained $Na_2{}^{14}CO_3$ (800 KBq kg^{-1} soil). The $^{14}CO_2$ gas was produced in the air tight jar by adding HCl into $Na_2{}^{14}CO_3$ using a syringe fitted with septum. After introducing $^{14}CO_2$, soils were incubated in a laboratory at 22°C for up to 60 days. Soils in the incubation chamber were maintained at field capacity by adding water at regular intervals. At the end of incubation period, residual $^{14}CO_2$ inside the jar's atmosphere was trapped by providing NaOH into the previously placed empty vial inside the jar and quantified by a scintillation counter. ^{14}C activity was measured in different pools of soil C including organic and inorganic pools after digestion of the soil samples using a modified acid-dichromate digestion- apparatus.

A negligible amount of total ^{14}C activity (< 0.4% of added ^{14}C) was observed in the fumigated soil whereas in the non-fumigated soil a significant amount of total ^{14}C activity (ca. 16% of added ^{14}C) was observed. This suggests that biological activity in non-fumigated soil was responsible for atmospheric CO_2 fixation. The data also confirmed that the accumulation of ^{14}C in soil was mainly due to microbial fixation rather than simple absorption by soil particles. The analysis of fixed ^{14}C revealed that a high percentage of ^{14}C activity (ca. 71% of fixed ^{14}C) was absorb as carbonate in the fumigated soil, whereas the majority of the radioactivity (ca. 84% of fixed ^{14}C) in the non-fumigated samples was fixed to soil microorganisms. However, the absolute amounts of carbonate form were similar (ca. 7% of added ^{14}C; $P = 0.096$, $F = 3.74$) in both the fumigated and non-fumigated soils. Significant ($P = 0.035$, $F = 21.85$) difference in CO_2 fixation was observed between field soils treated with various levels of biosolids, which may be attributed to the variation in microbial diversity and activity induced by plant species and amount of C in the systems. In the spiked soils, significantly ($P < 0.001$) higher CO_2 fixed in spiked soils than control (no organic amendments) suggests that organic amendments have a positive impact on CO_2 fixation, although the CO_2 fixation varied between the sources. The amount of C fixed in the soil corresponded to 0.01% to 0.08% of the organic C present in the soil at the beginning of the experiment. The enhancement and variation of CO_2 fixation by the addition of organic amendments and the linear correlation between CO_2 fixation and respiration suggest both the microbial diversity and activity are important in CO_2 fixation in soil.

Keywords: *Microbial CO_2 fixation, Biosolid, Organic amendment, Microbial diversity, Plant species*

P1-559

[C4.1-3] Soil Ecosystem under Climate Change

The Effect of Heavy Metal on the Priming of Soil Organic Carbon Induced by Glucose Addition

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The addition of organic amendments such as manures, composts and biosolids may increase the carbon (C) stock in soil. However, their addition can cause an impact on the decomposition of native soil organic carbon (SOC) which is known as priming effect (PE). Small changes in SOC levels can have global impacts on C sequestration and net emissions of the major greenhouse gas, CO_2. The C dynamics in soil can be influenced by microbial activity along with the labile C and nutrients status which can be potentially affected by heavy metal toxicity in soil. Although a number of studies have examined the PE as influenced by the availability of soil C and nutrients, there have been only limited works on the effect of heavy metals on PE. In this study, we investigated the effect of heavy metals on the PE using an incubation experiment with ^{14}C labelled glucose.

Heavy metal contaminated and uncontaminated soils were used in this study. The field cupper (Cu) contaminated and uncontaminated adjacent surface soils (0-10 cm) were collected from a Cu mining site, Kapunda in South Australia. The uncontaminated soil spiked with various levels of Cu was also used to examine the effect of Cu level on PE. Soils were spiked with ^{14}C labelled glucose at a rate of 1000 mg C kg^{-1} soil and the moisture content was maintained at field capacity. The ^{14}C activity in the sample was 100 KBq kg^{-1} soil. The soil samples were placed in 3 dm^{-3} jars containing a CO_2 trap (NaOH) and a beaker containing water to maintain a water saturated atmosphere. Additional jars containing only the CO_2 trap with and without soils plus water served as control and blank, respectively. The jars were then incubated in a laboratory at 22°C. The CO_2 trap was changed at various intervals over a period of seven days for the analysis of total and labelled CO_2 in the NaOH trap using a titration method and liquid scintillation counter, respectively. The first order exponential model was used to measure the decomposition rate of glucose C using the software SigmaPlot®.

The cumulative PE clearly indicated that the production of extra non-labelled CO_2 (i.e., PE) was significantly ($P < 0.001$) higher in adjacent uncontaminated than field contaminated soils. There may have been some toxic effects of heavy metals to microbial activity and growth in field contaminated soils, thereby decreasing (still positive) the PE. This is evident from the decrease in the decomposition rate of glucose C (measured by half-life) ($P < 0.001$) in field contaminated soils. The extent of PE was higher in adjacent uncontaminated than field contaminated soils which was attributed to higher microbial activity and growth in former than later soils. Calculated instantaneous PE suggested that the highest amount of the PE was observed within 48 to 72 h of incubation (ca. 8.2% and ca. 4.5% of added C, respectively for uncontaminated and contaminated soils) and then it decreased to ca. 3.2% and ca. 1.7% of added C, respectively up to four days of incubation. At the last three days of incubation period, PE then increased rapidly ($P < 0.001$) in uncontaminated soil whereas it increased slightly ($P = 0.084$; $F = 6.54$) in field contaminated soils, which was attributed to probable significant microbial growth in former soil. In the Cu spike soils, a decreasing trend in PE was observed with increasing the Cu levels used in this study. This indicates that metal toxicity has a negative effect on the PE due to the inhibition of microbial growth and activity.

We conclude that not only the quantity and quality of readily available C, and soil available nutrient but also the microbial environmental condition (i.e., toxicity) and metal-C interaction are important in the process of PE, thereby potentially impacting C stocks in soil.

Keywords：*Priming effect, Heavy metal, Microbial activity, Carbon dynamics*

P1-560

[C4.1-3] Soil Ecosystem under Climate Change

Effect of Different Organic Manures and Chemical Fertilizers on CO2 Emission, Carbon Sequestration and Rice Yield in Soils Under Rice-Rice Cropping Pattern.

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Small changes in the soil organic carbon (SOC) stock create great impacts on the atmospheric carbon concentration. Rice - fallow - rice, the most dominant cropping system in Bangladesh, received little attention in SOC changes through organic amendments. Understanding of the contributions of common soil organic amendments in carbon sequestration under the rice - fallow - rice cropping system is important for SOC budgeting in Bangladesh. The present study aimed to determine the effect of organic amendments on soil carbon sequestration and rice yields. A field experiment, for five consecutive seasons (August 2010 - November 2012), was conducted at the Bangabandhu Sheikh Mujibur Rahman Agricultural University farm. The experiment involved five treatments - application no organic materials and no fertilizer (control), 2 t ha - 1 C from cowdung (CD), from poultry manure (PM), from rice straw (RS) and soil test based fertilizer dose (STB). According to integrated plant nutrition system (IPNS) concept, CD and PM treatments received no chemical fertilizer, but RS treatment received 132 and 60 kg N with 2 and 0 kg P per ha from urea and triple super phosphate in both Boro and Aman seasons, respectively. During the five rice seasons, CD, PM and RS treated plots received 10 t C per ha. Aman and Boro rice were grown under lowland culture with full irrigation. Carbon dioxide production in all the treatments, from the fields, was measured through NaOH absorption followed by HCl titration. After five seasons, SOC along with other properties were measured from the post-harvest soil samples. The difference in the amount of cumulative CO2 evolution and SOC accretion between control and organic materials treatments gave the apparent C balance and C sequestration. Rice yield and nutrient uptake by rice under different organic and inorganic treatments including the control and STB were recorded. The experimental results show that the application of CD, PM and RS resulted in 38, 36 and 40% loss of applied C through CO2 respiration by the soil microorganisms. The application of organic C through CD and PM accounted for 30 and 49% sequestration while the sequestration of C from RS accounted for only 10%. There was an unaccounted amount of applied C in all the three sources with variable magnitude. The unaccounted portion of C in soil from CD and RS represented 31 and 50% respectively, but in case of PM it was only 15%. The unaccounted portion of the added C may be attributed to the anaerobic decomposition where CO2 was not produced or escaping of the produced CO2 through aerenchyma channel to the leaf surface. There was a slight C sequestration in STB treatment, which underpins the concept of SOC build up in rice - rice cropping system. The application of CD and PM as a source of C increased rice yield significantly higher than that obtained with STB. Cowdung, PM and RS contributed to the positive soil nutrient balance as well. However, the benefits of the organic amendments in terms of rice yield and soil nutrient build up may be regarded as utopian because of economic reason. Results of the study may be concluded as, in the rice - rice cropping system, the expected SOC build-up would be 40, 75 and 74 kg t - 1 of RS, CD and PM, respectively. The stability of the newly formed SOC from RS, CD and PM need to be examined in future studies.

Keywords：*Organic matter, CO2 emission, Carbon sequestration, Rice production*

P1-561

[C4.1-3] Soil Ecosystem under Climate Change

Effects of Thinning on Nitrogen Utilization of Hinoki Cypress and Understory Vegetation in Shikoku Island, Southern Japan

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Thinning in hinoki cypress plantation generally increases light, water and nutrient availability for remaining trees. Soil nitrification often increases after thinning. Abundance of understory vegetation also increases. These changes may affect nitrogen use strategy of hinoki cypress and understory vegetation. Deciduous understory vegetation generally has higher leaf nitrogen concentration and their ability to absorb soil nitrogen can prevent nitrogen losses from the ecosystem after thinning. If nitrification increases after thinning, the nitrate should have lower $\delta^{15}N$ value while remaining ammonium should have higher $\delta^{15}N$. The preferential uptake of nitrate and ammonium should affect $\delta^{15}N$ of plants. Therefore changes of nitrogen utilization by trees can be predicted from their $\delta^{15}N$ values.

In this study, we investigated changes of $\delta^{15}N$ in hinoki cypress plantations at two different altitudes (Tengu 1150m, Furumiya 710m) in Shikoku Island, southern Japan. Two adjacent plots (20m x 20m) were located. One plot was thinned in 2002 and the other was remained as a control. Organic layer and surface soil at 5cm depth were samples in 2002. Surface soil at 5 cm depth was collected from 2005-2007 and water content and water extractable ammonium and nitrate were measured. Leaves of hinoki cypress and understory vegetation (Lindera triloba in Tengu and Lindera sericea in Furumiya) were collected in July from 2002-2007. Nitrogen concentration of these samples were measured by NC analyzer while their $\delta^{15}N$ were measured by Isotope Ratio Mass Spectrometry.

There were significant difference in soil properties between thinned and control plots. Soil in the thinned plots had higher water content at both areas. Effects of thinning on water extractable ammonium and nitrate were different between high and low altitude. At higher altitude, nitrate concentration in the thinned plot significantly increased but ammonium concentration slightly decreased. At lower altitude ammonium concentration increased in the thinned plot but nitrate concentration is very low in the thinned and control plots. These results suggest that thinning increase water and nitrogen availability but their effects on soil nitrogen pool are different between two areas.

Nitrogen concentration of hinoki cypress was significantly increased in the thinned plot after 2 years but there was no difference in other years. Nitrogen concentration of understory vegetation at higher altitude increased after 1-2 years thinning but that at lower altitude increased after 5-6 years. $\delta^{15}N$ of hinoki cypress did not change within 3 years after thinning but significantly increased after 4-6 years at higher altitude and after 5 year at lower altitude. $\delta^{15}N$ of understory vegetation in the thinned plot decreased at higher altitude but increased at lower altitude just after the thinning. The results suggest that leaf $\delta^{15}N$ in understory vegetation is more rapidly affected by thinning than hinoki cypress. Lower $\delta^{15}N$ in leaves by understory vegetation at higher altitude suggests preferential uptake of nitrate in thinned forest. Therefore, shifts of nitrogen sources to nitrate by understory vegetation can prevent nitrate loss after thinning while hinoki cypress cannot respond to changes of soil nitrogen availability rapidly. The lower $\delta^{15}N$ in leaves of hinoki cypress at lower elevation cannot be explained by nitrate uptake due to very low soil nitrate pool but it suggests reliance of nitrogen sources in the upper layer of soil, i.e. organic horizon. These findings indicate that measurement of $\delta^{15}N$ in leaves provide valuable insights about the nitrogen sources for plants.

Keywords：*thinning, nitrate, stable isotope, understory vegetation, hinoki cypress*

P1-562

[C4.1-3] Soil Ecosystem under Climate Change

Soil Carbon Dynamics under Soil Management Systems for Maize Cultivation in Thailand

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Management of Crop residues for maize cultivation in the Northeastern Thailand during the year 2009 -2011 on Soil Group No. 29, Wang Saphung low base saturation, deep : Ws-lb-deep to bed rock) Soil Series was carried out at Pakchong, Nakhon Ratchasima Province by using a randomized complete block design of 4 replications and 3 treatments were (1) Crop residues removal (2) Stubble mulching (3) Slash and burn of crop residues. The results showed that there were no statistical different evidences of those practices in term of soil carbon dynamic, net carbon fluxes, soil carbon stock and maize biomass including yield for 3 studied years. Additional, it was noticed that the amount of soil carbon dynamic and net carbon fluxes were more much when the more moisture remained in the soil particularly during raining. The effecting on soil properties was not significantly different. However, the soil organic carbon was greater obtained from the stubble mulching practice than the others. This can contribute to mitigate the global warning event as well. The soil pH of the area was a bit low to acid reaction raging 5.4-5.8. Amount of available P of areas were quite low and K, were medium condition for maize cultivation.

Keywords：*Carbon Sequestration, Net carbon fluxes, Soil carbon stock, Biomass and Soil carbon dynamics.*

P1-563

[C4.1-3] Soil Ecosystem under Climate Change

Peat Soil CO2 Respiration along a Land-Use Change Gradient

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Indonesian peatlands cover ~21 million ha and estimated to contain a huge amount of terrestrial carbon (~57.8 Gt), ~ 5.9 million ha span in Kalimantan (~ 11% of 54.4 million ha of Kalimantan's total terrestrial land area). Land cover change of peatland forests results in significant sources carbon dioxide (CO2) emissions. Thus we sought to estimate the carbon emissions generated by land use change in Kalimantan's peatlands. Soil CO2 respiration was measured under three of the most prominent land cover types (drained, selectively logged forest, young oil palm plantation, and 2-3 yr post fire areas) in West Kalimantan peatlands. From 2009-2011, measurements were obtained from a set of 39 permanent 20 cm diameter soil collars with a Licor 8100 obtained over eighteen months spanning two major dry and rainy seasons. Among the three land cover types, monthly CO2 respiration (Mean ± SE) of peatland logged forest, oil palm, and post burned areas were 20.8 ± 1.0; 23.7 ± 1.3; and 32.2 ± 2.3 g CO2 m-2 d-1 or 75.9, 86.5, and 117.5 Mg CO2 ha-1y-1. Soil CO2 respiration within the logged forest and oil palm plantation area differed significantly from the burned area (Tukey Pairwise Multiple Comparisons: $p \leq 0.05$). Overall mean CO2 respiration at logged peatland forest area was unexpectedly similar to measures obtained from young oil palm plantation. Drier months demonstrated higher peat CO2 fluxes on three land cover types than rainy month s. Because many individual assessments of site environmental conditions display interdependencies among them, our data collection is essential to reveal the relevant impacts and contributions to peat CO2 respiration. Our results indicate that the site factors predicting peat CO2 respiration rates vary among the three land covers. The different controlling site factors in peat CO2 respiration among the land cover types suggested that the land use and land cover change affected the CO2 dynamics between peatland soil and atmosphere. Among the three land cover types assessed, water table is the one site factor that consistently influenced peat CO2 respiration. In addition, it also can be used to predict the CO2 flux across the three land covers. While peat temperature does not significantly affect the respiration in logged forest and recently burned peatlands, however, across the three land cover types, we found that temperature is one of the most important site factors predicting peat CO2 flux.

Kalimantan peatlands are one of the last frontiers for agricultural expansion and oil palm plantations, largely because of the decreasing availability and opportunity costs of obtaining contiguous relatively flat or undulating lowlands on mineral soils. Consequently, large-scale conversion of peatland forest for those purposes requires forest clearance and drainage to increase peatland productivity for specific crop plant requirements. Construction of drainage canals and water-table management is typically essential to manage productivity on these peatlands. However, drainage has substantial negative effects particularly in lowering water table, altering site conditions (e.g. peat and ambient temperature, peat water vapor, peat water content, peat bulk density etc.), and subsequently increasing peat CO2 respiration rates and other greenhouse gases exchanges. The canal construction also affects peatland forest nearby by altering soil and understory microclimates, and consequently increase CO2 flux as well (increase ~2 fold from non drained to drained-affected logged forest, ~15% from drained forest to oil palm, and ~50% from drained forest to open-burned peatlands). Moreover, using fire as a method of land clearing could induce higher losses, both from losses of peat layer and increase in CO2 flux after fire particularly 1 to 9 months post-burned. This peatland forest conversion to oil palm and open previously burned areas considerably intensifies soil CO2 flux and contribute larger positive feedbacks. Thus land use and land cover change on these peatlands coupled with potential strong ENSO events in the future have increasingly become pressing global issues due to their CO2 emissions and their contributions to climate change.

Keywords：*CO2 respiration, land cover types, site factors, dry and rainy season*

P1-564

[C4.1-3] Soil Ecosystem under Climate Change

Carbon Stocks in Various Carbon Pools of Acacia Mangium Planted Forest in Peninsular Malaysia.

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INTRODUCTION

The main carbon pools in tropical forest ecosystems are the living biomass of trees, understory vegetation, dead mass of litter, woody debris and soil organic matter (Gibbs et al. 2007). According to Lim (1988), in Peninsular Malaysia, the realization of a possible shortage in timber supply for general utility in the mid 1990's led to the Compensatory Plantation Programme, which spearheaded the establishment of over 180,000 ha of a fast growing species, Acacia mangium. Acacia mangium trees are generally large and can grow to a height of 30 m, with a straight bole. Today, besides wood production, forest plantation also plays an important role in reducing CO2 in the atmosphere. Atmospheric C can be absorbed and restored in above and below ground biomass, and reduce the CO2 buildup in atmosphere (Montagnini & Porras, 1998). Workers have also reported that substantial amount of C stock is available in A.mangium plantations (Heriansyah et al., 2007; Matsumura et al., 2007). It is important to know how rapidly storage occurs and how much carbon is stored in different components of the species. This study shares an insight on carbon stocks in 4 year old A.mangium plantations.

METHODOLOGY

The study was conducted in A.mangium plantations in Ulu Sedeli, Johor, Malaysia. The trees were planted in July 2007 (GPS: WM 655153, WMR 212769) with a planting distance of 2.5 x 2.5 m. Five replications of 20 x 30 m2 plots were established in study site. All trees within the plot were measured for diameter at breast height (dbh) and total height. Eighteen trees were felled which represented the various diameter classes in the plot. Trees were felled and processed according to Basuki et al., (2009). An allometric equation was developed based on the felled trees to fit a linear regression equation. The significance of the equation was tested in SAS system software. Undergrowth and litter were determined based on dry weight and converted to C stocks. Soil bulk density samples were collected at 0-15 and 15-30 cm depth and root/shoot ratio were determined for 12 trees.

RESULTS & DISCUSSION

The total number of trees recorded for dbh and height was 447 and the minimum and maximum dbh recorded was 2.5 and 21.2 cm respectively. A comparison between Ln DBH and Ln TAGB showed that there was a significant correlation and positive association ($r = 0.945$) between both variables at $p = 0.01$ which fits the equation:

Ln TAGB (kg/tree) : 2.46 (Ln DBH, cm) – 2.35.

Based on the allometric equation, the total carbon biomass of trees were 39.28 Mg C/ha. From previous studies, it was reported that

the aboveground biomass of C in 3 and 5 year old plantations were 22.93 and 44.25 Mg C/ha (Heriansyah et al., 2007) and 40 Mg C/ha (Matsumura, 2007). Total soil carbon stock at the depth of 30 cm was 132 Mg C/ha and we believe that this was due to the previous accumulation of soil organic matter of natural forest vegetation, the contribution of undergrowth and litterfall. The root to shoot ratios (R/S) ranged from 0.3 – 2.1 and the mean R/S was 0.77 for 4 year old A.mangium trees. However, Heriansyah et al., (2007) has reported that roots constitute 14% of the biomass storage of trees aged 3- 5 year olds where the values were similar to our studies. Based on 14%, the C content in roots maybe approximately 6.38 Mg/ha which should be used with caution due to variations in environmental conditions and sampling methods. The carbon stocks in litter and undergrowth were 5.02 and 0.42 Mg C/ha respectively.

CONCLUSION

Highest stock was contributed by soil (72 %), followed by aboveground biomass (22 %). Undergrowth, litter and root carbon biomass were minimal in this study. Forest plantation such as A.mangium contribute a significant amount of C stocks. Information from this study can be used for climate change mitigation.

Keywords：*carbon sinks, plantation, Acacia mangium, Allometric equation*

P1-565

[C4.1-3] Soil Ecosystem under Climate Change

Effect of Different Pasture Termination Strategies on N2O Emission in High Rainfall Cropping Systems

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Effect of different pasture termination strategies on N2O emission in high rainfall cropping systems

Soil is the major anthropogenic source of emissions of nitrous oxide (N2O), one of the most harmful greenhouse gases. This emission is mainly attributable to the actions of soil microorganisms. The global estimates of losses of N2O by denitrification are about 15-70 Tg N yr-1, while estimates of losses of N2O by combustion of fossil fuels are about 1-3 Tg N yr-1 and those for burning of vegetation 1-2 Tg N yr-1. No reliable estimates of N2O loses during nitrification have yet been made on a global scale. Farming practices, such as timing of pasture termination (autumn termination versus summer termination) and zero versus conventional tillage can affect soil properties, the productivity of ecosystems as well as greenhouse gas emissions.

This research compared several farming systems with respect to carbon dioxide and nitrous oxide emissions in an ongoing field experiment in Victoria, Australia, on a mottled-sodic, eutrophic brown Chromosol. Early and late termination of pasture (using zero or conventional tillage) were compared with continuous pasture. The soil was analysed for total nitrogen and carbon, organic carbon, mineral N, total and Olsen P, extractable S and K, pH and EC, exchangeable sodium percentage, exchangeable cations and bulk density. Crop growth was monitored using the Zadok scale and such parameters as crop emergence, above-ground biomass and grain yield were also measured. An automatic chamber technique was employed to study the effects of different treatments on N2O emission. Twelve automated gas collection chambers (one chamber per agronomic plot) are interfaced to a tuneable diode laser trace gas analyser and emission was measured continuously. Soil water content, temperature in the surface soil and air temperature were monitored using sensors installed within each agronomic treatment.

Use of early pasture termination systems generally increased nitrous oxide emission. The flux of N2O was up to 20% higher than in the late termination treatment or continuous pasture ($P<0.05$). Furthermore, using conventional tillage resulted in significant increase of nitrous oxide emission in comparison with direct drilling. This was attributed to the tillage-induced breakdown of soil aggregates and the resulting enhanced decomposition of organic nitrogen occluded within soil aggregates. These preliminary results suggest that using such an agricultural strategy as late pasture termination, in combination with zero tillage, could substantially reduce emissions of greenhouse gases. Future research will involve monitoring of greenhouse gas emissions from these field experiments over an extended period as well as investigations into the mechanisms by which some farming practices have resulted in greatly reduced emissions.

Keywords：*nitrous oxide, pasture, soil, automated chambers*

P1-566

[C4.1-3] Soil Ecosystem under Climate Change

Assessment of Projected Climate Change on Soil Organic Carbon and Crop Yield Based on The Recent 20 Yrs Fertilization Applications in the Loess Plateau, China

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Climate change may have great impacts on the dryland agriculture of the Loess Plateau of China, which is one of the most fragile agro-ecosystem in the world. Understanding the impacts of climate change on soil organic carbon (SOC) and crop yield is extremely helpful. The objective of this study was to investigate the trends of SOC content and crop yield, through long-term field data and numerical simulations. Field experiments with rotational crop managements (winter wheat + summer maize) were included control (CK) and four types of fertilization treatments, i.e., single inorganic fertilizer application (NPK), combined application of inorganic fertilizer and straw (NPK+S), combined application of inorganic fertilizer and low amount of manure (NPK+M1), and combined application of inorganic fertilizer and high amount of manure (NPK+M2) to verify the applicability in agro-ecosystems of the Loess Plateau of China. The DNDC model was calibrated and experimentally validated to simulate SOC changes and dynamics of crop yield using the 20 yrs data from 1990 to 2010. The results showed that CK treatment made soil deficit seriously and soil fertility continuing to decrease, and very significantly reduced the SOC content and crop yields; NPK and NPK+S could promote crop production, but less obvious role in promoting soil fertility, and even the former still significantly reduced the SOC content; NPK+M1 and NPK+M2 both had great effects on crop yield and soil fertility with the latter one had greater effects. The root mean square error (RMSE) and coefficient of determination (R^2) provide a satisfactory quantitative comparison of the goodness-of-fit between observed and simulated data, which demonstrated DNDC model as a reliable tool, so as to it can be used for analyzing soil-crop interactive processes under projected climate change. Based on this, we considered four climate change scenarios, i.e., increasing 2℃ temperature and 5% precipitation (scenario 1), increasing 2℃ temperature but decreasing 5% precipitation (scenario 2), decreasing 2℃ temperature but increasing 5% precipitation (scenario 3), and decreasing 2℃ temperature and 5% precipitation (scenario 4), to clarify how SOC and crop yield response to the assumed climate changes. In all five treatments, scenarios 1 and 2 could increase winter-wheat yield, while scenarios 3 and 4 decreased winter-wheat yield, respectively. However, scenarios 3 and 4 increased corn yields and SOC while scenarios 1 and 2 decreased them, respectively. These simulations indicate that the climate changes impacts on the first crop had been compensated by the impacts on the secondary crop in some degree. Furthermore, it seems that winter-wheat yields are easily influenced by temperature and therefore reasonable high temperature can enhance winter-wheat yields. However, corn yields are easily impacted by the SOC content, which has its peak under scenario 3. This finding might be helpful for the landuse managements under the potential future change in the local and even national region.

Keywords：*the DNDC model; fertilization; soil organic carbon; crop grain yields; climate changes*

P1-567

[C4.1-3] Soil Ecosystem under Climate Change

Prediction of Soil Nitrogen Mineralization as Affected by In-Situ Warming in Paddy Fields in Japan

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Introduction

Global warming may have serious impacts on soil nitrogen (N) mineralization that is one of the most important factors affecting the productivity of agricultural soil. In paddy fields, two following formulae have been proposed to estimate N mineralization as affected by soil temperature. The following formula is based on reaction kinetics.

N = N0?(1-exp(-k?t))+c (formula I)

where N is mineralized N (mg kg^{-1}), N0 is decomposable organic N (mg kg^{-1}), k is mineralization rate constant (day^{-1}), t is incubation time (day), c is integration constant (mg kg^{-1}), and T is soil temperature (^oC). The following one is based on effective accumulated temperature.

N=k?[∑_(t=0)▒?(T-15)*1?]^n (formula II)

where N is mineralized N (mg kg-1), T is incubation temperature (^oC). k is constant (mg kg^{-1} ^oC day^{-1}), and n is invariable. In this study, we conducted in-situ soil warming experiments in two locations, Tohoku and Kanto area in Japan having different climate and soil conditions, to test applicability of these formulae to global warming conditions and also to evaluate the accuracy of N mineralization estimation of the suggested two formulae.

Materials and Methods

The experimental paddy fields were located in Shizukuishi, Iwate prefecture and Tsukuba-Mirai, Ibaraki prefecture in Japan. As for the first process of N mineralization estimation, indoor soil incubation was conducted. We took soil samples from each field and sieved them through 2mm. A bottle containing 10g of soil and 20 mL of water with N2 gas replaced head space was incubated under 20, 25, and 30 oC for 187days. Over time, produced mineral N ($NH4^+$-N) concentration was measured after extraction (50mL of 1M KCl) and quantified by nitroprusside method. The amount of produced N was plotted against t on a graph, and fitting curve process identified special coefficient for the formulae I and II. Based on these formulae, we calculated theoretical N mineralization (Nt). As for the second process, we conducted in-situ incubation. We set normal temperature (NT) and elevated temperature (ET) (NT + 2^oC, elevated by electric heaters on soil surface) treatments in actual farmers' fields in Shizukuishi during 2007-2008 and in Tsukuba-Mirai during 2010-2013. Bottles prepared by the same processes described for indoor incubation were incubated in-situ during a rice-cultivation season, retrieved periodically, and measured for mineralized N. This result served as measured N (Nm).

Results and Discussion

Here, we describe the results from 2007 experiment. The effect of soil warming was statistically significant on mineralized N at DAT 103 (NT: 72.2, ET：83.1mg kg^{-1} , $P < 0.01$). The special coefficients were identified by indoor incubation, and then Nt was estimated using recorded in-situ soil temperature. The estimated mineralized N at DAT 103 were 69.8 in NT and 82.9 mg kg^{-1} in ET by formula I and 80.9 in NT and 94.7mg kg^{-1} in ET by formula II. Calculated root means square error (RMSE) were 2.29 for NT and 3.168 for ET in the case of formula I and 9.30 and 12.35 in the case of formulae II, respectively. Increased soil temperature significantly increased N mineralization; therefore, global warming may elevate soil N mineralization in a paddy field as well. Since formula II had higher RMSEs, we recommend choosing formula I to estimate soil N mineralization for a higher accuracy.

Keywords：*nitrogen mineralization*

P1-568

[C4.1-3] Soil Ecosystem under Climate Change

Regional Scale Modeling of Nitrogen Cycle on Andosols in an Intensive Livestock Farming Area

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The livestock sector is now one of the top two or three most significant contributors to environmental problems. To support a sustainable development in livestock system in Japan, it is urgent to evaluate the N environmental pollution strength due to the developed intensive livestock system and to explore efficient manure management methods. To achieve these objectives, the nitrogen (N) cycle was evaluated by DNDC in Upper Naka River Watershed, an important livestock region in Japan.

Firstly, the DNDC model was calibrated and validated using data from a wide range of soil textures, as well as manure managements and cropping systems. The results showed that: 1) The calibrated DNDC model was able to predict 83% of the measured variation in soil nitrous oxide (N2O) emission and over 94% of the observed variation in crop N uptake. To calibrate DNDC model, changing the microbial index for different organic amendments was the essential parameter to simulate N flow on Andosols. 2)The long term (30 years) simulation suggested that the current crop N use efficiency was 27-42% and 37-55% for upland and paddy rice systems, respectively. There poses a big risk of nitrate (NO3--N) leaching and N2O emission, especially in upland crop systems. The level of NO3--N leaching and N2O emission would increase significantly when the precipitation increases. Sandy soil showed a lower crop N uptake and higher N loss rate than other soil textures. The critical N rate was around 400 kg N ha-1 yr-1 for grass/maize and one season rice and 650 kg N ha-1 yr-1 for forage rice/barley crop systems, otherwise the crop N efficiency would significantly lower than 50% of input N.

Secondly, at regional scale the calibrated DNDC was applied into four scenarios: standard fertilization (STD), half of STD (HALF), chemical fertilizer only (CMC) and the combination of half chemical of STD with all local livestock manure (CMB). The STD showed high crop N use efficiency in paddy rice with and efficiency of 98% of N input use, while that of uplands was only 51.3%. Decreasing the input N as shown in the HALF scenario, the harvest crop N trended to decrease especial for paddy rice. But the HALF scenario still posed the high N2O emission and NO3--N leaching, and also faced a significant soil N loss. Changing all N input to chemical fertilizer under the scenario CMC, the harvest crop N increased and consequently a serious deficit in soil N was found in paddy rice area, while a significant NO3--N leaching would occur in uplands. The use of all manure in the region under the scenario CMB would significantly increase the N input to farmlands, while it does not increase harvest crop N but increase the N2O emission by two time and NO3- leaching by three times especially for uplands.

Integrated all results, the analysis showed the differences among soil types mainly derived from the different soil clay content as well as the amount of input N. The potential highest harvest N (150 kg N ha-1 yr-1) can reach when the input N was 200 kg N ha-1 yr-1; the N2O emission and NO3--N leaching was the significant N pollution source in the study region due to 68% of simulation grids with soil clay content 10-20% and only 30% of grids was higher than 20%. The highest value was up to 54.9 kg N ha-1 yr-1 and 1197 kg N ha-1 yr-1 in CMB scenario with the input N 1510 kg N ha-1 yr-1. Another finding was that the soil faced a significant N loss if input N was lower than crop nutrition requirement. In current STD condition 64% of simulated grids had a negative uncounted N value. If changing all input to chemical fertilizer, the situations become more serious than STD.

Keywords：*Intensive livestock, DNDC model, N cycle, Andosols*

P1-569

[C4.1-3] Soil Ecosystem under Climate Change

N_2O Emissions from a Solar Greenhouse Soil as Affected by Nutrient Management

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Chinese vegetable cropping takes up 11.4% of total national planting area. It has been estimated that vegetable production consumes approximately 17% of the total N fertilizer and contributed to 21-25% of total N2O emission from Chinese croplands. The present study was based on an ongoing experiment, where both irrigation strategy and N application rate were considered to optimize water and N input, as well as to reduce N leaching, to evaluate if the management practice had any effect on mitigation of N2O emission from such cropping systems. During the investigation, N2O emissions were monitored from a typical solar greenhouse with cucumber-cropping from 11th July, 2011 to 3rd September, 2012 with two planting seasons and one fallow period in three treatments. The treatments included a conventional nutrient management (CN), in which flooding irrigation and fertilization rate were based on to farmer's practice; an optimal nutrient management (RN), where drip irrigation was applied with optimized both irrigation rate and nitrogen rate; and RN in combination with a catch crop (sweet corn planting during fallow period and its residue amendment). Static chamber-gas chromatographic method was used to measure soil N2O flux. The results showed that N2O emissions had a high seasonal variations. The annual cumulative N2O emissions accounting for 0.31-0.40% of the total nitrogen input, with N2O gaseous losses ranged from 3.2 to 9.5 kg N ha-1. Compared with CN treatment, the RN treatment reduced 61-66% of total cumulative N2O emissions, where N was reduced to 52% of CN and 48% of irrigation water in CN was saved without any yield reduction. The results suggested that N2O emission were mitigated by improvement of management practice in an intensive greenhouse vegetable cropping system.

Keywords：*N2O, greenhouse soil*

P1-570

[C4.1-3] Soil Ecosystem under Climate Change

Pedo-Ecological Patchiness as Affected by Rock Fragments in Semiarid Rangelands

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Widespread areas in the semi-arid climatic regions of the Mediterranean basin have a significant cover of surface-lying or partially embedded rock fragments (RF).

In these regions, understanding the roles of RF in the eco-geomorphic system is of great importance because of their influence on overland flow generation, soil erosion, and soil properties – factors that help to create habitats for flora and fauna.

The present aims were: (a) to investigate the effects of RF, of divers sizes and in various positions, on soil temperature, and moisture, organic matter, and calcium carbonate contents; (b) to study the effects of hillslope aspect on the above properties of soil underneath RF; and (c) to assess the ecological benefits of RF.

On north- and south-facing hillslopes in the northern Negev region of Israel, soil was sampled from beneath RF of divers sizes – small, medium, and large, i.e., 4-6, 8-10, and 13-16 cm, respectively – that were positioned on the soil surface or partially embedded in the soil – hereafter designated as 'on top' and 'embedded', respectively. Control samples were taken from bare soil. Soil samples were taken in February from each aspect, and for each size and position of RF. Samples were taken from two depths: 0-2 and 5-10 cm. For each soil sample, moisture, organic matter, and calcium carbonate contents were determined. Soil temperatures at the above two depths were measured once per month during one year.

Organic matter, calcium carbonate, and moisture contents in soil under RF were higher than those in bare soil.

The rock fragment characteristics (size and position) affected the various soil properties with differing intensities. Under the large and medium RF soil moisture contents were significantly higher than those under the small ones; and embedded RF promoted higher moisture contents than those on top of the soil. Rock fragment position had the most significant effect on soil organic matter content, which was higher under 'on top' fragments.

Rock fragment size and position had significantly greater effects on the south-facing than on the north-facing hillslopes, with regard to increasing the spatial variability of soil temperature, and moisture and organic matter contents. Thus, the south-facing aspect clearly exhibited fragmentation of the soil.

On the south-facing hillslope the positive influence of RF on the organic matter content compensated to some extent for the smaller contribution of litter deposited by its sparse shrubs on this slope than on the north-facing one.

Variations in soil properties were associated with the RF, which can be seen as fertile micro-islands with similar functions to those of shrubs, i.e., concentrating natural resources and releasing them to the environment, and forming potential habitats for varied fauna and flora.

Furthermore, in light of the capability of flocks of sheep and goats to move RF of similar sizes to those in the present study, it can be concluded that in the long run the entire hillslope will experience the soil conditions found under rock fragments.

Keywords：*rock fragments, organic matter, calcium carbonate, soil moisture, soil temperature, semi-arid areas*

P1-571

[C4.1-3] Soil Ecosystem under Climate Change

Impact of Climate Change on Carbon Cycling and Soil Microorganisms in an Arable Ecosystem

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Carbon cycling in terrestrial ecosystems provides a feedback mechanism to climate change by releasing or sequestering additional atmospheric CO2. However, the role of soil microorganisms as key players in this feedback mechanism is still unclear. Most of previous studies focused on the effects of climate change on forest or grassland ecosystems, where much less is known about the response of arable ecosystems to a changing climate. Arable ecosystems considerably differ from more natural ecosystems in terms of e.g. soil management, nutrient availability and input of organic matter. The Hohenheim Climate Change (HoCC) experiment was established in summer 2008 to manipulate soil temperature and precipitation on an arable field. Soil temperature is increased by 2.5°C in 4 cm and is combined in a factorial design with the following precipitation manipulation treatments: a) ambient, b) precipitation amount decreased by 25% during summer and increased by 25% during winter, c) drought periods increased by 50% during summer, d) combination of b and c. The experimental plots were planted with spring wheat (Triticum aestivum, 2009), spring barley (Hordeum vulgare, 2010), oilseed rape (Brassica napus, 2011) and winter wheat (Triticum aestivum, 2012). Soil samples (0-5 cm, 5-15 cm and 15-30 cm depth) were taken at four occasions in 2009 and 2010 and at three and two occasions in 2011 and 2012, respectively. Data of aboveground biomass, soil organic carbon, soil microbial biomass, ergosterol content, hydrolytic enzyme activities and CO2 fluxes (weekly measurements) will be presented. Results from 2009 and 2010 indicated that changes in soil temperature and precipitation differently affected aboveground biomass and that these effects depended on the crop. Effects of elevated soil temperature on microbial biomass and CO2 fluxes were related to moisture conditions during the different seasons of the year in 2009 but not in the following years [Poll et al., 2013]. In the years 2010-2012, warming increased soil respiration across the seasons. Effects of reduced summer precipitation on soil respiration increased across the years with a significant reduction in summer 2011 and 2012. First evaluation of ergosterol contents and enzyme activities from 2009 to 2012 indicate that soil warming increases fungal biomass and microbial activity depending on the time of sampling. Overall, the presentation will give insight into the complex interactions between climate change, soil moisture and soil microorganisms as key players of carbon cycling in the investigated arable ecosystem.

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Keywords：*climate change, warming, precipitation, arable soil, soil respiration, ergosterol, enzyme activity*

P1-572

[C4.1-3] Soil Ecosystem under Climate Change

Effects of Tillage and Fertilization on Nitrate and Phosphate Desorbed from Anionic Exchange Membranes over Winter

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Projected global warming may result in large climatic conditions variations in soil temperatures and in the number of soil freezing and thawing cycles during winter in cool temperate and high-latitude regions. Determining how agricultural management practices affect changes of soil nitrogen (N) and phosphorus (P) over winter could further our understanding of soil N and P cycle. Anionic exchange membranes (AEMs) have been successfully used to estimate the availability of soil N and P under different agro-ecosystems. The main objective of this study was to assess the effects of tillage systems, mineral N and P fertilization on NO3- and PO4- accumulation on AEMs (AEM-N and AEM-P, respectively) over winter. The AEMs were buried in the surface horizon (0–15 cm) over winter (mid-Nov. to mid-April) in three consecutive years (2009/2010, 2010/2011, and 2011/2012) in a long-term corn-soybean rotation experiment established since 1992 in eastern Canada. Treatments consisted of two tillage systems including moldboard plow (MP) and no till (NT) and nine combination of fertilization application including three N rates (0,80,160 kg N ha-1) and three P rates (0,17.5 and 35 kg P ha-1) in a split plot design with four replications. Results show that AEM-N and AEM-P were significantly greater under NT than MP across all N and P treatments and years. The effect of N fertilization on AEM-N was year-depended; AEM-N was not affected by N application after winter of 2009/2010 but was greater with 160 kg N ha-1 compared with no N applied after winter of 2011/2012; in addition, AEM-N increased by the increasing of N application under NT but not under MP after winter of 2010/2011. The AEM-P increased by increasing P application under NT in all three winters, while AEM-P was greater with no N applied than with N applied under NT. No significant change was observed on AEM-P under MP. We conclude that tillage and fertilization affect soil N and P availability over winters, and that these effects were more evident under NT combined with fertilization.

P1-573

[C4.1-3] Soil Ecosystem under Climate Change

Comparison of CO_2 Emission from Two Different Soils in Vitro

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Ascendant trend of greenhouse gases such as (CO2) and (CH4), from soils to the atmosphere is one of the human fear in the past few decades. More than 60 percent of global warming is due to the CO2 greenhouse effect. In this study, the release of CO2 from two soils with different physiochemical characteristics and climate conditions in the presence of different levels of organic matter were investigated. The total amount of CO2 released was measured using static closed chamber in the presence of NaOH solution. Based on the results, the most CO2 released was obtained in Botanic soil with loamy texture. The rates of CO2 release by time were reduced in both soil types which can be related to the decrease in soil carbon content and reduced microbial activity of soils. Also, the initial rate of CO2 released in Eshtehard soil was greater than Botanic one.

Keywords：*Greenhouse gases, CO2, Soil respiration, Organic matter*

P1-574

[C4.1-3] Soil Ecosystem under Climate Change

Does Temperature Differentiate Decomposition Rates of Labile and Recalcitrant Soil Organic Carbon?

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In the last decades, climate change has been the focus of interest for several disciplines at world level. Thus, knowledge about the ecophysiological, economic and social effects in front of a new scenario related to global warming has been enhanced. Changes in the climatic pattern cause a strong impact in the life cycle and natural ecosystems. The Intergovernmental Panel on Climate Change (IPCC, 2007) concluded that predictions for the increase of temperature along Central and South America, will be variable and with a strong increase in Central America and Amazonia. It is expected a median, towards the end of 21st century, of 3.2 and 3.3º C, respectively, with a greater impact in central of Amazonia. For South America, the mean temperature will increase in 2.5º C in the same time period. Regarding changes projected in the annual mean precipitation, this report indicates a decrease over northern South America near the Caribbean coasts, as well as over large parts of northern Brazil, Chile and Patagonia, while it is projected an increase in Colombia, Ecuador and Peru, around the equator and in south-eastern South America. In this sense, global stocks of soil organic matter (SOM) acquire relevance because of their importance in the global carbon (C) cycle and potential feedbacks to climate change. Furthermore, present available data shows that an acceleration of the terrestrial C cycle will occur in response to global climate change (Bond-Lamberty and Thompson, 2010). These authors found that, between 1989 and 2008, the soil respiration (Rs) flux increased by 0.1 Pg C yr-1, which means a global Rs response to air temperature (Q10) of 1.5.

The temperature sensitivity of decomposition is related to inherent kinetic properties based on molecular structure and environmental temperature, usually described by Arrhenius functions, although another exponential function can also be used to relate the temperature dependence of Rs. The Carbon-Quality-Hypothesis (CQT) predicts that the temperature sensitivity of microbial decomposition should increase with increasing activation energy (Ea) of a reaction (e.g. oxidation of SOM). Thus, recalcitrant substrates (e.g. those that require a high Ea for their decomposition), should usually be more sensitive to changes in temperature than more labile substrates (Craine et al., 2010). However, lack of consensus exists on the temperature sensitivity of labile and recalcitrant fractions of SOM decomposition. For that, thirty seven sites (under natural prairie) were sampled from Arid-Semiarid, Mediterranean Arid, Mediterranean Humid, Humid and Magallanian soil zones of Chile (30 to 53°SL and 69 to 74°WL); according to criteria as different soil moisture regimes (aridic, ustic, xeric, udic and perudic), and soil temperature regimes (thermic, isothermic, mesic, isomesic and cryic). To investigate temperature sensitivity of SOM decomposition, through differences in the Ea, soil samples were long-term incubated (365 days), using 20ºC as basal temperature. Previously, the soil samples were conditioned at 60% WFPS (water filled pore space) and pre-incubated by 5-days. The incubation experiment followed the approach described by Craine et al. (2010). At different time periods they are shifted to temperatures at 10, 15, 20, 25 and 30°C. Then, soils are incubated for 72 h and Rs rates determined by removing 4 mL of gas using an infrared gas analyzer (Licor-820). Preliminary results shown a different Ea among soils although a low correlation (R2 = 0.31) between total C and Ea was observed. Advances of this research will allow to know which C pools are decomposed in soils (Andisols, Aridisols, Inceptisols, Alfisols, Mollisols, Entisols, and Ultisols) associated to different climate along Chile. Alterations in temperature sensitivity of SOC decomposition will be produced by different proportions of labile and recalcitrant pools of C. Statement that will be tested with data being processed.

We acknowledge to FONDECYT 1121138 for funding.

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Keywords: *global warming, lability index, soil respiration*

P1-575

[C4.1-3] Soil Ecosystem under Climate Change

Effect of Climatic Conditions on Physico-Chemical Properties of Soil from Panvel and Pune District Of Maharashtra, India

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Soil, a natural dynamic body which develops as a result of pedogenic processes that takes place during and after weathering of rocks and minerals in which plants and other forms of life able to grow. Soil on which plants depends for their nutrients, water and minerals supply. Soil types are a major factor in determining what types of plants will grow in a certain area. The present study deals with the analysis of the soil samples from Panvel region and Pune region. In Panvel region the samples from Poyange Village has been analyzed for their Physical and Chemical properties where the Rice is major crop. Whereas in Pune region soil samples from villages viz. Manjari, Hadapsar where sugarcane is major crop and from Phursungi area located south east of Pune city where there is disposal of solid waste of city as well as industrial activity plays important role in soil pollution has been collected for analysis of physico-chemical properties. The representative soil samples were collected from both the region and analyzed for macro as well as micro elements such as pH, E.C., %C, P, K, Cu, Zn, Fe, Mn. The study shows that the content of microelements in the increasing order of the Zn<Cu< Mn <Fe in panvel region where higher rainfall is received. The concentration of Copper, Manganese and Iron are found higher than normal range whereas Zn is within the normal range in high rainfall area. Pune region where rainfall is lower than the average shows higher concentration of P , K , Cu, Fe, Mn and Zn because most of the farmers from this area are using excessive dose of inorganic fertilizers which leads soil pollution and due to heavy soils the drainage condition is poor which leads the soil becoming saline and sodic in condition. Due to laterite soils the concentration of Fe and Mn in Panvel region is in higher side showing acidic soil condition than the Pune region which having sodic or saline or saline sodic soils. The present study deals with the effect of rain fall pattern, temperature variation, humidity change and drainage condition of two regions on soil formation processes, physic-chemical properties of soil in both the region.

Keywords：*Climatic parameters, representative Soil sampling, Soil analysis, Pune and Panvel region.*

P1-576

[C4.1-3] Soil Ecosystem under Climate Change

Effect of Various Organic Mulches on Soil Enzymes

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Mulching is a sustainable agricultural practice which has been shown to improve soil productivity and soil fertility substantially by positively affecting soil physical, chemical and biological, and biochemical properties. The practice of mulching has particular significance in the context of climate change, which is predicted to result in higher temperatures, reduced precipitation and increased probability of droughts. Small Island Developing States (SIDS) such as the Republic of Mauritius are particularly vulnerable to climate variability and climate change related impacts.

In this study, three organic mulches, namely banana leaves, vetiver leaves, and coconut leaves were surface applied to a Typic Haplustox soil at rates of 10, 20, 40 t/ha (dry weight) in a replicated randomised block design. The activity of the following enzymes was monitored : nitrogenase, phosphatae and urease.
Soil enzymes respond to changes in soil management more quickly than do other soil parameters and are therefore useful as early indicators of biological change and thereby soil fertility. Soil enzyme activity usually shows seasonal variation and is also dependent on other soil properties. Urease catalyses hydrolysis of urea into carbon dioxide and ammonia; nitrogenase is used by micro-organisms for atmospheric nitrogen fixation. It was found that application of organic mulches increased nitrogenase by 20%, phosphatase by 32% and urease by 12% in the 40t/ha banana mulch treated plots. Increased activity of these enzymes was also noted for the other two mulches, although at lower levels as compared to the banana mulch.
Furthermore, all enzyme activity was more or less proportionately increased by application rates of the three mulches. The study showed that soil fertility and productivity resulting from application of mulches also involves the contribution of enzymes, and can be monitored through enzyme activity. The increase in enzyme activity was the result of an improvement in the soil environment (such as soil temperature and soil moisture) due to increase in microbial populations following application of organic mulches.

Estimation of the enzyme activity represents a simple tool to evaluate temporal changes in soil fertility resulting from application of organic mulches.

Keywords：*mulching, soil enzymes, soil properties, climate change*

P1-577

[C4.1-3] Soil Ecosystem under Climate Change

The Effects of Fertilization on CO_2 Emissions from Peat Soils in Riau, Indonesia

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The conversion of peatlands to agricultural uses has several consequences, such as subsidence and the application of fertilizers and ameliorants. Appropriate management of drainage and fertilization should increase production and maintain the soil condition. However, in case of peat soil, emission factors should be considered. Concerns have been raised regarding increased CO2 emissions due to fertilization. Unfortunately, the effects of fertilizers on GHG emissions are not fully understood. The evidence on the effect of fertilization on CO2 emissions from peat soils is also rare and often inconsistence.

We measured the effects of different types of fertilizer, including N, P and K sources, and clay as an ameliorant on CO2 flux from a bare peat soil in Lubuk Ogong, Riau Province. The study sites are located between latitudes 0°44'52.0" N and longitudes 101°41'10.9" E. This area has an annual rainfall of 2,500 -3,000 mm and daily temperatures between 22-31°C. The peat maturity in the surficial soil (0-50 cm depth) was sapric, whereas hemic (50-100 cm) and fibric (100-150 cm) peats were present in the deeper. The observation area comprised 24, 2 m x 2 m plots with 4 replicates for each treatment. Nutrients were added in the following combinations: 0 (unfertilized plot), N, slow-release N, NP, NPK and NPK-Clay. CO2 flux were monitored using a Li-COR 820 portable infrared gas analyzer (IRGA). The water table depth, soil temperature and soil water content were measured at each measurement time point. Additional parameters were also observed, including the soil pH, peat maturity, organic C content, bulk density and other soil chemical properties of peat soil. The standard observations were conducted at all 24 plots for a period of approximately 6 months.

The results of the present study showed that the application of individual and combined treatments of N, P, K and NPK mixed with 5 t ha-1 clay led to significantly reduced CO2 flux from bare peat soil in Lubuk Ogong, Riau Province. After fertilization, the relative levels of CO2 emissions were as follows: Urea SL> Urea> NPK> NP> NPKClay. However, large variations in the levels of CO2 emissions were recorded during the experiment. Covariance analyses showed that the difference in CO2 emissions prior to treatment was not significant. In addition to fertilization, the water table depth was the only parameter that significantly affected the CO2 emissions ($P<0.05$). We conclude that the application of nutrient combinations, including N, P, K and clay, could reduce CO2 emissions because these treatments maintain a balanced nutritional condition in the soil with respect to the microbial activity. Combined fertilization, which included N, P, K and clay, maintained a balance in the soils, including the pH, the loss of ammonium to the air, decomposition processes, soil respiration, and other factors controlling peat soil reactions that are responsible for reducing CO2 emissions.

Keywords：*Key words: CO2 emission, fertilizer application, tropical peat soil*

P1-578

[C4.1-3] Soil Ecosystem under Climate Change

Effects of Elevated CO_2 on Soil Properties and Residue Decomposition

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Atmospheric carbon dioxide (CO_2) concentrations in Australia are expected to double by the year 2050. Changes in the amount and quality of soil organic matter inputs (plant growth; biomass partitioning; carbon:nitrogen ratio) and the mineralisation of soil organic matter and added residues are likely to significantly affect carbon and nitrogen cycling and overall soil fertility. In 2013, two experiments were conducted using soils collected from the free-air carbon dioxide enrichment (SoilFACE) facility, Horsham, Australia. Mesocosms at this site, containing three major cropping soils of south-eastern Australia (Vertosol, Dermosol and Calcarosol) were exposed to either elevated CO_2 (eCO_2; 550 ppm) or ambient CO_2 (aCO_2; 370 ppm) for up to 5 years. The current paper presents (a) soil chemical and biological properties of surface soil (0-5 and 5-10 cm) from mesocosms under a pulse-wheat-pulse-canola rotation and (b) a laboratory incubation study which examined the effect of previous exposure of soils to either eCO_2 or aCO_2 concentrations on the decomposition of dual-labelled ($^{13}C/^{15}N$) wheat and field pea residues.

Keywords：*Elevated CO_2, carbon and nitrogen cycling, residue decomposition*

P1-579

[C4.1-3] Soil Ecosystem under Climate Change

Integrated Soil Fertility Management Strategies for Climate Change Adaptation in Africa

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Because over 80% of smallholder farmers in sub-Saharan Africa rely entirely on rain fed agriculture, ISFM could facilitate adaptation to climate change by improving water and nutrient supply and use efficiency leading to improved crop yields, food security and household incomes. For while the maize pigeon pea for in Kondoa declined by 50% as a result of drought, the yield from maize + pigeon pea intercrop + Minjingu fertilizer and maize + pigeon pea + DAP fertilizer declined by less than 20%. Drought notwithstanding, the food produced under maize pigeon-pea intercrop was sufficient to meet annual food requirement for average household of 5.5 persons and leave a surplus for sale or storage as a security for future. In another case, across 5 countries soybean yield in 20 kg p ha-1 was more than double the yield from farmer practice. By advancing this ISFM further through inoculation of soybean seeds, soybean yields from 20 kg P ha-1 + innoculum plots increased relative to those of 20 kg ha-1 only plots by between 0.6 and 1 ton ha-1. As the market value of soybean is good, this translated to additional benefits of between US$ 250 and US$ 450. These type of financial gains are very crucial adaptation mechanisms for poor African households majority of whom live on less than US$ 2 per day as it could provide means for accessing food from the markets during bad seasons. Similar results have been observed for other legumes and maize under scenarios of with and without fertilizers. In a third case, inclusion of fast growing agro-forestry species in arable steep landscapes of central Kenya reduced soil erosion losses from 200 tons ha-1yr-1 to less than 100 tons ha-1yr-1 leading to significant savings N, P and K and better maize crop yields over a 3 years period. The annual tangible net benefits of these systems were estimated at between US$ 1000 and 1600 ha-1. In this study we shall highlight these and many other cases to showcase the success stories of adaptation to climate change through ISFM interventions in SSA. The situation of requirements for widespread adoption of these climate adaptation strategies which include; access to inputs, availability of output markets, extension services, finances and the key ongoing initiatives will also be discussed. We conclude by justifying a need for climate change consortia for Africa, bringing together all the key stakeholders in agriculture to develop clear strategies for improving understanding and widespread use of sustainable land production systems with a capacity for improving mitigation and adaptation to climate change.

Keywords：*Africa, Integrated Soil Fertility Management, Climate change*

P1-580

[C4.1-3] Soil Ecosystem under Climate Change

Germinated Oil Palm (elaeis Guineensis Jacq.) Seedlings Responses towards Gibberellic Acid (ga3) Treatment Under Glasshouse Condition

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Introduction

Oil palm (Elaeis guineensis Jacq.) is the highest oil bearing crops at the present (Corley and Tinker, 2003). Today, 4.49 million hectares of land in Malaysia is under oil palm cultivation; producing 17.73 million tonnes of palm oil and 2.13 tonnes of palm kernel oil (MPOB, 2011). In addition, the demand for palm oil is expected to increase in the future as the world population increase (Thuc et al., 2010).These vast areas under oil palm cultivation are dominated with palms more than 20 years old and this requires replanting and deals with high supply of oil palm planting materials. However, oil palm seedlings takes long time to be ready before it can be transferred to the field (13-15 months after open stage nursery establishment) to ensure good field growth for low mortality rate. Prior to nursery stage, pre- germinated seedlings will take additional 3 months. The use of external stimuli e.g. plant hormones can enhance the growth and development of the plant (Sawan et al., 1993: Voesenek et al., 1996: Mostafa and Salleh, 2006: Mir et al., 2010) thus, can reduce the time in nurseries. The application of one of plant hormone such as Gibberellin might reduce juvenility of the oil palm seedlings. Previous research have found the use of Gibberellin have successfully enhanced plant development, including seed germination, shoot growth, flowering, and fruit expansion (Bhattacharya et al., 2009). This present study was performed in order to investigate the growth performance of germinated oil palm (Elaeis guineensis Jacq.) seedlings using four concentrations of GA3 (0, 30, 50 and 70 ppm). This study might be the first study of the application of GA3 on the growth of oil palm seedlings.

Materials and Methods

Healthy and uniform oil palm (Elaeis guineensis Jacq.) seedlings Deli Yangambi of similar age (2 months old) were purchased from FELDA Agricultural Services Sdn. Bhd, Sg. Tekam and chosen for treatment. When the plant aged 3 months old, they were transferred into poly-bags containing media mixture of topsoil and sand (3:1v/v). The GA3 was applied using foliar spray with four different levels of Gibberellic Acid (GA3) i.e 0ppm (control), 30ppm, 50ppm and 70ppm) and were grown under glasshouse condition at Ladang 2, Universiti Putra Malaysia, Serdang. The microclimate of the greenhouse was temperature (27.84°C-41.52°C), relative humidity (41.62%-72.87%) and light intensity (42.30%-74.08%). After 1 month of acclimatization, treatment was performed by spraying two times per shoots at every 15 days interval. During the course of the experiment, normal cultural practices were carried out. The oil palm plants were harvested after 2 weeks interval. During the harvest date, the variables that were taken into account for this experiment were growth performance which includes plant height (cm)(ruler and tape), total chlorophyll content (SPAD-502, Minolta), Fv/Fm ratio and F0 value (Chlorophyll Fluorometer- Handy Pea), leaf area (cm^2) (Leaf Area Meter), total root length (cm^2), root surface area (cm^2), root average diameter (mm), root volume (cm^3)(All root parameters measured using – Root Scanner-Rhyzo, . Single factor experiment was arranged in a randomized complete block design (RCBD)

with four treatments and three replications. Analysis were conducted using statistical software package (SAS version 9.2) and Analysis of Variance (ANOVA) were done to determine the treatment means and means were compared by using Tukey's Multiple tests at 0.05 level of probability.

Generally, the application of GA was found to improve the growth of oil palm seedlings. It was found that GA have statistically ($P \leq 0.05$) influenced the plant height, leaf area, root length, root volume, root diameter and total chlorophyll content. From table 1, it was observed that the application of GA3 ≤50 mg/L can enhance the aboveground growth of oil palm seedlings. This was shown by enhanced plant height and leaf area upon application ≤50 mg/L. Similar result was also observed by Monselise and Halevy (1962), where they found that high application of GA3 can reduce the leaf growth. However application of GA3 ≥50 mg/L was found to enhance the belowground growth. Oil palm seedlings that were sprayed with 70 mg/L GA was found to obtain the highest root length, root volume and root diameter. For Total Chlorophyll Content, the application of 30 mg/L GA3 resulted in higher content of chlorophyll compared to other treatment. These results is confirmed by MaCubin (1957) that application of 50 mg/L of GA3 compared to 10 mg/L produced longest stem in cauliflower, lettuce and cabbage. So it can be concluded that application of ≤ 50 mg/L GA3 can enhanced the shoot growth and application ≥50 mg/L can enhanced the root development of oil palm seedlings.

The frond of palm is an important source of a successful photochemical process as a main photosynthetic organ (Clement, 1983). Analysis data shown in Table 2 indicates application of GA3 significantly influence the efficiency of photosystem II (Fv/Fm) ratio. Application of 30 mg/L GA3, resulted in increased of Fv/Fm ratio which is in line with experiment conducted by Ouzounidou et. al (2010) on green pepper plants. With high Fv/Fm ratio, plant efficiency in using light energy for photochemical process is in favoured. This data indicate that enhancement of photosystem II is due to high total chlorophyll content under application of 30 mg/L of GA3. The increase in Fv/Fm ratio under high chlorophyll content might indicate higher distribution of PSII 680 antenna. However, with application of ≥70 mg/L of GA3, minimum fluorescence (F0) value is increased which is a sign of plant stress as compared with ≥30 mg/L GA3.

Conclusion

In conclusion, application of GA3 had a significant effect on the growth performance of germinated oil palm seedlings. Different concentration responds variedly within the variables. It can be suggested that by spraying the right amount of GA3 concentrations could possibly enhanced the growth of oil palm seedlings.

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Keywords：*plant growth regulators, oil palm, gibberellic acid*

P1-581

[C4.1-3] Soil Ecosystem under Climate Change

Soil Fluxes of Carbonyl Sulfide (cos) and Carbon Dioxide (co2) in a Tropical Forest Ecosystem

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The response of tropical forests to changes in climate, atmospheric composition, and other anthropogenic stressors can have significant effects on atmospheric greenhouse gases, the regional energy balance, and global biodiversity. Soil microbial communities and their associated enzymes play a dominant role in tropical carbon fluxes. They act as catalysts of biogeochemical cycles by converting organic material to inorganic substances. Tracers such as carbonyl sulfide (COS) provide tools to study the mechanisms underlying plant and soil gas exchange. COS is an atmospheric trace gas that participates in some key processes of the carbon cycle. Specifically, COS is consumed inside leaf cells by the enzyme carbonic anhydrase (CA). As CA is also active in many soils, soils are generally considered a sink for COS. However, the lack of systematic field measurements of soil COS fluxes limits our ability to develop process-based models for use at ecosystem to global scales. Here we present the first dataset of soil COS and CO2 fluxes in a tropical forest ecosystem. We installed three soil chambers along a soil moisture gradient at La Selva Biological Station, Costa Rica. We observed both the largest COS uptake and the largest CO2 emissions at the lowest soil moisture. The smallest COS uptake fluxes and smallest CO2 emissions were found at intermediate soil moisture but higher soil temperatures. This pattern is consistent with diffusion limitation at higher soil moisture combined with a temperature optimum curve for enzymatic activity. We also measured the structure of the soil microbial communities as well as the enzyme activity at each of the landscape positions. This links the soil COS uptake and CO2 emissions to the biological parameters underlying the fluxes. The environmental variables and biological characterization are implemented in a soil gas exchange model to improve our understanding of microbial dynamics and carbon cycling in tropical forest soils.

Keywords：*Soil carbonyl sulfide fluxes, Soil carbon dioxyde fluxes, Climate change, Tropical forest ecosystem, Carbonic anhydrase, Microbial communities structures*

P1-582

[C4.1-3] Soil Ecosystem under Climate Change

Increased CO2 and Temperature Effects on Soil Water Balances Under Maize and Potato

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The carbon dioxide concentration of the atmosphere and average global temperatures have been rising over the past decades and are projected to continue to rise in the future. Potential plant growth is defined by particular ranges of environmental variables including temperature, irradiance and CO2. Furthermore, potential and actual transpiration in crops are dependent on both plant and environmental properties. High CO2 values in the atmosphere reduce transpiration rates because leaf stomata do not have to stay open relative to lower CO2 concentrations. High temperatures increase the development and senescence rates of plants thus reducing the growing period length. High temperatures can also result in increased potential transpiration rates. Global climate change in the form of increased CO2 and temperature potentially impact water uptake from the soil relative to conditions of historic temperature and CO2. The objective of this study is to use experimental results and simulation models to assess the interactive effects of CO2 and temperature on the soil water balance for two crops, Maize, (Zea mays L., a C4 crop) and Potato (Solanum tuberosum L., a C3 crop) in Maryland, U.S. The experimental data come from several experiments in outdoor, sunlit growth chambers at the USDA-ARS Beltsville Agricultural Research Center in Bletsville, MD, U.S. Different experiments utilizing maize and potato were carried out over a number of years with different levels of carbon dioxide concentrations (400 and 800 ppm) and water stress (well-watered control, mild, moderate, and severe). The water stress treatments were applied at both CO2 levels. Water contents were monitored hourly by a Time Domain Reflectometry (TDR) system and transpiration calculated from condensate collected from the cooling coils. The experiments demonstrated that water use efficiency increased under elevated CO2, especially under well watered conditions. The CO2 effect decreased as water stress increased in corn but increased in potato. High temperatures decreased the growing period of both crops. Although soil water content at harvest was lower under high temperature vs normal, soil water content was higher in the elevated temperature simulations by the end of October. This was due to the soil being bare for a longer period of time in the high temperature scenario. This higher soil water content contributes to greater leaching of nitrogen to ground water via fall rains. Elevated CO2 also resulted in higher soil water contents at the end of the season under irrigated conditions. Measurement of water uptake by roots and carbon assimilation rates in the chambers will be addressed.

P1-583

[C4.1-3] Soil Ecosystem under Climate Change

Warmer Atmospheric Temperature Enhances Microbial Activity to Facilitate the Rate of Organic C Mineralization in Soil Of North-Eastern India

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Soil microorganisms might be used as bio-indicators to the changes in soil properties. In this study, a future atmospheric condition was generated in an open-top chamber (OTC) by injecting additional 20 ppm CO2 concentration to maintain 1.8oC higher temperature than the ambient. Soil microbial biomass and activity were increased under OTC condition. OTC soils also recorded higher dissolved organic C content due to higher activity and metabolic quotient of soil microorganisms. Microbial community structure was also changed under warmer atmospheric condition. Comparatively higher abundance of some specific group of microorganisms namely fungi, denitrifying bacteria etc. were observed. Therefore, global warming has potential to facilitate organic C mineralization and C-loss by hastening microbial activity in tea soils of North East India.

Keywords：*atmospheric CO2 level; soil microbial activity; soil organic C; C-loss.*

P1-584

[C4.1-3] Soil Ecosystem under Climate Change

The Impact of Increasing Temperature on Carbon Dynamics in the Antarctic Soil

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Increasing temperature may enhance the microbial activity in the Antarctic soil and effect on the microbial degradation of soil organic carbon and carbon dynamics in the soil system. The objectives of this study were ⅰ) to evaluate the soil respiration and the loss of soil carbon in response to temperature change and ⅱ) to predict the change of soil respiration by the increasing temperature. Three PTFE bottles, filled with 10 cm of the composite sample of the Antarctic soils on the sterilized sand, were incubated in aerobic condition at different temperature ranges (274.1 ± 1.9 K, 278.4 ± 0.7 K, and 280.8 ± 0.7 K) for 11 days. The concentration of carbon dioxide (CO2) was measured every 1 minute during the incubation. Total organic carbon (TOC) of the control sample and incubated samples was measured by walkley-black method. Also, β-glucosidase activity and dehydrogenase activity in the control and incubated samples were measured after incubation. At the highest temperature range (290.8 ± 0.7 K), the cumulative carbon production by soil respiration was the largest, more than 4 times of the other temperature ranges. Especially, in the overlapped temperature range (278.2 ~ 280.2 K), the soil respiration showed the difference between the three temperature ranges. The loss percent of TOC was 3.4 % at the lowest temperature range (274.1 ± 1.9 K), while the loss percent of TOC at the highest temperature range (280.8 ± 0.7 K) was 44.3 %. The carbon production and loss showed a good correlation (r2 = 0.9972). β-glucosidase and dehydrogenase activities were increased when the temperature increases. Also, the relationship between soil respiration (R) and temperature (T) for the experimental data was fitted well by the equation, R = 6.02×10-69e0.574T (r2 = 0.9949). These results suggest that increasing temperature promotes the microbial degradation of soil organic matter, which will subsequently increase the flux of CO2 from the Antarctic soil.

Keywords：*Antarctic soil, Carbon dynamics, Increasing temperature*

P1-585

[C4.1-3] Soil Ecosystem under Climate Change

Temporal Change in Soil Carbon Dynamics under Pinus Koraiensis and Quercus Acutissima Forest Floors

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It is very difficult to investigate the changes in the amount and capacity of soil carbon sequestration in forest floor soils, since climatic factors influence soil carbon sequestration dynamics. We investigated the influence of temperature on the changes in the amount of soil carbon stocks and the δ13C in forest soils under two contrasting tree species. Nut pine trees (Pinus koraiensis) and Silk worm oak trees (Quercus acutissima) were chosen for comparison during the periods from 2009 to 2013. To do so, we selected two experimental forest sites located at different latitudes to compare the effect of temperature under global warming scenarios: Mt. Baekun (annual mean air temperature = 14°C, latitude = 35°01′N) and Mt. Taehwa (annual mean air temperature = 11°C, latitude = 37°18′N). Soil profile samples were collected at 20 cm depth intervals from the soil surface to 80 cm depth, and then were analyzed for total carbon concentration and the corresponding δ13C values. Irrespective of tree species, total carbon concentration decreased with depth, while their corresponding δ13C values increased. Overall, soil carbon stocks increased during the experimental periods. Total carbon concentration was higher in Mt. Baekun than in Mt. Taehwa, while the reverse was observed for δ13C value. Changes in natural 13C abundance of total soil carbon profile showed that leaf litter C penetrated deeper with time as a result of 13C isotope mixing. However, long-term analysis and interpretation should be required to fully understand soil C dynamics in relation to the effect of leaf litter input.

Keywords：*Carbon Dynamics, Forest Soil, Stable Isotope*

P1-586

[C4.1-3] Soil Ecosystem under Climate Change

Effects of Soil Temperature and Aging Time on the Toxicity of Glyphosate to Two Collembolan Species

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Climate change is a global phenomenon and is expected to alter interaction between organism and toxic compound. A greater metabolic activity at the higher temperature results in an increase in the rate of uptake and degradation of toxic compound. Therefore, the research of temperature effect on toxicity is needed to understand the change of toxic effect under climate change.

Glyphosate-based herbicides are one of the most widely used pesticides in the world and have been known to be easily degraded by microorganisms in soil. Many studies concern the effect on non-target species. In this regards, the response of Paronychiurus kimi and Paranura rosea (Collembola) to glyphosate-based herbicide (Geunsami™) were evaluated at different temperatures (20℃, 25℃) and aging time (7, 15 days). Survived adults and hatched juveniles were counted after 28-day exposures in artificial soil spiked with 0.1, 0.5, 1, 5, 50 mg/kg of herbicide in different temperature conditions. In addition, soils spiked with herbicide were tested after 7, 15 days to confirm aging effect.

The toxicity results were different in each temperature and aging time. This result shows that soil temperature and aging time affect the response of two Collembolan species and degradation of herbicides.

Keywords：*Artificial soil, Climate change, Glyphosate-based herbicide*

P1-587

[C4.1-3] Soil Ecosystem under Climate Change

Assessment of Soil Carbon Stock Change on Cut-Slope

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Background and Significance

Recently, the role of soil carbon is highly interested by researchers since Soil Organic Carbon (SOC) could be one of the stepping stones for mitigating and adapting to the climate change. However, the rapid development of the urban area causes loss of soil, fragmentation of natural vegetation and other adverse impact on soil. Even though people know that the preservation of natural ecosystem itself is the best way to protect natural soil, we face space shortage, need for development for better life. Therefore, there are need for of artificial environment to natural ecosystem.

In these context, the slope area is one of the common sector that tries to restore original ecosystem for many reasons such as stability of slope, aesthetic appreciation and so on. There were several researches on the biotechnical stabilization of the slope area. But the researches which consider the slope area as a carbon sink is very few. Thus, in this study, we monitored the biotechnical stabilization slope by using JSB technique to assess the possibility of the carbon sink both vegetation and soil.

Methods

We selected 7 sites for monitoring and collected 2 samples on each plot. All sites are restored by JSB technique from 2002 to 2007. We analyzed bulk density, soil organic matter, and Cat ion Exchange Capacity (CEC) and soil pH for measuring the physical and chemical properties of soil. And also we collected vegetation data for each plot (1m x 1m) for measuring characteristics of plot.

Result and Discussion

The Soil Organic Matter (OM) decreases as time passes. Organic matter in Korean soil is typically less than 5%. But the base material that we used for restoration is about 27% which is excessively higher than normal condition. So it seems natural that the organic matters in soil decreased by the vegetation, wind and micro bacteria. When we consider the vegetation the restoration site, the organic carbon increases as the time goes, which means the organic matter in soil was transferred to the growth of vegetation community.

We monitored the slope restoration site for analyzing the possibility of carbon sink. We found the loss of soil organic carbon in restored slope. But the vegetation played significant role in carbon stock in slope area. So it is necessary to make proper restoration methods for better vegetation and soil.

Keywords：*biothechnical stabilization, slope revegetation, soil organic carbon, carbon stock*

P1-588

[C4.1-3] Soil Ecosystem under Climate Change

Abiotic Stress on Photosynthetic Machinery in C4 Plants: Insights from Sorghum Chloroplast Proteomics

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C4 plants proclaim much higher CO2 assimilation rates than C3 plants under certain conditions. Sorghum (Sorghum bicolor) is an important crop and model with C4 photosynthetic machinery. Heavy metal (HM) toxicity is thought to be one of the major abiotic stresses leading to hazardous effects in plants. The contamination of heavy metal in water bodies is increasing at an alarming rate due to industrial and anthropogenic activities. Heavy metals cannot be degraded, and therefore are persistent. However, chloroplasts are organelles whose main role is to conduct photosynthesis. Chloroplasts also participate in the biosynthesis of amino acid, vitamin, isoprenoid, and lipid, as well as reduction of nitrite and sulfate. The proteome of plastid, and in particular of chloroplast, have received significant amounts of attention in recent years. 2DE and high-throughput quantitative proteomics approaches have been employed to investigate sorghum chloroplast structure and function. These proteomics studies have provided valuable information on C4 chloroplast protein components, photosynthesis, and other metabolic mechanisms underlying chloroplast biogenesis, stromal, and membrane differentiation, as well as response to abiotic stress. The present work helps understanding photosynthesis process in C4 plants at the molecular level and provides a new insight of the photosynthetic machinery of the chloroplast in sorghum.

Acknowledgement: This work was supported by grant from the Bio-Green 21 project (No. PJ009101012013) of the Rural Development Administration, Republic of Korea.

Keywords：*Abiotic stress; photosynthetic machinery; sub-cellular compartments; sorghum; proteomics*

P1-589

[C4.1-3] Soil Ecosystem under Climate Change

Characterization of Abiotic Stress Responsive Protein in Wheat Grain

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Abiotic stress is widely considered a detrimental effect; the research on this branch of the issue is extensive. Abiotic stresses usually cause protein dysfunction. The analysis of stress-responsiveness in plants is an important route to the discovery of genes conferring stress tolerance and their exercise in breeding programs. Responses to stress have been related to changes in protein composition at both quantitative and qualitative levels. Evaluation of two-dimensional electrophoresis gels revealed several proteins to be differentially expressed as a result of abiotic stress among cultivars. 217 protein spots of interest were, after an in-gel tryptic digestion, identified by using matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) mass spectrometry. Ten percent of abiotic stress responsive proteins were identified in cv. Keumgang followed by 7% in cv. Jinpum and cv. China-108, 12% in cv. Yeonnon-78, 31% in cv. Norin-61 and 33% in cv. Kantou-107 in our experiment. Of the total number of 575 identified proteins, 345 proteins were recognized as abiotic stress responses unique proteins with isoforms, of which 34% are induced by heat, 27% by drought, 15% by salt, 13% by cold and 11% by other environmental stress. Furthermore, elucidating the function of proteins expressed by genes in stress tolerant and susceptible plants will not only advance our understanding of plant adaptation and tolerance to environmental stresses, but also may provide important information for designing new strategies for crop improvement.

Acknowledgements: This work was supported by the BioGreen 21 Program (20070301034043), RDA, Korea

Keywords：*Abiotic stress; matrix-assisted laser desorption/ionization-time of flight; proteomics; wheat*

P1-590

[C4.1-3] Soil Ecosystem under Climate Change

Comparative Analysis of Biotic Stress-Responsive Proteins in Hexaploid Wheat

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It is a major focus of agricultural research, due to the vast economic losses caused by biotic stress to cash crops. To gain a better understanding of the biotic stress responses at molecular level in dry land cereal grains, wheat (Triticum aestivum L.), we carried out a comparative proteomic investigation and identification of the biotic stress responses proteins in different wheat cultivars as two Korean cvs. Keumgang, Jinpum; two Chinese cvs. China-108, Yennon-78 and two Japanese cvs. Norin-61, Kantou-107. Among 217 protein spots reproducibly detected from six gels, some were up regulated and few others were down regulated at least at one time. After tryptic digestion, MALDI-TOF/MS analysis and database searching of some of the identified proteins indicated that the proteins are known to be involved in several biotic stress related functions as disease associate with pathogens. Mass spectrometry analysis allowed the identification of 185 differential expressed proteins with isoforms including well known biotic stress responsive proteins. Keumgang (13%), Jinpum (8%), China-108 (14%), Yeonnon-67 (11%), Norin-61 (22%) and Kantou-107 (32%) were identified as biotic stress responses proteins directly coupled to disease and pathogen infection on wheat. Nevertheless, our studies provides new insights into identification of biotic stress responses protein by natural in wheat, studies the post-translational modification in protein sequences, verify eventual differences among the genotypes in relation to them, and demonstrates the advantages of proteomic analysis.

Acknowledgements: This work was supported by BioGreen 21 Program (20070301034043), RDA, Korea

Keywords：*Biotic stress; matrix-assisted laser desorption ionization-time of flight; proteomics; wheat*

P1-591

[C4.1-3] Soil Ecosystem under Climate Change

Evaluation of Flooding Tolerance of Soybean Cultivars and Analysis of the Tolerance Mechanism Using Proteomics Techniques

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Soybean (Glycine max L.) is sensitive to flooding stress and its yield is substantially reduced in response to the flooding stress. Higher plants are aerobic organisms that die when oxygen availability is limited due to soil flooding. Flooding is one of the unbearable environmental factors which spoil growth and yield in soybean plant in many areas of Japan and around the world. In this study, 132 soybean cultivars including Korean, Japanese and US cultivars were used to explore the flooding-tolerant cultivars. The seeds of soybean were germinated for 48 h and subjected to flooding stress for 120 h. After the flooding, soybeans were grown for 72 h. The growth characteristics such as growth rate during flooding, growth rate after flooding, survival rate, and damaged rate were investigated. Among the 132 cultivars, 8 cultivars were classified as tolerant (4 Korean cultivars), moderate tolerant (1 from US and another from Japan) and sensitive (1 from US and another from Japan). To investigate mechanisms responsible for their tolerance, difference in their proteomic changes was analyzed using gel-free proteomics techniques coupled with nano LC MS/MS. The comparative analysis showed that invertases were significantly decreased in response to flooding in tolerant cultivars (Korean), but those were not observed in moderate tolerant and sensitive cultivars. Additionally, enolases were significantly decreased in tolerant cultivars, but these were increased in the other cultivars. These results suggest that modulation of carbohydrate metabolisms may affect their flooding tolerance in soybean.

Acknowledgement: This work was partially supported by a Bilateral Joint Project between the Japan Society for the Promotion of Science and the National Research Foundation of Korea.

Keywords：*Soybean; flooding tolerance mechanism; growth characteristics; gel free proteomics*

P1-592

[C4.1-3] Soil Ecosystem under Climate Change

Metabolites Analysis in Wheat Root Under Salinity Stress

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Salinity stress is one of the most important abiotic stresses and severely impairs plant growth and production. Root is the first site for nutrient accumulation like as Na+ in plant. To investigate the response of wheat root under salinity stress, we executed the characterization of morphology and analysis of metabolites. Wheat seeds cv. Keumgang (Korean cultivar) were grown on the moist filter paper in petridish. After 5 days, seedlings were transferred in hydroponic apparatus at 1500 LUX light intensity, at 20ºC with 70% relative humidity in growth chamber. Seedlings (5-day-old) were exposed to 50mM, 75mM, 100mM NaCl for 5 days. Ten-day-old seedlings were used for morphological characterization and metabolite analysis. Root and leaf length became shorter in high NaCl concentration compared to following NaCl treatment. For confirmation of salt accumulation, wheat roots were stained with CoroNa+ Green AM, and fluoresce and image was taken by confocal microscopy. Na+ ion accumulation rate was higher at 100mM compared to the untreated sample. Furthermore, to analyze metabolites in wheat root, samples were extracted by D2O solvent, and extracted sample were analyzed by 1H NMR spectroscopy. Fourteen metabolites were identified in wheat roots using NMR spectroscopy. Methanol and ethanol were up-regulated, whereas formate, aspartate, aminobutyrate, acetate and valine were down-regulated under salinity stress on roots of wheat. Fumarate had no change, while glucose, betaine, choline, glutamate and lactate were unevenly affected during salinity stress.

Acknowledgements:
This work was supported by grant from the Bio-Green 21 project (No. PJ009101012013) of the Rural Development Administration, Republic of Korea.

Keywords： *Wheat; root; metabolites; salinity stress*

P1-593

[C4.1-3] Soil Ecosystem under Climate Change

Profiling of Mitochondrial Proteome in Wheat Roots

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Mitochondria are important organelles for cellular respiration within the eukaryotic cell and have many important functions including vitamin synthesis, amino acid metabolism and photorespiration. To investigate the mitochondrial proteome of the roots of wheat seedlings, a systematic and targeted analysis were carried out on the mitochondrial proteome from 15 day-old wheat seedling root material. Mitochondria were isolated by Percoll gradient centrifugation; and extracted proteins were separated and analyzed by Tricine SDS-PAGE along with LTQ-FTICR mass spectrometry. From the isolated the sample, 184 proteins were identified which is composed of 140 proteins as mitochondria and 44 proteins as other subcellular proteins that are predicted by freeware subcellular locator. The identified proteins in mitochondria were functionally classified into 12 classes using the ProtFun 2.2 server based on biological processes. Proteins were shown to be involved in amino acid biosynthesis (17.1%), biosynthesis of cofactors (6.4%), cell envelope (11.4%), central intermediary metabolism (10%), energy metabolism (20%), fatty acid metabolism (0.7%), purines and pyrimidines (5.7%), regulatory functions (0.7%), replication and transcription (1.4%), translation (22.1%), transport and binding (1.4%), and unknown (2.8%). These results indicate that many of the protein components present and functions of identified proteins are common to other profiles of mitochondrial proteomes performed to date. This dataset provides the first extensive picture, to our knowledge, of mitochondrial proteins from wheat roots.

Acknowledgments: This work was supported by a grant from the AGENDA (9069532012), RDA, Korea to S. H. Woo, College of Agriculture, Life and Environments, Chungbuk National University, Korea.

Keywords：*Mitochondrial proteins; wheat roots; SDS-PAGE; LTQ-FTICR; proteomics*

P1-594

[C4.1-3] Soil Ecosystem under Climate Change

Proteome Analysis of Roots of Wheat Seedlings Under Aluminum Stress

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The root apex is considered the first sites of Aluminum (Al) toxicity and the reduction in root biomass leads to poor uptake of water and nutrients. Aluminum is considered the most limiting factor for plant productivity in acidic soils. Aluminum is a light metal that makes up 7% of the earth's scab dissolving ionic forms. The inhibition of root growth is recognized as the primary effect of Al toxicity. Seeds of wheat cv. Keumkang were germinated on petridish for 5 days and then transferred to hydroponic apparatus which was treated without or with 100 μM and 150 μM AlCl3 for 5 days. The length of roots, shoots and fresh weight of wheat seedlings were decreased under aluminum stress. The concentration of K+, Mg2+ and Ca2+ were decreased whereas Al3+ and P2O5- concentration was increased under aluminum stress. Using confocal microscopy, the fluorescence intensity of aluminum increased with morin staining. A proteome analysis was performed to identify proteins, which are responsible to aluminum stress in wheat roots. Proteins were extracted from roots and separated by 2-DE. A total of 47 protein spots were detected under Al stress. However, among the 47 proteins, 19 proteins were significantly increased whereas 28 protein spots were significantly decreased. Our results highlight the importance and identification of stress and defense responsive proteins with morphological and physiological state under Al stress.

Acknowledgement: We obtained financial support for this study from the AGENDA (9069532012), RDA, Korea to S. H. Woo, College of Agriculture, Life and Environments, Chungbuk National University, Korea.

Keywords：*Aluminum stress; LTQ-FTICR-MS; proteomics; wheat root, 2-DE*

P1-595

[C4.1-3] Soil Ecosystem under Climate Change

Proteomics Analysis of the Wheat Chloroplast and Sub-Organeller Compartments: Isolation and Fractionation by Using Gradient Centrifugation

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Plastid proteomics are essential organelles present in virtually all cells in plants and green algae. Plastids are responsible for the synthesis and storage of key molecules required for the basic architecture and functions of plant cells. The proteome of plastid, and in particular of chloroplast, have received significant amounts of attention in recent years. Various fractionation and mass spectrometry (MS) techniques have been applied to catalogue the chloroplast proteome and its sub-organelles compartments. To provide the most exhaustive view of the protein repertoire of chloroplast and sub-organeller compartments, we isolation and fractioned this membrane system from fully developed wheat leaves using a combination of differential and gradient centrifugation such as small high speed refrigerated centrifuge and ultra-centrifuge. Then, we carried out the proteomic analysis of chloroplast and sub-organeller compartments in wheat by using tris-tricine one-dimensional-poly acrylamide gel electrophoresis (1D-PAGE), which is especially used for separating membrane proteins, shotgun mass spectrometry analysis (LCQ-DECA), followed by database searching. Finally, we will provide to profiling of the chloroplast sub-organeller, all nuclear coded proteins identified on the 1D-PAGE gels were used to test predictions for chloroplast localization and transit peptides, transmembranes made by using some bioinformatics programs such as ChloroP, PSORT, SignalP, TargetP, Predotar, Mitoport, PredSL and ARAMEMNON. After correcting to possible isoforms, all identified proteins will be modified by post-translational modifications by using dbPTM and sumoylation site prediction (SUMOsp). The present work helps understanding photosynthesis process in wheat at the molecular level and provides a new overview of the biochemical machinery of the chloroplast membranes in wheat.

Acknowledgement: BioGreen 21 Program (20070301034043), RDA, Korea (Republic of)

Keywords： *Wheat; chloroplast; sub-cellular compartments; proteomics*

P1-596

[C4.1-3] Soil Ecosystem under Climate Change

Effects of Added Organic Carbon and Increasing Temperature on Soil Respiration Rate

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Carbon cycle in ecosystems is considered to be significantly influenced by global warming. Soil in terrestrial ecosystem contains at least twice as much carbon as the atmosphere or vegetation. Therefore, decomposition of soil organic matter can considerably influence the global carbon balance. To investigate the effects of substrate type of organic carbon and increasing temperature on microbial decomposition, we conducted an incubation experiment using loam soil collected from two contrasting land use types with different soil organic matter composition: agricultural and forest plantation. Each single or mixture of organic substrates having different chemical compositions, sucrose and cellulose, was added to soils, and CO2 efflux from the soils was examined during incubating at 20 and 30°C during 19 days. Cumulative CO2 efflux for both soils during incubation was higher in sucrose treatments than cellulose treatments: 6.45±0.12 & 5.86±0.28 (agriculture & forest soils, respectively) and 2.60±0.01 & 2.31±0.33 g CO2 kg-1 for sucrose and cellulose treatments, respectively. However, an opposite result was observed for the ratio (Q10) between respirations rates at 20 and 30°C: 1.13±0.02 & 1.08±0.06 and 1.36±0.04 & 1.37±0.21 for sucrose and cellulose treatments, respectively. In case of soil added with mixture of sucrose and cellulose, cumulative respired-C (3.64±0.02 & 3.95±0.11 g CO2 kg-1) was between substrate and cellulose treatments. However, Q10 values had different patterns between agricultural and forest soils. Q10 ratio (1.36±0.04) in agricultural soil was not significantly different from that of cellulose treatment, but that (1.17±0.07) in forest soil was close to that of sucrose treatment, probably reflecting differences in microbial composition between agricultural and forest soils. From those results it was suggested that decomposition rate of recalcitrant organic carbon in soil is slower but would increase more with increasing temperature than that of labile organic carbon. Therefore, recalcitrant organic carbon would contribute more to an increase in soil respiration rate by global warming than labile organic carbon.

Keywords：*global warming, labile organic matter, recalcitrant organic matter, soil respiration rate*

P1-597

[C4.1-3] Soil Ecosystem under Climate Change

Intermittent Drainage Suppresses More Effectively Methane Emission in High Biomass Amended Paddy during Rice Cultivation

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Winter cover crop cultivation is recommended to improve soil carbon sequestration and quality. However, its biomass addition as a green manure can significantly increase methane (CH4) in rice paddy soil, and then soil management strategy which can effectively suppress CH4 emission should be developed. There are many soil management practices to reduce CH4 emission in rice paddy soil, but the intermittent drainage is regarded as a key soil management to reduce CH4 emission during rice cultivation. However, it is expected to increase significantly carbon di-oxide (CO2) emission, in particular under high biomass amended condition. In this study, the effect of a 30-day intermittent drainage from the 20th day after transplanting (DAT) to the 50th DAT on two greenhouse gas (GHG) fluxes and yield properties were compared with those of a continuous flooding system under different rates of cover crop biomass addition as a green manure during rice cultivation. The biomass of cover crop which cultivated during the fallow season on site was applied with the different rates (0-100%) of total biomass (12 Mg ha-1 on dried weight). Methane and CO2 gas samples were collected simultaneously twice a week by two different pairs of closed chamber. The one for CH4 sampling included rice plants inner the chamber, but the other for CO2 sampling excluded rice plants. The effect of intermittent drainage on changing two GHG emissions were compared using the GWP value which was calculated as CO2 equivalents by multiplying 25 to the seasonal CH4 flux. Methane and CO2 emission rates were significantly ($p<0.05$) increased with increasing application rates of cover crop biomass in both irrigation treatments. The intermittent drainage effectively reduced seasonal CH4 fluxes by ca. 51% to that of the continuous flooding under total biomass removal, but its effect was significantly increased under higher biomass application. The intermittent drainage reduced around 69% of total CH4 flux under total biomass recycling, but increased CO2 fluxes by 18-20% under the same levels of biomass addition. However, the intermittent drainage significantly reduced the total GWP value, and its effect significantly increased under higher biomass addition from 66% to 77%. The highest rice grain yield (53% increase over the control) was observed for 25% recycling, but its significantly ($p<0.05$) decreased with increasing cover crop application rates above 25% recycling ratio. However, there was no significant difference in terms of rice yield either in continuous flooding or intermittent irrigation under the same fertilization background. In conclusion, the intermittent drainage could be a good soil management strategy under high levels of biomass addition to reduce GWP value by suppressing effectively CH4 emission.

Keywords：*rice, paddy soil, CH4 emission, CO2 emission, water management*

P1-598

[C4.1-3] Soil Ecosystem under Climate Change

Importance of Rice Root Oxidation Potential as a Regulator of Ch4 Production under Waterlogged Conditions

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One of the most important characteristic of a rice cultivar controlling CH4 production can be the root oxidation potential because a cultivar with high oxygen (O2)-releasing capacity can create a root oxidized area in the rhizosphere soil and this can oxidize CH4 during rice cultivation. Root oxidation potential of six Korean rice cultivars grown in a minirhizotron was measured by the digital image analysis of the root oxidized areas and compared with the conventional method (root oxidase activity using α-napthylamine as a substrate). In addition, soil methanotrophic bacterial population (pmoA genes copy numbers) was characterized by qPCR to find out its relationship with the root oxidized area and root oxidase activity. Root oxidized area differed significantly among cultivars ($P<0.05$), but not the root oxidase activity. A significant negative correlation was found between root oxidized area and dissolved CH4-C concentration and mean CH4 emission rate while positively and significantly correlating with pmoA gene copy number, root volume and root biomass suggesting that a cultivar with high root oxidation potential using th e root oxidized area tend to produce less CH4 during the rice cultivation period. Moreover, characterization of the root oxidized area by digital image analysis may be an effective method to determine the root oxidation potential of a cultivar, which is an important physiological trait of rice plants for controlling CH4 production in paddy soil.

Keywords：*Rice cultivar; root oxidation potential; root oxidized area; root oxidase activity; paddy soil*

P1-599

[C4.1-3] Soil Ecosystem under Climate Change

Evaluation of Root Oxidizing Potential as a Regulator of Rice Root Iron Uptake Using Image Analysis

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In rice paddies, root oxidation potential by rice plants is an important physiological trait since it controls iron (Fe2+) toxicity by formation of Fe plaque in the root surface altogether facilitate root respiration and microbial activities in the soil-root rhizospheric zones. The objective of this study was to investigate the interaction between root oxidation potential and Fe uptake of different Korean rice (Oryza sativa L.) cultivars. The root-zone of different rice cultivars was monitored in a flooded paddy soil condition with the aid of a rhizotron experiment. Six cultivars (Chuchung, Dongjin, Ilmi, Junam, Nampyeong, and Samkwang) were transplanted in an acrylic rhizotron, (b) digital images of the root-zone were taken at the important growing stage, and (c) rice iron (Fe) uptake was simultaneously characterized. The images were processed by image analysis to display the reduction and oxidation areas in the soil, and the distinct areas which were colorized due to varying soil redox changes were localized and quantified. The aerenchymal transport of oxygen to rice roots significantly influenced the anaerobic root-zones of the flooded paddy soils. Visualization of redox dynamics may be useful to characterize rice root oxidation potentials and the dynamics of redox-influenced ions in the root-zone of paddy soils. Oxidized areas were mainly observed in the surrounding of active roots and in a distinct layer on the soil surface. The selected rice cultivars had significantly different root oxidized area at the same rice growing stage. Root oxidized area was significantly and positively correlated with total Fe content of rice root, but negatively correlated with the inner root Fe content. Rice cultivars having higher root oxidation potential precipitated more Fe with a Fe plaque form in the outer root surface. In conclusion, digital image analysis is an effective tool for evaluating the oxidizing potential of rice root under anaerobic soil condition.

Keywords：*digital image analysis, Fe uptake, paddy soil, root oxidized area*

P1-600

[C4.1-3] Soil Ecosystem under Climate Change

Combination of Methanogenesis and Microbial Respiration as a Scalar to Determine Microbial Biomass Activity in Waterlogged Soils

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Both aerobic and anaerobic microorganisms are exist in soil and have to be considered for measuring total microbial biomass, especially in case of anaerobic rice paddy soils. Substrate-induced respiration (SIR) procedure is generally measured by the responses of soil microbial biomass (MBC) to the addition of readily available carbonaceous substrates. However, anaerobic microbes like methanogens dominate in submerged rice paddy soils. These soils act as a source of methane (CH4) to the atmosphere. There are also other anaerobic microbes in addition to methanogens in the water-logged soils. However, this group of microorganisms was used as a scalar for them. Therefore, suitability of equation to evaluate MBC from SIR of the waterlogged soil like rice paddy soil is questionable. We developed a method to determine microbial biomass in the waterlogged soils by combining of anaerobic and aerobic microbial processes as a scalar for the microbial biomass. Potential methanogenesis was used to describe the anaerobic microbial community, while SIR is related to the aerobic microbes. The calibration of the method was based on the total microbial biomass determined by fumigation extraction (FE) method. Methanogens may contribute up to 14% of the total microbes in rice paddy soil. MBC of rice paddy was related to total C mineralization rather than substrate-induced microbial respiration (SMR). Microbial biomass carbon could be calculated using the following equation: MBC = kcf (1.956 MA + 0.710 SIR + 10.192), where kcf = 2.142 ± 0.337 (coefficient based on the calibration against FE), MA = potential methanogenesis and SIR = substrate induced respiration. The MBC had shown significantly positive correlation (r = 0.830*) with the total C loss potential or C mineralization potential (μg C loss g?1 soil d?1) of waterlogged soils. In conclusion, the activity of potential methanogenesis should be included to estimate more exactly total microbial activity in anaerobic soil like rice paddy.

Keywords : *Microbial biomass C, Methanogen activity, Microbial respiration, anaerobic soil*

P1-601

[C4.1-3] Soil Ecosystem under Climate Change

Effect of Plastic Film Mulching on Greenhouse Gases Emission in Cover Crop Amended Soil as a Green Manure During Corn Cultivation

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Plastic film mulching (PFM) as an agricultural management practice is used commonly to suppress weed growth, conserve soil moisture and increase crop production in upland soils, however, its effect on greenhouse gases (GHGs) emission has not been evaluated well. In order to investigate the effect of PFM on GHGs emission and crop productivity during corn cultivation, barley (Hordeum vulgare L.) and hairy vetch (Vicia villosa Roth) as cover crop were cultivated during the fallow season (cold season) without mulching, and the chopped above ground biomass of respective cover crops were mechanically incorporated within the surface layer (0-15 cm depth) as green manure in mid June 2012. The main treatments included mulching (PFM) and no-mulching, and investigated further using subtreatments barley (16.67 Mg ha-1 on a fresh weight base); hairy vetch (33.3 Mg ha-1 on a fresh weight base.); and NPK (N-P2O5-K2O=186-35-70 kg ha-1). Fifteen day old corn seedlings were transplanted at 50 cm x 40 cm planting distance. Regardless of soil amendment, PFM increased soil temperature and moisture content by mean of 2˚C and 0.04 m3 m-3 over the no-mulching during corn cultivation, respectively, and significantly increased GHGs emission such as CH4, CO2 and N2O. Plastic film mulching increased total global warming potential (GWP) by 21-40% over the no-mulching; calculated as CO2 equivalents by multiplying seasonal CH4, CO2 and N2O fluxes by 25, 1 and 298, respectively, mainly due to increased CO2 emissions. Plastic film mulching increased corn productivity ($P<0.05$), but the impact of GHGs emission expressed as the GWP per grain yield was much higher in the PFM than in no-mulching. In conclusion, PFM was effective on suppressing weeds growth and increasing corn productivity but can also significantly increase GHGs emission. Therefore, new mulching technologies that can decrease GHGs emission during cropping season would be required in soils with PFM.

Keywords：*plastic film, mulching, greenhouse gases, global warming potential, corn productivity*

P1-602

[C4.1-3] Soil Ecosystem under Climate Change

Comparison of Global Warming Potential Between Rice Paddy and Upland Soils during Cropping Season

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The emissions of carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) from agriculture together account for approximately one-fifth of the annual increase in radiative forcing of climate change. In particular, around 12 and 33% of anthropogenic CH4 and N2O are known to be emitted from rice paddy and upland soils during cropping season, respectively. However, the impact of these greenhouse gases (GHGs) emission on the global warming potential (GWP) was not compared well between rice paddy and upland soils during cropping season. In order to compare total GWP scale, which was calculated as CO2 equivalents by multiplying the seasonal GHG fluxes by 1, 25, and 298, respectively, between rice paddy and upland soils, the emission patterns of three major GHG (CO2, CH4 and N2O) were characterized in both soils under the same fertilizing condition like chemical fertilization (NPK), and two green manures (barley, and hairy vetch) without chemical fertilizer during cropping season. Rice and corn were cultivated in paddy and upland soils, respectively. The total GWP scale was 20-72% bigger in upland soil than that in rice paddy soil under the same fertilization during cropping season. However, total GWP scales were mainly affected by CO2 and CH4 flux in upland and paddy soil, respectively, which accounted for 94-98% and 46-80% of total GWP values. In comparison, the contribution of N2O emission to total GWP value was negligible in two different types of soil, irrespective with fertilization background. Green manure addition as an alternative of chemical fertilizer increased significantly total GWP scale irrespective with soil types, mainly due to significant increase of CO2, and CO2 and CH4 emissions in upland and paddy soils, respectively. In conclusion, soil management strategies which can effectively decrease CO2, and CH4 emissions in upland and paddy soil, respectively, should be developed.

Keywords: *greenhouse gas, global warming potential, paddy soil, upland soil*

P1-603

[C4.1-3] Soil Ecosystem under Climate Change

Effect of Temperature and Soil Properties on Collembola Communities in Korean Forest Soil

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Collembola are abundant terrestrial arthropods. They have ecological importance in soil ecosystem and high ecological relevance. Collembola have limited ability to regulate their body temperature and usually they have optimal temperature.

To assess the temperature change effects on Collembola communities, we selected 10 korean mountains in different latitudes. Top soil was collected and Collembola extracted from 3 sites in different elevation in each mountain. Extracted Collembola were sorted to family and this data were summarized as total abundance, family richness and species richness. Additionally, soil temperature in each plot, physical and chemical properties of the soil, and soil enzyme activities was investigated and that correlated with Collembola data.

Plot elevation correlated with soil temperature and this factor affected patterns in Collembola abundance and family richness. However two sampling site (Euisung and Sooncheon) showed low Collembola abundance because this site contaminated by heavy metals (Cd and As). The results indicate that temperature change and soil properties strongly affected Collembola communities. Therefore, Climate change has high potential to affect Collembola communities.

Keywords：: Climate change, Collembola, forest soil, temperature, soil properties

P2-1

[IDS3] Soil Information and Food Security

Growth Performance and Mineral Composition of Moringa Oleifera Seedlings as Influenced by Surface And Subsoil under Water Stress Conditions

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Different parts of Moringa oleifera plant are reportedly useful for nutrition, medicine, water purification and as raw material for the nutritional and pharmaceutical industries. It is however hypothesized that the growth of Moringa and the mineral composition of its shoot (leaf + stem) could be affected by the quality of the medium in which it is grown. Consequently, a factorial experiment involving three pre-determined soil depths of 0-15, 15-30 and 30-45 cm at four soil water levels, namely 100, 75, 50 and 25% field moisture capacity (FMC) was conducted in Ibadan, South western Nigeria. The objective was to investigate effect of surface and subsoil under different water stress conditions on the growth of Moringa and the mineral composition of its shoot. Results indicated that the total percent N and C, available P and exchangeable K, Mg and Ca contained in the soil samples were in the following order: 0-15>15-30>30-45 cm. Total porosity and soil available water followed similar trend. Positive correlation was found between the growth of Moringa seedlings and the available plant nutrients, total porosity and available water in the soil samples. The plants produced in the surface soil were statistically superior in height, stem girth, number of leaves and dry matter yield to those grown in the sub-soils irrespective of water- stress condition. At eight weeks after sowing (WAS), the fresh weight of plant shoot was 3.8, 2.6 and 2.0 g for 0-15, 15-30 and 30-45 cm soil depth respectively. Reduction in FMC from 100 to 50% did not significantly affect growth performance of Moringa at the three soil depths but water reduction below this range appeared to be detrimental to the growth of the plant. Moringa seedlings planted in surface soil produced stems and leaves richer in Ca, Mg, K, Fe, Cu and Zn than those in the remaining subsoil depths.

Keywords：*Soil depth, Water stress, Moringa, Mineral composition*

P2-2

[IDS3] Soil Information and Food Security

Screening of Ten Rice Genotypes for Zn Efficiency by Using Solution Culture

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Key words: screening, rice genotypes, Zn efficiency, solution culture

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Zinc nutrition is very sensitive to rice crop and can be reduced yield up to 40% with out showing any visible symptom. A glass house experiment was conducted to evaluate Zn efficiency of ten (Kadaria, MR 219, MR220, MR211, Bhagia, Seri Malaysia Dua, MR 185, MR 106, MRQ 74 and Jaya) rice genotypes for Zn efficiency and inefficiency by using solution culture technique with modified Yoshida's rice culture solution as nutrient medium. The experiment was laid out in spilt plot design. Ten rice genotypes were raised with three Zn treatments (Zn 0.007, 0.035, and 3.5 mg L-1), replicated six times and maintained for 44 days. Zn efficiency of each genotype was determined according to formula (dry matter yield at Zn-deficient level/dry matter yield at Zn-sufficient level) x 100. Rice genotypes were ranked according to their Zn efficiency. Seri Malaysia Dua,MR106, Kadaria were found most Zn efficient,MR219, MR 220 and MR 185 were medium Zn efficient and Java, MRQ74,MR211 and Bhagia were observed to be the most Zn inefficient rice genotypes.

Keywords：*screening, rice genotypes, Zn efficiency, solution culture*

P2-3

[IDS3] Soil Information and Food Security

The Study of Lead (pb) Remediation, Antioxidant Enzyme Activity and Malondialdehyde Biomarker Content in Two Barely Species in Contaminated Soils Under Greenhouse Condition

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This study was done to investigate the accumulation of heavy metal lead, Malondialdehyde, super oxide dismutase and chlorophyll in two barely species under greenhouse conditions of research greenhouse of agricultural school and Ilam Azad university in 2011-2012. This experiment was carried out as a from of factorial through complete randomized block with three replictions. Factor of experiment were lead rate of soil in four levels (0, 100, 200 and 300 mg/kg dry weight soil and two barely species in Izeh (lignees 527/ saws an/Bc figure) and Sararod-1 (chicm/ An57// Albert). Result showed that barely species had significant effects (P>0.01) on Root lead content, Superoxide dismutase enzyme (SOD), Catalase (CAT) and Biomarker Malon dialdehyde (MDA) contents. No difference was perceived between barely species in terms of lead rate in Airial organs, soil and Transfer factor (TF). Between barley species, Sararound-1 with 6.45 (mg/kg dry weight) and Izeh with 5.28 (mg/kg dry weight) had the highest and lowest lead concentration content in root, respectively. Also Sararod-1 with 90.13 (mg/kg dry weight) and Izeh with 79.04 (mg/kg dry weight) had the most and least lead concentration rate in aerial organs, respectively. The greatest amount of producing (SOD), (CAT) Antioxidant enzymes and also the least amount of (MDA) Biomarker were related to Sararod-1. This shows that compared to 6 ? row barely of Izeh two ? rows barely species of Sararod is relatively more tolerant with stress of heavy metal lead. Different doses of lead in soil had highly significant effect (P>0.01) on all traits under study. Result shows that having lead dose increased in soil, lead contration in aerial organs and root increased as well and the greatest amount of lead accumulation belongs to dose 300 (mg/kg dry weight of soil). The greatest amount of remained lead in soil is for 300 doses (mg/kg dry weight of soil). The highest and lowest amount of transfer factor is for 200 and 0 (mg in kg dry weight of soil) doses, respectively. In general, as lead dose in soil increased the amount of antioxidant enzymes decreased and on the contrary. The biomarker Malondialdehyde increased.

Keywords：*Phytoremediation, Lead, Transfer factor, Barely, Catalase, Superoxide dismutase and Malondialdehyde.*

P2-4

[IDS3] Soil Information and Food Security

Screening of Early and Late-Season Sugarcane Varieties On Sprinkler Irrigated Ferralsols in Northern Ivory Coast Following a New Selection Scheme

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A set of 8 Mauritian sugarcane varieties were screened over a first step of 3 years as one plant cane and two ratoons. The study was carried out on early as well as late-season crops each of them being sprinkler irrigated with a centre pivot. Both experiments, designed following a randomised complete block in 6 replicates with cane variety as a single factor being studied, were located on ferralsols in two commercial farms of Ferke 1 sugar mill, north-eastern Ivory Coast. It came out that M2256/88 and M1042/86 were equivalent to the control (R579) as early-season varieties with an average yield of 13.3 t of sugar/ha. As a result, both varieties were suggested to undergo pre-commercial observation tests as early-season crops. Regarding the very limited number of late-season commercial cane varieties under cultivation on Ferke farmlands, only M1565/87 was found promising on ferralsols over that season among the tested varieties with 10.5 t of sugar/ha although it performed a bit lower than the control (-17 %). For crop sanitation reasons, M1186/86 and M2024/88 as highly susceptible varieties to smut were suggested to be eradicated in Ferke genetic resource conservations.

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Keywords：*variety improvement, disease, drought, tolerance, irrigated crop, sugar yield, sustainable ratoon*

P2-5

[IDS3] Soil Information and Food Security

The Scottish Government's Portfolio of Research Providing the Research Base and Tools for Understanding Soil and How That Impacts on Key Global Issues: Food Security & Sustainable Intensification

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(The Scottish Government's Strategic Research Portfolio (SRP) focuses on building knowledge and delivering outputs to inform and support the major policy areas of climate change, land use and food security, and to impact on the 'Wealthier', 'Healthier' and 'Greener' strategic objectives of the Scottish Government, in addition to contributing to the delivery of the Government's overall purpose of sustainable economic growth.

The research is delivered through an interdisciplinary portfolio of research, the core strength of which is the collaboration between the Scottish Government's Main Research Providers -The James Hutton Institute, the Moredun Research Institute, Rowett Institute of Nutrition and Health University of Aberdeen, Scotland's Rural College, Biomathematics and Statistics Scotland and The Royal Botanic Gardens Edinburgh, in addition to working closely with the Scottish higher education establishments to deliver science to policy and industry.

Unlike many policy-informed or led initiatives, the SRP has embedded direct linkage to Scottish Government science-advisor teams and pro-actively works to enhance knowledge flow to and from policymakers while its annual performance review checks delivery and value of input to policymakers. In addition, the research actively seeks to inform and be informed by stakeholders from farming, land use, water and energy supply, food production and manufacturing, non-governmental organisations, voluntary organisations, community groups and the general public. This presentation will provide an overview of the SRP's interdisciplinary research, and will focus on important examples where direct collaboration between several disciplines and organisations can contribute to the understanding of soil and how that impacts on many aspects of agri-food production, climate, biodiversity and society. Examples from research on soil organic matter, soil erosion, GHG emissions, soil biodiversity, water quality and food quality and how these deliver to our policy evidence base will be discussed.

The priorities are informing and supporting policy and practice, contributing to economic growth and innovation, enhancing collaborative and multidisciplinary research, growing scientific resilience and delivering scientific excellence. This is set in the context of responding to climate and land use change and of increasing demands for food, water and energy security, in addition to delivering to key policy areas of Soil, Food Security and Sustainable Intensification. This innovative interdisciplinary approach to informing policymaking is providing some important messages, such as the need to manage a range of expectations and the need to communicate the right messages, at the right level, at the right time. This presents particular challenges in the context of a research portfolio that includes a mix of both strategic and applied research. Significant impacts of research on policy have been demonstrated, and will be showcased; such as in CAP reform and High Nature Value Farming.

Reference:

http://www.scotland.gov.uk/Topics/Research/About/EBAR/StrategicResearch/future-research-strategy/Themes/

The Scottish Government's Rural and Environment Science and Analytical Services Division (RESAS) funded this work.

Keywords: *Government policy, soil strategy, research, strategic objectives, food security, sustainable intensi*

P2-6

[IDS3] Soil Information and Food Security

Using Soil Information in Geospatial Natural Disaster Analysis

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Beginning from the middle of the 1990s, Azerbaijan gradually started to revive and take confident steps towards resolving fateful issues under the leadership of the great leader Heydar Aliyev. The dynamics of economic growth, which gained a new impulse through the comprehensive extraction and export of natural resources and economic growth in Azerbaijan even during the 2009 global economic crisis, show that the strategic line that was chosen was being conducted successfully.

the Development Concept "Azerbaijan - 2020: Look into the Future" approved by the President of the Azerbaijan Republic Ilham Aliyev a next year is a good excursion to the history of modern independent Azerbaijan which is only 20 years old. Good management of spatial data and geographic information systems is one of the key tools to put country's strategy into practice.

Accurate, timely and reliable geospatial information plays a vital role in helping advance sustainable development across the globe. As in many other countries, Azerbaijan implements special programs to strengthen the geospatial information capacity. It is meant to:

- support institutional and policy frameworks;
- data acquisition, management and delivery;
- enabling technologies and information services;
- and the requirements for data standards, sharing, accessibility, and dissemination.

Strengthening this geospatial information 'supply chain' is inclusive of the need to integrate multiple sources of information - traditional and non-traditional - while meeting the specific needs of the end user. This has particular relevance to sustainable development, disaster management, and humanitarian aid in developing countries in the region.

The importance of comprehensive hazard and risk assessments, and knowledge and information sharing, including the use of reliable geospatial information is acknowledged

In this paper author consider Type of Disasters Occur in Azerbaijan. South Caucases is the seismic active zone. Active rock forming processes are going on here that's why more frequent natural disasters which happen are earthquakes. Then we can mention active slide processes according to statistics. Big problem is numerous mudslides especially in mountainous areas.

Floods are happening on the plains as well as in mountainous areas.

From time to time there are sudden storms and mud volcanos.

As a practical examples for Practical Examples for Type of Disasters author describe the followings:

Eathquakes-earthquakes which happen in the region of the Great Caucasian Mountain Ridge are in Balakan, Zakatala and Gakh regions. In 2011-2013 they've been up to 6-7 points. Earthquake in Baku area in year 2000 was 6.8 point.

Landslides-this is specially typical for the regions of Great Caucases and Small Caucases. Mainly these are Gedabek, Gusar and Shamakha regions.

Mud flows mostly happen in mountain rivers during melting of snows, and during cloudbursts. More often mud flows happen in Sheki, Zakatala, Gakh and other mountainous areas.

Floods mostly regions of Kura-Araz lowlands are affected by floods. The strongest flood was in 2010. After pouring rains dykes of Kura river couldn't stand and water flooded the territory of 6-7 regions.

Then author describe the efforts the State Committee on Land and Cartography to liquidate consequences to the natural disasters. As one of the main part of geographical information system author shows the layers with the soil information.

Finally author states, that as a government organization State Committee on Land and Cartography of the Republic of Azerbaijan will continue to play a key role in providing a reliable, trustful and maintained geospatial information base and in the field of control for the principles and mechanisms which necessary for maintaining of the main structures.

Keywords：*soil information, geospatial, Azerbaijan*

P2-7
[IDS3] Soil Information and Food Security

Effect of Potassium Fertilization Forms on Growth, Yield and Quality of the Sugar Beet Crop in Salt Affected Soils in Eastnorthern Delta Of Egypt

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Two fields' experiments were carried out at Port Said Agricultural Research station, in the eastern bank of the as El Salam canal in 2009/2010 and 2010/2011 seasons to study the effect of two potassium fertilizer rates i.e. (o and 24 kg K2O/fad) in two forms i.e. Potassium sulphate (SOP) and Potassium chloride (MOP) on growth and yield of sugar beet plant as well as its resistance against Cercospora Leaf Spot disease under three different levels of natural soil salinity i.e. (2.8-5, 6-10 and 11-12 ds/m at 25 0c).

The obtained results of the combined analysis of the three levels of soil salinity in the two growing seasons showed the following trends:

1- The highest and best optimum beet root yield and quality were obtained at the soil salinity level of 2.8-5 ds/m, compared to the other soil salinity levels.

2- Soil salinity level more than 10 ds/m indicate the hazard and deteriorating effect on growth and yield of sugar beet in eastnorthern Delta region.

3- Results also showed that fertilizing sugar beet plants with 24 kg K2O in the form of potassium sulphate (SOP) or potassium chloride (MOP) gave the highest values of all studied characters without significant difference between them as compared with the control (no K addition).

4- The interaction effects between soil salinity levels and potassium forms were significant on all studied characters in both seasons. The highest values of all studied characters were recorded with soil salinity level up to 5.0 ds/m with 24 kg K2O/fad in the form of MOP or Sop as compared with all the other treatments in both seasons.

5- Potassium fertilization in the form of both MOP and SOP obviously increased the resistance of sugar beet to leaf spot disease caused by Cercospora beticola Sacc. Comparably no potassium additions under all the three soil salinity levels.

6- Soil salinity level more than 10 ds/m achieved higher Na and Cl% and lower K% in beet roots. Also, both MOP and Sop caused lower Na% in beet roots, while SOP caused lower Cl% in beet roots.

7- Generally, it could be concluded that under salt affected soil conditions, fertilized sugar beet plants with 24 kg K2O/fed in the form of MOP or Sop greatened root and sugar yield (ton/fad) as well as induced its resistance to leaf spot disease caused by Cercospora Beticola Sacc.

Keywords：*Sugar beet, potassium fertilization, Salt affected soil*

P2-8

[IDS3] Soil Information and Food Security

Interaction of Nitrogen and Phosphorous Rates on Fertilizer Use Efficiency in Lettuce and Spinach

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Urea hydrolyzes rapidly following its application to soils. To solve NH3 Volatilization problems and enhance urea efficiency, it is essential to slow down urea hydrolysis to avoid both NH3 build up and pH increase in soil. Ammonia volatilization could also be decreased by mixing urea with triple super phosphate applied to an acid soil (Fan and Mackenzia. 1993), or mixing with KCl. The objectives of the present work were studying efficiency of N uptake by plants in soil and studying the effect of triple super phosphate blended urea fertilizer on plant properties.

Keywords：*Phosphorous, Nitrogen, Fertilizer Use Efficiency*

P2-9

[IDS3] Soil Information and Food Security

Soil Quality and Crop Production in an Agricultural Catchment of the Typical Mollisol Region, Northeast China

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With rapid economic and population growth throughout the world, agricultural sustainability has been recognized as crucial for economic development and as foundational for food demand in developing populous countries such as China. However, the FAOSTAT in 2007 displayed that increasing rate of crop yield such as soybean, corn, and rice has slowed since 1995. The Mollisol region in Northeast China has been cultivated as farmland in the 1950s and is considered essential for Chinese crop production. However, soil erosion has become serious due to large-scale cultivation and improper land management since 1950. In some places the loess parent material has been exposed, as result, soil productivity mostly lost. So controlling soil erosion and improving or maintaining soil quality is important to sustain or increase crop production in this region. The objective of this study was to identify the key indicators of soil quality and analyze how soil quantify affects soil quality corn yield in the typical Mollisol region of Northeast China. Soil samples were collected based on a 100*100 grid cell in an agricultural catchment in Bin County, Heilongjiang province. The 11 soil properties including soil bulk density (BD), geometric mean diameter of soil particles (GMD), mean weight diameter of soil aggregate (MWD), soil organic matter (SOM), available nitrogen (AN), available phosphorus (AP), microbial biomass carbon (MBC), microbial biomass nitrogen (MBN), urease activities, sucrease activities and alkaline phosphatase activities were measured. After analysing the correlation among 11 soil properties, the principal component analysis (PCA) was used to select the key soil quality parameters and soil quality index was used to calculate soil quality. On this base, regression analysis was used to analyze the relationship between soil quality and crop yield. Over the study area, different soil properties had different degrees of heterogeneity, indicating that they were maybe affected by the different agricultural practices or natural factors. The correlation analysis of soil properties displayed that out of 78 pairs of soil quality attributes, 22 pairs were found significantly correlated ($p < 0.05$) and the soil characteristics could be grouped into factors. The result of PCA was that the key indices that contributed towards changes in soil quality were SOM, TN, Sucrase, BD, AP and MBC. Soil quality index varied from 0.224 to 0.695. Moreover, in the most part of the study soil quality index were less than 0.5 which showed soil quality was low in this small catchment. Further, the spatial distribution of soil quality index was generated by inverse distance weighting interpolation (IDW) with ARCGIS software. It was crumb in this study with the characteristic of the high soil quality located in the east and north, the low in west and south. The slope distribution of soil quality index showed that the highest value of SQI occurred at the foot slope position or at the upper position. While the lowest value of SQI at middle slope position and the middle value of SQI at the transition zone between the upper position and middle position, as well as between the middle position and foot position. It was concluded that the spatial distribution feature soil quality may be influenced not only by soil erosion, but also by topography. Then, the regression analysis showed a significant relationship between soil quality and crop yield which indicated that soil quality effected crop yield. So the effective soil quality conservation measures are highly demanded in increasing crop yield and realizing a sustainable land-use management in this study.

Keywords：*an agricultural catchment; corn yield; Mollisol; PCA; soil quality*

P2-10

[IDS3] Soil Information and Food Security

Transmission of Selenium and Cobalt in “Soil-Pasture-Feed-Animal Chain”(spfac) and Their Regulation to the Nutritions of Pasture and Animal

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A field experiment was arranged in yellow river beach lasting 3 years from 2006 to 2009 to study the regulation of selenium and cobalt combined fertilizers（570 ~765 g/hm2 for Na2SeO3-5H2O； 762 ~1548 g/hm2 for CoSO4-7H2O） on qualities of alfalfa hays and animal products by“soil-pasture-feed-animal chain”（SPAFC）by basal application. Results showed that：(1)Alfalfa had more stronge capacities to not only absorb selenium from soil fertilizers,but also transfer from inorganic selenium to organic selenium, effectiveness and securities of selenium could be enhanced greatly.(2) When application rates of Se and Co being 765 and 762 g/hm2, Se-Co combined fertilizers could enhance the contents of crude protein (CP) and ether extract(EE), but had no apparent effects on the contents of crude fiber(CF) and non-nitrogen extract(NFE), feed nalues was raised greatly. furthermore the contents of Cu、Fe、Mn、Zn were also enhanced significantly（P?0.05）. (3) Alfalfa hays rich in Se and Co could enhance Se contents of animal products,and Se contents in soil, Se contents in pasture and Se contents in animal products were all significant conrelation（P?0.01）.

Keywords：*Selenium, Cobalt, SPAFC, Nutrition*

P2-11

[IDS3] Soil Information and Food Security

Soil Science Publications: Trends and Impact

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Scientific journals first developed in the seventeenth century to systematize the letters and circular letters through which intellectuals interested in science had begun communicating their discoveries. Scientific publishing is now at the centre of scientific activity. The number of scientific publications is increasing each year and there are no reasons to assume that the rate of expansion will decline. Citation analysis and impact factor ratings combined with publishing records are increasingly being used as an evaluation tool for institutes, universities, academic promotions, grant evaluations and evaluation of job vacancy candidates.

Until the end of the nineteenth century soil investigations were published through books and monographs and the first journal dedicated to soil science, Pochvovedenie, was published in 1899 in Russia. Up to the 1950s, there were four scientific journals in which soil investigations were published. Seven soil science journals were started in the 1940s and 1950s and another peak occurred in the early 1980s.

In this paper we focus on three aspects (i) the number of soil science publications, (ii) rates of self citation, (iii) citation metrics using different databases, and (iv) some future considerations.

At present, there are some 35 journals with their main focus on soil science. More than half a million soil science papers have been published since the 1920s. There is a considerable increase in the number of papers from China. Soil biology is a rapidly growing area and journals with a soil biology and biochemistry focus have a high impact. Inter-annual variation in impact factors has always been considerable but since the early 2000s, the impact of some soil science journals is stable or even declining whereas others have a steady growth.

Related to the journal's impact factor is the degree of self-citation. Any analysis of 31 soil science journals showed that the median rate of self-citations was 12% but ranged from 5 to 60%. High rates of self-citation were accompanied by high impact factor ranking. China and the USA had high rates of self-citations and with few exceptions self-citation rates in soil science are reasonable and comparable to the other biophysical sciences.

Scientific careers are dependent on what one has written (and where) but not so much on what one has read. Displaying being widely read and erudite used to be momentous in academic positions, but publication record is an important evaluation criterion in addition to grants, student evaluations and outreach successes (to name a few) We compiled the number of publications, number of citations, h index and year since the first publication from 340 soil researchers from all over the world using the Web of Science, Scopus, and Google Scholar. Considerable differences were found between these databases and on average, Google Scholar has the highest h index, number of publications and citations per researcher, and the Web of Science the lowest. There are considerable differences between the databases but bibliometric transfer functions exist to relate the metrics between databases.

The high rates of publications confirm that the soil science discipline is vibrant and has an expanding knowledge base. The diffusion and application of that increasing body of knowledge and its impact is not so easy to measure. The past decade saw methods to assess the productivity and impact of individual soil scientist (e.g. the h index) but the impact of soil science as a whole on key issues like food production, soil carbon sequestration or biodiversity remains to be properly quantified. Scientific publications per se may offer little insight in quantifying the impact on such issues – they reflect the advances in the discipline. A subdisciplinary or 'key issue' analysis of our scientific productions may be needed. Or: more is less.

Keywords: *soil science publications, soil science information*

P2-12

[IDS3] Soil Information and Food Security

Model Development for Multi-Sensor Irrigation Systems to Optimise Water Use in Crop Production

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Agriculture is the biggest water consumer, accounting for 70% of fresh water worldwide. Our remaining water resources are under immense pressure because of population growth and global climate changes. It is, therefore, crucially important to advance irrigation scheduling techniques to optimise water use in agriculture. Currently, the most commonly used approaches in irrigation scheduling include: (1) water balance methods, or (2) direct measurements of soil water content or potential at a specific depth in the soil profile (Greenwood et al., 2010). Water balance methods are more inherently prone to cumulative errors in estimating evapotranspiration. Although direct measurement of soil water status has the potential to be more accurate than indirect water balance methods, the measurements of soil water status from a specific depth are unable to reflect soil water status in the whole root zone, and thus cannot make reliable irrigation decisions for optimal use of water. A multi-sensor system should therefore be attempted (Greenwood et al., 2010).

To assist multi-sensor irrigation systems, a numerical model has been developed to interpret the sensor measurements from various depths in the soil profile and to make decisions for irrigation scheduling. The model is able to make irrigation recommendations based on the soil water status of the entire root zone using the principles outlined by FAO56 (Allen et al., 1998). In particular, the model has the following distinctive features: (1) it works for different crop species, soil types and weather, (2) it employs variable threshold of soil water content for different crop growth stages, and (3) it estimates rooting depth during the growth period.

Four separate field experiments on potato, cabbage, lettuce and courgette were carried out at Warwick HRI, Wellesbourne, UK in 2009 to collect data for validation of the developed model. The soil type was of the Wick series and was relatively uniform to 1.2 m. A fully randomised experiment was designed with five replicates. In all experiments there were 2 irrigation treatments: the Control and Optimal irrigation treatments. The Control irrigation timing and volume of application was based on a soil moisture deficit trigger. The Optimal irrigation recommendations were calculated by the model. Watermark 200ss-V sensors (Irrometer Company, USA) were used to measure soil water potential at depths in the profile. Soil sensors were installed at depths of 15, 45 and 75 cm for both cabbage and courgette; at 10, 50 and 70 cm for potato, and at 10 and 30 cm for lettuce.

The model was run for irrigation scheduling throughout the life of all the crops using the measured data from soil sensors. Results show that the Control treatment received a total of 376.3 mm irrigation, while the Optimal treatment received a total of 165.1 mm irrigation for potato. The corresponding figures were 409.8 mm and 200.2 mm for cabbage, 219.1 mm and 135.9 mm for courgette, and 75.6 mm and 50.4 mm for lettuce, respectively. There were no significant differences between the Control and Optimal

treatments for dry weight for any of the crops. The overall water savings ranged from 33.3% for lettuce to 56.1% for potato, indicating that the model works reasonably well, and thus has the potential to be used widely for optimising water use in agriculture.

Acknowledgements: The authors are grateful to the financial support from the EC Seventh Framework Programme for research, technological development and demonstration activities (2007-2013) through the WaterBee project (No. 222440). KZ wishes to thank National Science Foundation of China (NO. 51379187) which partly supports the work.

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Keywords：*Irrigation systems, Smart irrigation, Optimal water use, Water management*

P2-13

[IDS3] Soil Information and Food Security

Use of Phosphoric Acid as a Source of P-Fertilizer in Calcareous Soils

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Calcareous soils are dominant in the Middle East region and are known to have low available P for plant uptake. This study was conducted to compare fertilization efficiency of H3PO4 and Triplesuperphosphate(TSP) as sources for P in calcareous soils in two experiments (field and greenhouse). The indicator crops were cucumber in the field experiment and corn in the green house pot experiment. The design of the field experiment was factorial 4x2 and it was factorial 4x3 in the greenhouse experiment. The treatments of the field experiment were T1 (0P), T2 (TSP), T3 (TSP + H3PO4), and T4 (H3PO4) at 50 and 150 kg P2O5/Ha rates. As for the greenhouse experiment the levels of applied P were (50, 100, and150 kg/Ha P2O5). The results of both experiments showed that cucumber yield, corn growth, concentrations of P and Mg in plant tissues responded positively and at significant levels to the H3PO4 application as a single P- source or in combination with TSP. This indicates that H3PO4 is a more efficient source for P in calcareous soils and its usage led to significantly improve the availability of P, Ca and Mg in soils, which led to a higher uptake of these elements and higher production.

Keywords：*Calcareous Soils, Phosphoric acid, TSP (Triplesuperphosphate), fertilization efficiency.*

P2-14

[IDS3] Soil Information and Food Security

Effect of Phosphorus Uptake Efficiency on Micronutrients Content in Grains of Wheat and Soybean Cultivars

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Brazil is one of the largest producers of soybean (Glycine max) in world, around 80.0 million tons on the crop season 2012/2013, on the other hand, is one of the top three importers of wheat (Triticum aestivum), due the small domestic acreage (around 2 million ha) and low production (5.78 million tons). Low phosphorus (P) availability is a primary constraint to plant yield in Brazilian soil, so it is necessary to apply large quantities of P fertilizer. In addition to fertilizers, it is possible identify cultivars that have a greater ability of P uptake, since, crop genotypes differ in phosphorus acquisition (Lynch, 2001).

However, application of P fertilizers may also cause detrimental effects on grain quality, in particular the concentration and bioavailability of micronutrients (Buerkert et al. 1998), as well, selecting cultivars with higher P uptake efficiency may reduce uptake of Zn or Zn concentrations in the plant (Zhu et al. 2001).

Using a 32P isotope technique, this study evaluated P uptake efficiency by wheat and soybeans cultivars and, if the P uptake efficiency affects the content of the micronutrient in the grain.

The experiment was carried out in a greenhouse. The study was performed in plastic pots, lined with polyethylene bags, holding 2.0 kg of air dried soil taken from topsoil of Typic Haplustox. Phosphorus fertilization was accomplished by applying a mixture of triple superphosphate (20 mg kg-1 of P) and Patos de Minas phosphate rock (150 mg kg-1 of P). The soil was labeled with 32P in solution applied at 9.62 MBq and 2 mg kg-1 P carrier.

Were evaluated 42 wheat and 57 soybean cultivars. The experimental design was a completely randomized with three replications. Part of the grains was used in seeding and the other part was used to determine the content of micronutrient. The shoot of wheat and soybean was collected 40 days after emergence and dried at 60 ºC. Phosphorus content in the shoot tissue and grain was determined by colorimetric method. The activity of ^{32}P in the shoot tissue was determined in a liquid scintillation counter by Cerenkov effect and L-value was calculated according to the following equation, where: L-value (mg kg-1 of P); SA0 is specific activity of applied solution (dpm µg P-1); SAp is specific activity of plant (dpm µg P-1); x is amount of applied P.

L-value = x(SAO/SAp -1)

The results indicated that there were substantial variations for P uptake among the 42 wheat and 57 soybean cultivars evaluated. The overall average of L-value was 8.19 and 14.78 mg kg-1 for wheat and soybean cultivars, respectively. The highest value of L-value for wheat was 12.13 mg kg-1 (cultivar IPR 136) and the lowest was 5.33 mg kg-1 (cultivar BRS 220). For the soybean, the highest and lowest were 19.90 and 10.92 mg kg-1, cultivar BRS Nova Savana and Sambaiba, respectively.

There were not significant correlation among L-value (P uptake efficiency) and micronutrient content in the grain both for wheat and soybean cultivars.

The means of 42 cultivars of wheat were 4.73, 37.26, 36.68, 33.47 mg kg-1, and means of 57 cultivars of soybean were 12.01, 213.27, 90.91, 102.91 mg kg-1 of Cu, Fe, Mn and Zn, respectively.

Although cultivars with high P uptake efficiency may reduce uptake of micronutrients, particularly Zn, in the plant, it does not necessary follow that all cultivars with high P uptake also produce grain with lower content of micronutrient, which was confirmed by the lack of significant correlation between variables L-value and content of micronutrient in the cultivars of soybeans and wheat.

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Keywords：*32P, radioisotope, L-value*

P2-15

[IDS3] Soil Information and Food Security

Deficit Irrigation and Nitrogen Fertilizers Effects on Crop Production and Environment Hazardous of Nitrate Leaching in Upper Egypt

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A field experiments was conducted at the Experimental Farm, Faculty of Agriculture, Al-Azahar University, Assuit, Egypt which is located at 27° 12- 16.67= N latitude and 31° 09- 36.86= E longitude for two successive growing winter seasons of 2008/09 and 2009/10 in order to reach optimum management practices of both irrigation water amount and nitrogen application to attain high crop yields, while minimizing risks of environmental impairment and aquifer contamination. Three levels of soil moisture depletion (25, 50 and 75% of SMD) were assigned to the main plots. The split plots were assigned for three nitrogen fertilizers sources (Urea 46.5% N, Ammonium nitrate 33.5% N as a fast nitrogen fertilizer and ureaform 40% N as a slow nitrogen fertilizer).

The amounts of leached nitrate increased as the soil moisture depletion increases. The leached nitrate as average values of two seasons of wheat crop are 133, 158 and 178 ppm at 25, 50 and 75% SMD, respectively which increases by 19 and 34 % at 50 and 75 % SMD, respectively compared to that at 25% SMD. The leached amounts of nitrogen have no change whenever the nitrogen source is urea or ammonium nitrate and almost have the same distribution through 130 cm soil depth. While the leached amounts of nitrogen resulted from ureaform fertilizer appears to be not as much as those of other nitrogen sources. The amounts of leached nitrate was more obviously under soluble fertilizers and it could be arranged in descending order of ammonium nitrate > urea > ureaform. The amounts of leached nitrate as average values of two seasons of wheat crop are 193, 197 and 83 ppm under urea, ammonium nitrate and ureaform fertilizers, respectively which increased by about 135 % under urea or ammonium nitrate fertilizer compared to that under ureaform fertilizer.

Wheat crop water use efficiency (CWUEw) could be arranged in descending order of 50 > 25 > 75 % SMD. Regarding nitrogen sources it could be arranged in descending order of ureaform > urea > ammonium nitrate. The highest value of nitrogen use efficiency by wheat plants, NUEw, (46.65 kg/ kg N) is recorded in treatment of 25 % SMD with ureaform fertilizer. The highest nitrogen leaching during the growing season was concurrent with the highest irrigation application and fertilization event. It is possible to control NO3- leaching out of the root zone during the growing season with a proper combination of irrigation and fertilizer management.

Keywords：*Deficit irrigation, Nitrogen fertilizers, Nitrogen leaching, Water use efficiency, Nitrogen use effi*

P2-16

[IDS3] Soil Information and Food Security

[IDS3] Soil Information and Food Security

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Dynamic interactions between and within the biogeophysical and human environments lead to the production, processing, distribution, preparation and consumption of food, resulting in food systems that underpin food security. Food systems encompass food availability (production, distribution and exchange), food access (affordability, allocation and preference) and food utilization (nutritional and societal values and safety), so that food security is, therefore, diminished when food systems are stressed. Such stresses may be induced by a range of factors in addition to climate change and/or other agents of environmental change (e.g. conflict, HIV/AIDS) and may be particularly severe when these factors act in combination. Urbanization and globalization are causing rapid changes to food systems.

Climate change may affect food systems in several ways ranging from direct effects on crop production (e.g. changes in rainfall leading to drought or flooding, or warmer or cooler temperatures leading to changes in the length of growing season), to changes in markets, food prices and supply chain infrastructure. The relative importance of climate change for food security differs between regions. For example, in southern Africa, climate is among the most frequently cited drivers of food insecurity because it acts both as an underlying, ongoing issue and as a short-lived shock. The low ability to cope with shocks and to mitigate long-term stresses means that coping strategies that might be available in other regions are unavailable or inappropriate. In other regions, though, such as parts of the Indo-Gangetic Plain of India, other drivers, such as labour issues and the availability and quality of ground water for irrigation, rank higher than the direct effects of climate change as factors influencing food security.

Because of the multiple socio-economic and bio-physical factors affecting food systems and hence food security, the capacity to adapt food systems to reduce their vulnerability to climate change is not uniform. Improved systems of food production, food distribution and economic access may all contribute to food systems adapted to cope with climate change, but in adopting such changes it will be important to ensure that they contribute to sustainability. Agriculture is a major contributor of the greenhouse gases methane (CH4) and nitrous oxide (N2O), so that regionally derived policies promoting adapted food systems need to mitigate further climate change.

Keywords :

P2-17

[IDS3] Soil Information and Food Security

Sufficiency Ranges and Optimal Levels of Soil Fertility to the Coffee Crop in Minas Gerais, Brazil

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The relationship between the chemical and physicochemical characteristics of the soil and the productivity of field crops is established through calibration curves, obtained by field experiments, under controlled conditions. The use of mathematical models, such as Mathematical Chance (MCh), can be an alternative to the traditional processes of calibration, since it uses a high number of data. The objective of this work was to obtain sufficiency ranges and optimal levels of soil fertility, based on the relationship of chemical and physicochemical characteristics of the soil and the productivity observed in coffee regions of the State of Minas Gerais, in Brazil. We have collected soils from 168 sampling units of five coffee regions of Minas Gerais State. A sampling unit was composed of 0.5 ha of coffee crop aged about five years, without loss of productive branches and diseases, plant population from 3000 to 5000 plants per hectare and with records of productivity at least for the two most recent harvests. The samples were collected in the 0-20 cm layer and submitted to routine analysis of organic matter, pH, aluminum (Al3+), phosphorus (P), base saturation, potassium (K), calcium (Ca2+) and magnesium (Mg2+). Each soil characteristic was paired with the mean productivity of the orchard. The data of each fertility characteristic were divided in classes, being determined the data amplitude (A) and calculated the number of possible classes (I) according to the sample size (n), where I= √n. The ratio between A and I resulted in class interval (CI = A/I). Finally, the Mathematical Chance of the soil characteristic in the class 'i' (MChi) is given by: MChi =√ {[P(Ai/A) . PRODi] . [P(Ai/Ni) . PRODi]}. To obtain the Relative Mathematical Chance (RMCh) we have attributed, in each case, the value of 100% to the highest value of MCh. With such results, we have done regression curves between the average value of the factor of production for each class 'i' and their respective RMCh, generating an equation and a trend curve. Based on the greater estimated value (taken as the optimum level for such soil characteristic) we have estimated the sufficiency ranges. We obtained sufficiency ranges, for the 0-20 cm depth layer: organic matter of 32 to 40 g/kg, pH 5.0 to 5.4 , Al3+ 0.07 to 0.08 cmolc/dm ^{3}, base saturation 34 to 50%, K+ 57 to 73 mg/dm ^{3}, Ca2+ 1.9 to 2.6 cmolc/dm ^{3} and Mg2+ 0.9 to 1.1 cmolc/dm ^{3}. These findings evidence the importance of organic matter to obtain high coffee productivity, but also evidence that values higher than 40 g/kg promote negative responses. The pH related to high productivities was slightly acid, however the aluminum need to be totally neutralized by liming. The sufficient range of K obtained in this work is lower than the commonly used, but the ranges for base saturation, Ca and Mg contents are in agreement with the ranges used for coffee crop.

Keywords：*Coffea arabica L., soil analysis, mathematical chance*

P2-18

[IDS3] Soil Information and Food Security

Evaluation of Rice and Maize Cropping System Under Contrasting Tillage Practices in Alluvial Soil of Eastern Indo-Gangetic Plains of India

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Rice and winter maize is an important cropping system in the alluvial soils of eastern Indo-Gangetic plains of India, which needs some identification and quantification of the optimum levels of tillage, irrigation, and nitrogen combinations that will not only provide the maximum return per unit investment but also sustain the productivity of this system without deteriorating soil health. A series of experiments were conducted for two consecutive wet and winter seasons at Rajendra Agricultural University, Pusa, India. The experiment was designed in split-split plot with the treatments of tillage (main), irrigation (sub) and nitrogen (sub-sub plot) having three levels each with three replication during wet seasons for rice under timely planting (24th July) and late (16th August) and during winter season maize was sown under timely (06th November) and late (28th November) conditions. During post rice harvest studies, only tillage could fetch significant variation by reducing bulk density from 1.49 to 1.41, penetration resistance from 3.26 to 2.63 M Pa and mean weight diameter from 8.19 to 6.40 mm with subsequent increase in water stable macro aggregate (71 mm) from 4.91 to 7.32 per cent, infiltration rate from 0.129 to 0.321 cm hr-1 and mean value of root volume from 4.53 to 6.52 cc during both years of experimentation. The same trend was observed in post-maize harvested fields. There was reduction in bulk density from 1.41 to 1.30 M gm-3, penetration resistance from 2.94 to 2.11 Mpa, mean weight diameter from 6.97 to 5.68 mm with subsequent increase in water stable aggregate from 6.76 to 10.37 per cent and infiltrate rate from 0.218 to 0.512 cm hr-1. Maximum root volume was 35.30 and 40.38 cc under late and timely sown mould board (MB) ploughed fields, respectively. Further, mould board plough plus cultivator followed by planking and irrigation at all five physiological stages in rice and at IW: CPE ratio of 1.2 in winter maize with 120 kg N ha-1 was the best combination. Rice ? equivalent yield (REY) increase was more pronounced under timely than late conditions. Significant interactions showed the possibilities to manipulate the level of these resources without scarifying REY of this system up to some extent.

Keywords：*Rice; Maize; Tillage; Irrigation; Nitrogen; Soil Physical Characteristics; Root Studies*

P2-19

[IDS3] Soil Information and Food Security

Estimating Load Bearing Capacity of Some Agricultural Soils of the Cerrado Region Using Precompression Stress Data

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The Brazil agricultural landscape most especially the cerrado region has been subjected to some highest level of mechanization in recent times, due to the increasing significance in economic development. This mechanization programme are often implemented without due regard to long term effect on soil hydro-physical processes in the soil. We sampled structural distinct soils widely spread in the cerrado region and determined the compression stress values under varying moisture regime. These were used to characterize the bearing capacity and compression index of the soils with a view to establish a decision support tool in sustainable use of these soil. Dominant minerals were found to influence the soil structure and compressibillity properties. Changes in the soil strength functions were also found to be influenced by the landscape positions and organic matter content among other factors.

Keywords：*compressibilty, cerrado*

P2-20

[IDS3] Soil Information and Food Security

Spatial Variability of Available Potassium in Arable Soils of Mazandaran and its Relationship With Soil Properties And Rainfall

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Potassium is one of the important nutrients and is vital for plants growth. Spatial variability of soil potassium is very essential to management and proper utilization of K fertilizers. Likewise soil Intrinsic factors such as soil particles (especially clay and sand), climatic factors such as rainfall can affect the available potassium for plants. Rainfall may leach available potassium and is considered to be one of the important factors on distribution of available K in the region. Spatial distribution of available K indicated that area with high annual rainfall had lower amount of available potassium. Available K was significantly negatively correlated with soil sand portion (r= .377). Spatial structure analysis was done with GS+ version 5.1 (Gamma design software) and the maps drown with ArcGIS (version 9.2). Rainfall interpolation was done with Inverse Distance Method (IDW).

Keywords：*available potassium, annual rainfall, ordinary kriging, inverse distance weighting, ArcGIS*

P2-21

[IDS3] Soil Information and Food Security

Mapping Soil Zinc Levels and Spatial Variability in Brazil: Is Zinc Deficiency a Problem for Highly Technified Farmers in the Brazilian Cerrado?

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Nutrient deficiencies are widespread in Brazilian Cerrado soils. Zinc availability is one of the major yield constrains in these soils, affecting 90-95% of the native Cerrado soils. The Cerrado biome occurs in 22% of Brazilian territory (~200 million ha), mostly in the central area of the country. This biome comprises the main and most challenging agricultural area in the country. Today, the Cerrado region accounts for a massive 70% of Brazil's farm output.

Due to the geographical and agricultural importance of the Cerrado region, this work aimed to evaluate the Zn levels and spatial variability in Brazilian Cerrado soils. A total of 18,636 geo-referenced soil samples (0-20 cm) from agricultural areas in Central Brazil were statistically analyzed. Additionally, in order to better assess the Zn status with respect to plant needs, we evaluated not only available Zn but also other soil attributes that have a direct effect upon the phytoavailability of this micronutrient (e.g., pH, P, clay).

The skewness and kurtosis coefficients reinforce the normal data distribution, thus allowing the use of geostatistical tools. Then, kriging or other technique is eligible to be applied accordingly.

Soil Zn levels (Mehlich-1 extractable) ranged from 0.1 to 16.2 mg Zn dm-3 (average = 4.8 mg dm-3; median = 4.0 mg dm-3). Nearly one out of every four samples (n = 4520) contained < 1.6 mg dm-3, which is the lower limit for adequate Zn levels for crop production in Cerrado soils. As a single indicator of plant availability, the Mehlich-1 extractable Zn levels found in these areas do not suggest that Zn deficiency could be a problem in Cerrado soils. However, one should realize that these samples were taken only in highly technified farms that use precision agriculture as a management tool. Due to the investment itself and the highly qualified labor required by this system, such figures may have overestimated the Zn levels in the region, as farmers with such high technology are probably more accurate in their plant nutrition programs, often overcoming acute deficiencies in their farms.

Yet, considering that pH, P levels and soil texture are important factors influencing Zn availability in tropical soils, we decided to analyze such attributes in order to better assess the Zn status in these Cerrado soils. Values for pH varied from 3.8 to 8.0, with an average of 5.94. This value is within the 5.5-6.3 range described as ideal in the region. Phosphorous levels, in contrast, were rather variable, ranging from 0.1 to 194.7 mg P dm-3 (average = 9.5 mg dm-3). This upper limit observed for soil P is well above the agronomic classification where farmers would have an economic crop response from added P. Furthermore, this high P levels can promote the reduction of Zn uptake by plants.

In addition to high P, high clay contents can also lead to increasing Zn deficiency due to adsorption of this element. In our study, clay values ranged from 2.0 to 88% (average = 53%; median = 57%). Nearly 40% of the samples were classified as very clayey (clay > 60%) and 44% as clayey soils (36-60% clay).

Although 76% of the samples have presented adequate available Zn (Mehlich-1), we noticed that high pH and high P occurred for nearly 40% of the samples. Furthermore, 84% of samples presented high values of clay. Thus, considering the area covered by the database we used (~40 million hectares), and based on the analyses and cross-checkings of soil information, there are indications that 57% of the area studied (~23 million ha) is under risk of Zn deficiency, either due to low soil Zn levels or because of a combination of factors (high P levels, pH or clay content) that could induce Zn deficiency to plants. This is in agreement with worldwide estimates, which indicate that nearly 50% of the soils cultivated worldwide with grains are Zn deficient.

A previous pilot study conducted in Minas Gerais State in a region mostly covered by the Cerrado vegetation have suggested that Brazil could have a deficit of 43,600 tones of Zn year-1. In this study, the authors considered some natural and agricultural practices that influence Zn availability status in soils and plants, e.g. soil texture, fertilization rates and pH.

Keywords：*zinc deficiency, Cerrado Soils, precision agriculture, Brazil*

P2-22

[IDS3] Soil Information and Food Security

Screening and Selection of Sri Lankan Rice Varieties for Phosphate Deficiency Tolerance

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Phosphorus (P) is one of the six essential macronutrients required by plants. Plant roots acquire phosphorous primarily in the form of H2PO4-, from the soil solution. In soil generally phosphate is the most unavailable and inaccessible compound for plant growth. Comparing other nutrition's phosphate concentration in soil solution is relatively low and soils with low pH, high aluminum and ferrous ion content tightly bound soil available phosphates. More than half of the world's rice (Oryza sativa) lands are phosphorus-deficient. Phosphorus deficiency has been identified as one of the major limiting factors in rice production. Phosphate deficiency causes rice plants to become stunted, reduced yield and delayed flowering and maturity. Addition of fertilizers may solve the problem. Excessive amounts of phosphate fertilizer usage causes environment and health problems. The source of phosphate fertilizer, phosphate rocks will become a finite resource and which will be available only for next few generations. Increasing fertilizer prices will be a serious problem for poor farmers in developing countries. Development of phosphate efficient crop cultivars is one of the solutions.

Eleven rice varieties (traditional and Improved) in first season and thirty varieties in second season were screened under greenhouse conditions and twelve varieties in first season and twenty varieties in second season were screened under field conditions. Nitrogen, Potassium, Zink fertilizers were added in recommended level. Two levels of phosphate P0 (P2O5 5 Kg/ha or less present in soil) and P30 (P2O5 30 Kg/ha) was applied. In the experiment phosphorous was the limited factor for plant growth in P0 level. Experimental design was completely randomized design (CRD) with four replicates. Growth medium was soil collected from non fertilizer field at RRDI (Rice Research and Development Institute, Bathalagoda, Sri Lanka), which maintained without applying fertilizers for last 30 years. Plants were maintained with daily watering and other standard management practices till flowering stage.

Plant height and number of tillers were taken in every two weeks interval. Plant leaf color measurement (dL, da, db) was taken two months after planting. All plants were harvested at flowering stage and plant dry weight, plant phosphorous content, remaining soil phosphorous content, root length were measured.

Data analysis was done by SAS 9.1 statistical software. Shoot dry weight and tiller number were found to be the plant parameters most sensitive to phosphorus deficiency. These two parameters were used for screening rice genotypes for phosphate deficiency tolerance under greenhouse and field conditions. In deficient soils plants developed larger root system with more and longer roots, which enables plants to explore a greater area in the soil and find more phosphates than usual. Also there is a prominent dark green

coloration development can be observed in rice leaves under deficient conditions. It is a better visual deficiency symptom that can be used to identify hunger at early growth stages. As plant height is a variety dependant character which cannot be used as a reliable parameter for screening phosphate deficiency tolerance.

From morphological screening and biochemical analysis of thirty rice varieties, five rice varieties from each extreme were selected as highly deficient tolerant and highly sensitive. Varieties H4, Murungakayan, Mas, Kokuwellai, and H10 were grouped in to highly tolerance and Bg 352, Bg 357, Bg 300, Bg 250, H7 varieties were highly sensitive. It was made crosses between the two extremes of parents (phosphate deficiency tolerance and sensitive) by using clipping method. F1 generation was grown at field condition and F1 was self to produce F2 population. Three F2 populations with two hundred individuals in each were maintained till flowering stage. Each individual plant in each F2 population will be screened for phosphate deficiency tolerant. Genetically phosphorus uptake1 (Pup1) is a major QTL responsible for the phosphate deficiency tolerance in rice. Pup1 specific markers can be used to validate the selected tolerant rice genotypes for phosphate deficiency. In future it will be identified more genes and QTLs for the phosphate deficiency tolerant in local rice germplasm. Developed gene specific markers can be used for future breeding programmes. Marker assisted breeding considerably enhance crop productivity under low phosphate conditions. Development of rice varieties with high yield under low phosphorus input will be a solution for profitable rice farming in marginal lands.

Keywords：*rice, phosphorus, phosphate deficiency, fertilizer, marker assisted breeding*

P2-23

[IDS3] Soil Information and Food Security

Can Diffuse Mid Infrared Reflectance Provide Information on Soil Micronutrient Status?

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Soil micronutrients are important for plant-, human- and animal health but their availability in soils is usually variable: from extreme deficiency to sometimes abundant and even toxic levels. The availability levels and relationship with eco-regions (e.g. areas of similar soils and vegetation) are determined by soil properties e.g. mineralogy, organic matter, pH and redox reactions. These properties present challenges in the choice of analytical techniques for the determination of micronutrients. Commonly used reference methods for analyses include AAAc-EDTA extraction to determine easily soluble Cu, Fe, Mn, Zn, Mo, Pb and hot water extraction to determine soluble B, but these are often expensive and time-consuming and hence have been rarely used in routine soil micronutrient analysis. Mid infrared (MIR) spectroscopy is increasingly used to predict a number of soil properties and it has potential to bridge the gaps in the data.

The objectives of this study were to evaluate the potential of MIR to predict micronutrient status while reanalyzing archived soil (n=1649) samples after long-term storage (40 years). The samples were collected from 30 countries from across the world and measured for Cu, Mn, Mo, Zn, B, Pb, Co, and Fe using reference methods. The micronutrients were in a wide range: Cu (0.03 - 100), Mn (0.9 - 378), Mo (0.007 - 3.6), Zn (0.09 - 185), B (0.06 - 10), Pb (0 - 38), Co (0 - 421), and Fe (0 - 445) showing significant differences in the micronutrient contents of the different soils. The spectra of the samples were recorded between 4000-600 cm-1 range. A modified partial least squares method with cross-validation will be used to develop calibration models for prediction of micronutrient properties of the samples from their spectra. Predictive models based on MIR spectra are under development for all properties.

Keywords：*Mid infrared, micronutrients*

P2-24

[IDS3] Soil Information and Food Security

Potential of Mir, Txrf And Xrd as Complementary Techniques for Assessment of Soil Properties

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New, rapid methods to quantify soil properties are needed especially in developing countries of sub-Saharan Africa (SSA) where reliable data on soil properties is sparse and dated. Mid-infrared Fourier-transform diffuse reflectance spectroscopy (MIR) offers rapid and low cost analysis, with little sample preparation requirements. MIR is now being applied to develop new digital soil maps in Africa (www.africasoils.net). However, MIR has limitations in predicting some elements e.g. extractable P and K, the main limiting nutrient in soils of SSA. In addition, MIR is limited in its applicability to a small range of elements and often matrix interferences require extensive calibration for different environments. There is potential to complement MIR with other high-throughput techniques such as Total X-ray Reflectance Spectroscopy (TXRF) for total element composition fingerprinting, and X-Ray Diffraction (XRD) for mineral profiling. In this study, we evaluated the potential of combinations of MIR, TXRF and XRD techniques for prediction of soil properties. MIR prediction of a number of soil properties for a set of georeferenced soil samples associated with the Africa Soil Information Service (AfSIS) project collected from 44 stratified randomly-located 100-km2 sentinel sites, randomized across sub-Sahara Africa, were done using the Random Forests (RF) algorithm. RF regression models were developed using MIR data and also used to model the residuals of the predictions against TXRF spectra combined with MIR first derivative spectra. We also used RF regression of TXRF element concentrations against dominant mineralogy groupings and raw semi-quant mineralogy data measured using XRD.

MIR resulted in good prediction models (R2>0.80) using RF out-of-bag validation for organic and total C and N, Mehlich 3 extractable Ca and Al, and pH. Acceptable models (R2>0.60) were obtained for exchangeable bases and exchangeable Mg, but models were poor (R2<0.60) for exchangeable Na, and Mehlich-3 extractable P, K, S, Na, Cu, and Zn. The prediction performance of combined MIR and TXRF spectra was better than MIR alone for several soil properties. Relative improvements in prediction accuracy over MIR alone were: exchangeable Na (828%), Mehlich-3 S 350%; Mehlich-3 Zn; 150%; and Mehlich-3 Cu, 10%. However, TXRF data was generally limited in explaining the residuals of the MIR predictions for extractable P and K. Element concentrations measured using TXRF could be predicted relatively well from XRD-measured mineralogy composition with prediction r-square of 0.71 for raw mineralogy traces and 0.81 for dominant mineralogy grouping. The results indicate that TXRF fingerprinting reflects mineralogical composition. Thus, high-throughput TXRF and/or XRD measurements could supplement MIR prediction of soil properties and help stabilize calibration models across soil types with widely different mineralogy.

Keywords：*Mid infared spectroscopy,Total X-ray Reflectance Spectroscopy, X-ray diffraction*

P2-25

[IDS3] Soil Information and Food Security

Effects of Different Soil Inputs of Swat on Basin-Scale Hydrological Simulations in China

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The well-informed spatial and attribute bio-physical databases are essential inputs for distributed hydrological models when investigating hydrological cycles and performing water resources assessments at basin scale. China, as a developing country, lacks such developed databases when performing similar studies, i.e. national-scale soil spatial and attribute database. To conduct model-based national-level basin-scale water resource investigation, it's of necessity to establish a prototype soil database covering dominating soil types and embracing main soil physical and chemical properties. The objective of the research is threefold: 1) introduction and adaptation of UNFAO global soil spatial and attribute databases into SWAT (Soil and Water Assessment Tool) to perform water cycles analysis; 2) development of SWAT-required China National Soil Database based on the soil profiles data of China National Soil Survey; 3) comparison of the effects of the two soil databases on simulating main hydrological cycle components, i.e. stream flow, soil moisture (plant available water) and surface water resources at basin level. In order to compare the effects of different databases, five scenarios of soil databases are formulated: 1) original UNFAO soil database, FAO1; 2) UNFAO soil database with revised Available Water Content (AWC), FAO2; 3) original China soil database, China1; 4) China soil database with revised AWC, China2; 5) China soil database with revised AWC and soil depth, China3. Huai River Basin is selected as the case study area, and 2000-2005, 1980-1989, 1996-2000 are specified as the model running time periods to validate the daily stream flow, monthly soil moisture and annual surface water resources, respectively. The research results revealed that the original China soil database performed better than original FAO soil database in simulating daily stream flow, while original FAO soil database better than original China database in simulating soil moisture. After equally revising soil AWC, China soil database displayed better results than FAO database in all three components simulation. For China soil database, the effects of combined revision of AWC and soil depth obtained a much more satisfactory outcome than singly revision of AWC. The paper concludes that the revised China soil database could be applicable in simulating hydrological components to conduct water resource assessment at basin scale; the revised UNFAO soil database is a second-best alternative and still appropriate for similar investigations in the context of scarcer soil data availability.

Keywords：*Distributed hydrological model; SWAT; Soil database; Available soil water; Soil depth; Huai River Ba*

P2-26

[IDS3] Soil Information and Food Security

Extracting Soil Water Storage Pattern Using a Self-Organizing Map

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Soil water is one of the important controlling factors regulating plant growth in a semi-arid environment. It is distributed non-uniformly and exhibits spatial patterns in the landscape. Research has identified different controls of soil water in wet and dry state,; however, there are no objective methods for differentiating the dry and wet state. The objective of this study was to extract the temporally persistent temporal spatial patterns of soil water using a Self-Organizing Map (SOM) and identify benchmark sites for different patterns of soil water. Soil water storage along a transect of 576 m at 4.5 m intervals in a farm field in Saskatchewan, Canada was monitored from 2007 to 2009. A SOM was used to extract the patterns of soil water storage of the surface 0.2 m depth compartment. Two patterns were identified: pattern 1 for dry states and pattern 2 for wet states, with the occurrence frequency of 52.9% and 47.1%, respectively. Pattern 1 was often found in summer and fall, and pattern 2 in early spring, and summer in wet years. Soil texture and organic carbon (OC) content have showed a strong correlation with soil water storage in dry states (pattern 1) and wet states (pattern 2). Based on the above finding, benchmark sites from each of the two patterns were identified, and they were not adjacent in terms of spatial location. Therefore, soil water states can be identified by using SOM and differentiation of wet and dry states enable identification of more representative benchmark sites.

Keywords：*Self-Organizing Map (SOM), soil water storage, temporal time stability*

P2-27

[IDS3] Soil Information and Food Security

The Effect of Soil Nitrogen and Relevant Microorganism under Different Fertilization Treatment in Camellia Oleifera Forest

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Using 'Ganwu' Clone of Camellia oleifera Abel as experimental material, this test set four different fertilizer treatments: Camellia specialty fertilizer(ZYF), organic fertilizer(YJF), compound fertilizer(FHF), no fertilizer(CK) and each treatment set 3 sample plots, totaling 12 plots. The results showed that: (1) Under different fertilizer treatments, the content of total nitrogen, ammonium nitrogen and nitrate nitrogen varied greatly. The annual average content of total nitrogen was ranked as ZYF > FHF > YJF > CK. Under different fertilizer treatments, seasonal variations produced a remarkable effect on the average content of total nitrogen whose trends were an increase from spring to autumn and the content reached the maximum in autumn. The annual average content of ammonium nitrogen was ranked as ZYF > YJF > FHF > CK and the content reached the highest in summer and the lowest in winter. The annual average content of nitrate nitrogen was ranked as ZYF > FHF > YJF > CK. The content of nitrate nitrogen had distinct seasonal variations, but the seasonal variations were not consistent in different fertilizer treatments. (2) Under different fertilizer treatments, the number of ammonifier and nitrite bacteria varied greatly. The annual average number of ammonifier and nitrite bacteria was ranked as YJF > ZYF > FHF > CK. The number of ammonifier had distinct and consistent changes in relation to seasonal variations, it reaching the highest in autumn and the lowest in winter. The number of nitrite bacteria did not change obviously in relation to seasonal variations. (3) Different fertilizer treatments in same season brought about significant differences to both ammonification intensity and nitrification intensity excepting ammonification intensity with FHF and ZYF treatments in autumn. The average annual levels of ammonification and nitrification intensity were ranked as YJF > ZYF > FHF > CK. Under different fertilizer treatments ammonification intensity accorded with consistent tendency in four seasons, which began to increase from spring till it reached its maximum in autumn and then started to decline till it reached its minimum in winter while the changes of nitrification intensity were inconsistent in four seasons under different treatments. (4) Under different fertilizer treatments, ammonium nitrogen, ammonifying bacteria and ammonification intensity significantly correlate at the 0.01 level. There is significant correlation among nitrate nitrogen, nitrite bacteria and nitrification intensity at the 0.01 level. Total nitrogen, ammonium nitrogen and nitrate nitrogen also significantly correlate at the 0.01 level.

Acknowledgement:The work reported here has been funded by National Natural Science Foundation of China (30960312)、（31360177）and National Science and Technology Support Project (2012BAC11B06),The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Soil nitrogen;Microorganism;fertilization treatment;Camellia oleifera*

P2-28

[IDS3] Soil Information and Food Security

Land Evaluation with Digital Soil Mapping for Regional Agricultural Resource Assessment

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Northern Australia is a vast are of the continent with a sparse population and comparably low economic output. There is a ever present desire for agricultural intensification in Northern Australia to increase agricultural output and become a food bowl to Asia. With these goals in mind, the Australian and Queensland Governments have partnered to undertake the Flinders and Gilbert Agricultural Resource Assessment (FGARA) to evaluate at a regional level the possible opportunities to deliver on the visions of vast areas of new high intensity agricultural production in Queensland's Southern Gulf region.

The project evaluated crop suitability in the 155,000 km2 Flinders and Gilbert River catchments for some 40 different crops under different land management and irrigation scenarios. This complex project in a remote area had a number of constraints including the limited 18 month timeframe, a paucity of legacy data with some dating to the 1950's and the variable climate and therefore field accessibility of a monsoonal climate regime.

Thomas et al at this conference have described the digital soil mapping that was completed for the project which produced the suite of 16 soil attributes which were used to complete the land evaluation.

The land evaluation approach is based on the traditional FAO style of evaluating land use requirements for each land management scenario. Each land use is rated on a five-class scale for being suitable with no limitations to being unsuitable with severe limitations. The land use requirements are then turned into limitations and limitation values are described to assess against. The limitations used in this study include rockiness, soil depth, soil water availability, soil wetness and water erosion potential. Each limitation is described and then rated against the outputs of the digital soil mapping. For example, soil water availability is the limitation for plant available water capacity (PAWC). In the digital soil mapping, PAWC was modelled and predicted across the catchments, the continuous PAWC prediction was converted to categories against the limitation values. Every land management scenario is evaluated for each limitation with the most limiting factor being the overall land suitability. The land suitability assessments were carried out using custom Python scripting to rapidly evaluate each land use scenario across the study area.

The marriage of cutting edge digital soil mapping techniques with more traditional land evaluation approaches proved to be a robust combination for rapid assessment of regional scale agricultural potential in remote areas. The short timeframes coupled with a lack of data and a lack of empirical evidence about crop behaviour in northern Australia precluded the use of production systems modelling to have a fully quantitative approach to land evaluation. The ability to perform a rapid evaluation of the likely scale of opportunity for agricultural intensification for the FGARA project proved invaluable to the broader project team and the client governments. Furthermore, the availability of reliability estimates from the digital soil mapping has allowed further information to be communicated about the reliability of the land evaluation assessments.

Keywords: *agricultural resource assessment, digital soil mapping*

P2-29

[IDS3] Soil Information and Food Security

Wheat Seedlings Urease Activity as Affected by Nickel and Nitrogen Sources

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Nickel is one of the essential micronutrients for higher plants and its main function is acting as prosthetic group for urease. The effects of different concentrations of nickel and two different nitrogen sources, urea or ammonium nitrate, on wheat seedlings urease activity were investigated. The experiments were carried out as completely randomized blocks with three replications. Wheat seedlings were grown in nutrient solutions containing 84 mg L-1 of urea or ammonium nitrate and 0, 0.01, 0.05 and 0.1 mg L-1 nickel in the form of NiSO4. Plants were grown in nutrient solutions for six weeks. The urease activity of both roots and leaves was determined after the second, fourth and sixth week of the experiment, and at the end, shoots and roots dry weights were determined. Urease activity in young leaves of plants supplied with ammonium nitrate, increased up to the second nickel level (0.01 mg L-1) however, further increase in nickel supply reduced urease activity. The highest urease activity in this group occurred on the second week. Urease activity in young leaves of plants supplied with urea increased significantly up to third nickel level (0.05 mg L-1) and was reduced beyond this concentration. The highest urease activity in this group occurred on the 4th week. Urease activity in the roots of plants supplied with ammonium nitrate and urea was the highest at the second nickel level which occurred on the second week. With the increase in both nickel levels and the duration of experiment, urease activity started to decrease. Roots enzyme activity was higher than that of shoots and was also higher in plants supplied with urea. Similarly, the shoots and roots dry weights of plants supplied with urea were higher.

Keywords：*Ammonium nitrate, nickel, urea, urease activity, Wheat.*

P2-30

[IDS3] Soil Information and Food Security

Tea Green-Leaf Yield as Affected by Soil Fertility: A Case Study with Small-Holder Tea Planters in Kegalle and Kandy Districts in Sri Lanka

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Sri Lanka is one of the world's leading tea exporters catering to 19% of the global tea demand. Tea (Camellia sinensis (L.) O. Kuntze) is being cultivated in approximately 222,000 ha in Sri Lanka as estates or small holder's plantations. Tea industry contributes to 1.6% of GDP. Declining trend in green-leaf tea yield over the years has become a major concern for tea growers. Soil fertility deterioration could be a major reason though its link with diminishing tea yield has not been studied in Sri Lanka. Soil organic matter (SOM) contributes to maintain overall soil fertility and productivity. Most of the tea plantations are being cultivated with minimum or no measures to replenish SOM. The objective of the present study is to understand whether SOM levels, CEC and pH of soils affect green-leaf tea yields. Small holder tea plantations (extents of < 4 ha) from two districts, Kandy and Kegalle, were selected for the study.

Soil samples were collected from 0 to 15 cm soil depth from 47 locations in Kandy (Wet-zone Mid-country) and 50 locations in Kegalle (Wet-zone Low-country). Yield data and management practices related information of the sites were collected via a survey. Soils were analyzed for pH, soil organic carbon (SOC) and cation exchange capacity (CEC), using glass electrode method (1:2.5w/v soil to water ratio), Walkley and Black method and NH_4^+ ion as an index ion method at pH 7, respectively. Data were statistically analyzed performing multiple regression analysis to obtain relationships between yield and measured soil properties and management practices. Correlation analysis were conducted at $p < 0.05$.

green-leaf tea yield in the selected plantations ranged from 230 to 2,350 kg ha^{-1} $month^{-1}$. From this 50% of fields had poor yields (<1,000 kg ha^{-1} $month^{-1}$) and 4 % had good yields (3,200 kg^{-1} ha^{-1} $month^{-1}$) and the remaining 46 % had moderate yields. The age of the crop varied from 4 to 35 years. Soil organic carbon, pH and CEC varied in the ranges of 0.25 – 2.97 %, 3.98 – 7.17 and 3 – 17 $cmol_c$ kg^{-1} dry soil, respectively. Result indicated a positive correlation between SOC and tea green-leaf yield (r = 0.63). A stronger correlation between tea yield and SOC was observed in Kegalle (r = 0.74) than in Kandy (r = 0.54). A significant trend in declining SOC with increasing crop age was observed only in Kegalle tea fields (r = -0.85). Less than 1% SOC was found in 68% of samples from Kandy and 22% in Kegalle. In Kandy district soil pH had a strong negative correlation with the age of crop (r=-0.57).

Multiple regression analysis was conducted separately for the two sites. Results indicated that the regression coefficient of the model developed using yield as the dependent variable and three soil properties measured as predictors is significant at $p<0.05$. The contribution of SOC, pH and CEC collectively to the variability in green-leaf tea yield among fields in Kandy was 33 % and it was 56 % for Kegalle. Accordingly, 67 % remained unexplained from the linear regression model for Kandy and 44% was unexplained

for yield variability in Kegalle. Both in Kandy and Kegalle districts the highest contribution to the yield was from SOC, which explained 96 and 97%, respectively, of the variability predicted from measured soil properties.

The analysis of survey data on management practices at small-holder tea plantations in Kandy districts indicated good management practices such as timely application of fertilizers according to recommendations, sufficient shade management, application of lopping's as a green manure, adapting soil conservation measures, liming of soil and rehabilitation before planting tea, collectively contributed to improve tea yield ($r = 0.63$). The contribution of practicing soil rehabilitation and adopting soil conservation measures to improve yield in Kandy was significant ($r = 0.45$). The effect of management practices on green-leaf tea yield was not significant in Kegalle tea plantations.

The results indicate that there is a potential to increase tea green-leaf yield by improving soil fertility. Strategies to replenish SOM are worth for considering for improving soil productivity in tea plantations in Sri Lanka.

Keywords：*Soil organic carbon, pH, CEC, Tea green-leaf yield, soil fertility*

P2-31

[IDS3] Soil Information and Food Security

Corn Growth and Corn Yield Due to Organic Matter Treatments and Npk Fertilizer Applications in South Sumatera Uplands, Indonesia

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The aim of this study was to investigate the effects of organic matter treatments and NPK fertilization at several rates on the soil chemical and physical characters, the growth and yield of corn. The research were conducted at Agro Techno Park Indralaya, from February 2011 through July 2011. The method used was split plot design to evaluate organic matter and NPK fertilizer effects. The organic matter treatments consisted of K1 = soils planted with mucuna, K2 = soils planted with cowpea, K3 = soils with mucuna compost, K4 = soils with dried corn stalks compost, K5 = corn stalks incorporated, K6 = soils incorporated with cowdung, and K7 = soils left fallow. The organic matter used was 3 ton ha-1. The area that were applied with organic matter 3 months before was planted with maize with NPK fertilizer treatments. The organic matter represented the main plot, while NPK fertilizer treatments were as sub-plots. The NPK fertilizer applications consisted of : P0 = without NPK fertilizer, P1 = 25%, P2 = 50%, P3 = 75%, and P4 = 100% of standard rate (urea 400 kg ha-1, SP-36 100 kg ha-1, KCl 50 kg ha-1). Cowpea (Vigna unguiculata) gave the highest corn yield. The use of organic matter was able to reduce the use of NPK fertilizer. The combination of incorporated corn stalks with 50% of NPK fertilizer registered the highest corn yield.

Keywords : Corn, fallow, mucuna, organic matters, fertilizer.

P2-32

[IDS3] Soil Information and Food Security

Introduction Of Pulse Crop in Rice - Fallow System Through Use of Conservation Agriculture Practices In Western Odisha

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In eastern India, vast areas are lying fallow after the rice crop is harvested. Rice ? fallow areas can be better utilized in establishing pulse crop utilizing the residual soil moisture through conservation agricultural practices. To exploit these rice fallow areas with pulses, location specific and economically viable technology for better performances of pulses are required to be standardize through proper understanding of the system ecology and constraints. Conservation agriculture practices may help to establish the pulse crops like green gram, lentil, pea etc. with the help of zero tillage and residue mulching. Zero tillage helps in conserving in-situ residual moisture and timely sowing of crops after rice harvest and residue mulch helps in maintaining/conserving the in-situ soil moisture for longer period, thus enhancing the crop productivity. A field experiment was conducted for 2 consecutive years during 2011 and 2012, to study the effect of conservation agricultural practices on green gram after the harvest of rice crop by utilizing the residual soil moisture. The study revealed that the grain yield, stover yield and yield attributes were significantly improved with conservation agricultural practice involving zero tillage and rice residue cover on soil surface @ 3.0 t/ha. The maximum grain and stover yield of 531 and 1568 kg/ha, respectively was obtained in treatment receiving zero tillage followed by rice straw covering as mulch. Crop residue cover over ZT helped in covering the soil moisture and creating better micro-climate for crop growth and development. The energy requirement for greengram cultivation was maximum of 8756 MJ/ha in conventional tillage without residue, while its requirement for energy was lowest of 7322 MJ/ha in zero tillage without residue. It was concluded that a pulse crop like greengram can be successfully established with the help of conservation agriculture practices with maximum yield and profit.

Keywords：*Conservation agriculture, Greengram, yield, energy*

P2-33

[IDS3] Soil Information and Food Security

How Soil Erosion Affects Soil Quality and Corn Yield in the Mollisol Region of Northeast China

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The Mollisol region of Northeast China is an important base of crop production for China, However, due to improper land management, soil erosion in this region becomes increasingly serious during the past 50 years, which greatly decreases soil quality and soil productivity, consequently, all those reduce crop yield and further threaten the food security of China. Therefore, a better understanding how soil erosion affects soil quality and crop yield is important for controlling soil erosion and sustaining soil productivity in this region. This study used ^{137}Cs tracer technique to estimate soil erosion rate and used soil quality index to characterize soil quality, and then we investigated how soil erosion and deposition affects soil quality and crop yield. The results showed that along the slope length, erosion rate increased from the summit to the shoulder and back slopes, then decreased at the foot-slope, while deposition occurred at the toe of slope. When slope gradient was less that 5%, erosion rate increased slowly, while when slope gradient was larger 5%, erosion rate increased greatly. Soil erosion intensity increased from upstream to downstream in catchment. In the upstream of catchment, erosion regime was dominant and erosion rate was 1922.0 $t•km^{-2}•a^{-1}$; in the middle-stream of catchment, both of detachment dominant and deposition dominant existed, erosion rate was 1330.6 $t•km^{-2}•a^{-1}$1 and deposition rate was 1107.8 $t•km^{-2}•a^{-1}$; in the down-stream of catchment, deposition dominant was dominant and deposition rate was 1348.5 $t•km-^{-2}•a^{-1}$. Based on correlation analysis, sensitivity analysis and principal component analysis, we chose MWD_{sw}> 0.2mm soil water-stable aggregate, soil organic matter, total nitrogen, available nitrogen, rapid available phosphorus, invertase, soil microbial biomass carbon from 18 soil feature indicators as appropriate indicators for soil quality evaluation. Soil quality in the downstream of catchment was best, and then followed the middle-stream of catchment, while soil quality in the upstream of catchment was worse. Soil quality in the eroded areas was lower than deposed areas in the catchment. Soil quality indexes had very significant negative correlation with soil erosion rate. Soil erosion intensity not only had an important influence on spatial distribution of soil quality, but also had significant negative impacts on the soil quality level, which revealed that soil erosion was the key driving force to reduce soil quality. Corn yield in eroded areas was significantly lower than deposed areas in the catchment, while corn yield had a highly significant positive correlation with soil quality. The results showed that soil quality had a positive effect on crop yield and well its spatial distribution, while soil erosion had negative effects on corn yield and its distribution.

Keywords：*corn yield; Mollisol region; soil erosion; deposition; soil quality*

P2-34

[IDS3] Soil Information and Food Security

Drip Fertigation on the Nutrient Uptake and Grain Yield of Pigeonpea

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Pigeonpea (Cajanus cajan (L.) Millsp.) is nutritionally well balanced and is an excellent source of protein. In addition to protein, pigeonpea provides carbohydrates and high levels of vitamins A and C. In India, pigeonpea is grown in an area of 4.37 m.ha, with a production of 2.65 m.t and the average productivity is 655 kg ha-1(FAOSTAT, 2012). Water and nutrient are the most important production factors influencing productivity of pigeonpea.

Drip fertigation permits application of nutrients directly at the site of high concentration of active roots (Sivanappan et. al., 1987). With this background, field experiments were conducted during August-February of 2011-12 and 2012-13 at Tamil Nadu Agricultural University, Coimbatore to study the effect of drip fertigation on the performance of pigeonpea. Fourteen treatments comprising of three irrigation regimes (50, 75 & 100% WRc) and three fertilizer levels (water soluble fertilizer (WSF) viz., 75, 100 & 125% RDF) and conventional fertilizer through drip fertigation along with surface method of irrigation and conventional method of fertilizer application were evaluated in pigeonpea for their effect on nutrient uptake and yield. The treatments were laid out in randomized block design with three replications. The soil of the experimental site was sandy clay loam. The soil available N, P2O5 and K2O were 226, 18 and 429 kg ha-1, respectively. Pigeonpea var. LRG 41 (180 days) was used as the test variety.

The spacing adopted was 150 cm between laterals and 60 cm between drippers. Surface irrigation was scheduled with IW /CPE ratio of 0.6 at 5.0 cm depth. For irrigation through drip system, first irrigation was given immediately after sowing and life irrigation was given on 3 days after sowing. Subsequent irrigations were scheduled once in seven days. The computed water requirement of crop (WRc) was calculated based on the formula,

WRc = CPE x Kp x Kc x Wp x A

where, WRc : Computed water requirement (lit plant-1)

CPE : Cumulative pan evaporation for seven days (mm)

Kp : Pan factor (Ravikumar et al. 2011)

Kc : Crop factor (Singandhupe et al. 2005)

Wp : Wetting percentage (0.8)

A : Area per plant (150 x 60 cm)

In surface method of irrigation, the recommended dose of fertilizers (25:50:25 kg N, P2O5, K2O ha-1) were applied as basal for surface irrigated and drip irrigated plots. The conventional fertilizer (CF) sources used were urea, single super phosphate and muriate of potash. In drip fertigation with water soluble fertilizer (WSF), nitrogen, phosphorus and potassium were applied as per the fertigation schedule in the form of mono ammonium phosphate (12:61:0), urea (46 % N) and sulphate of potash (50 % K).

The total nutrient uptake by pigeonpea at different growth stages and yield data revealed that the total nitrogen, phosphorus and potassium uptake and grain yield varied significantly due to drip irrigation and fertigation levels during both the years of study. The drip fertigated crop either with WSF or CF registered higher total nitrogen, phosphorus and potassium uptake and yield over surface irrigation with conventional method of fertilizer application. Drip irrigated crop at 100 % WRc with fertigation at 125 % RDF through WSF recorded the highest nitrogen, phosphorus and potassium uptake and grain yield (2812 and 2586 kg ha-1 during 2011-12 and 2012-13, respectively) and was comparable with drip irrigation at 100 % WRc along with fertigation at 100 % RDF through WSF.

` The maximum uptake of nutrients might be due to continuous availability of moisture which in turn helped in easy absorption of plant nutrients. In surface irrigation, the plant nutrients leached beyond the root zone due to higher quantity of irrigation water and also observed leaching of plant nutrients when downward soil moisture movement exceeded effective root zone. Fertigation with water soluble fertilizers allows easy application of nutrients directly to the rhizosphere so as to match the physiological needs of the crops for better root development with P fertilizers and N and K fertilizers for better vegetative and pod development stages. Hence, for enhanced productivity of pigeonpea and water use efficiency, drip irrigation at 100 % WRc with fertigation at 100 % RDF through WSF can be recommended.

Keywords：*Drip fertigation, computed water requirement, water soluble fertilizer, conventional fertilizer, nut*

P2-35

[IDS3] Soil Information and Food Security

Genotypic Variations in Phosphorus Acquisition and Utilization Efficiency in Rice

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Phosphorus (P) is one of the major factors worldwide limiting crop growth. P efficient plants play a major role in increasing crop yields due to shortage of inorganic P fertilizer resources, limited land and water resources and increasing environmental concerns. Plants have evolved a diverse array of strategies to obtain adequate P under limiting conditions, including modifications of root architecture, carbon metabolism, membrane structure, exudation of low molecular weight organic acids, protons, enzymes and enhanced expression of the numerous genes involved in low-P adaptation. Therefore, the development of P-efficient rice varieties that can grow and yield better with low P supply is a key to improve crop production. Exploitation of genetic variation in plants in nutrient efficiency has been increasingly explored and emerging as a variable alternative approach to crop production in low nutrient environment. Enhancing P efficiency in plants can be achieved through improving acquisition and utilization or both. However, the contribution from P acquisition efficiency (PAE) or Phosphorus use efficiency (PUE) to crop P efficiency varies with crop species and environment conditions.

Focusing on this, a field experiment was conducted in a clay soil belong to Noyyal soi series (Vertic Ustochrept) with twenty two rice genotypes (varieties, pre-release cultures and land races) in low phosphorus soil at Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore with two levels of P viz., 0 and 50 kg P2O5 ha-1 in a randomised block design with three replications. Nitrogen and K was applied in four equal splits and full dose of phosphorus was applied as basal. Among the twenty two genotypes evaluated, 12 genotypes yielded higher at control P with N and K application and ten genotypes yielded higher at enhanced level of P with N and K application. Maximum grain yield was registered in TNRH-180 (7434 kg ha-1) at control P while CB08504 (7061 kg ha-1) at higher level of P. In rice genotypes, the phosphorus efficiency was highest in the order of CB08513 (152.1%) > ASD-16 (128 %) > CB08509 (126.9 %) > CB06732 (125.4 %) > CORH 3 (121.2%) > TNRH 180 (121.1%). Rice genotype TM07278 recorded the highest phosphorus uptake efficiency (9.3 kg kg-1) followed by CB08504 (8.1 kg kg-1), TNRH 180 and CB08509 (7.6 kg kg-1) and ADT 47 (7.5 kg kg-1). The lowest value of phosphorus uptake efficiency was recorded in the rice genotype ASD-16.

To study the root associated factors such as root morphology, architecture, nutrient absorption rate which can strongly influence Pi acquisition, seven rice genotypes viz., TNRH-180, ADT-47, CB08504, CB08504, AD07038 ASD-16 and AS06016 (5 highly efficient and 2 low efficient) were selected based on the P use efficiency and P uptake efficiency values from field experiment and screened at 0, 2.5 and 10 ppm P by employing solution culture technique in hydroponics experiment. Root morphological characters were studied at 30 and 60 DAS. Root volume, number of roots per plant, number of lateral roots, root : shoot ratio, shoot dry weight and total plant dry weight were higher at 60 DAS compared to 30 DAS. Enhanced level of P from 0 to 10 ppm increased the root volume, root dry weight and shoot dry weight at
60 DAS. The rice genotypes viz., TNRH-180, CB08509 showed higher root length at 30 DAS and 60 DAS.

The rice genotype CB08504 recorded the highest for root volume, TNRH 180 for root length and number of lateral roots, ASD 16 for shoot dry weight, AS06016 for root dry weight and CB08509 for root:shoot ratio at 60 DAS. The increase in root volume was due increase in longer and denser root hairs in response to low P availability. Rice genotype TNRH-180 registered the higher major nutrients (N, P and K) uptake. A large root system capable of exploring greater soil volume has therefore been recognized as one of the important adaptation of plants to ensure sufficient uptake of phosphorus at P deficiency. The acid phosphatase activity was the highest at 30 DAS for rice genotype ADT-47 while at 60 DAS CB08509 recorded the highest activity. Rice genotype TNRH-180 recorded the highest ATPase activity while AD07038 registered the lowest activity.

Keywords：*Rice, genotypes, Yield, root parameters, ATPase activity, acid phosphatase activity, Pi acquisition*

P2-36

[IDS3] Soil Information and Food Security

Soil Management Systems on Annual Crops in Brazil: Figures from the 2006 Agricultural Census

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During the 1970s, Brazil experienced rapid growth in area of land covered by annual crops (AC), and this has radically altered soil management practices as traditional tillage techniques have been replaced with mechanized processes. Traditional tillage causes soil compaction and leads to rainfall losses of soil, organic matter and nutrients. In the 1970s and 1980s, southern Brazil experienced major soil erosion, and these events were followed by mitigation measures implemented primarily by farmers, which were further supported by institutions (mainly government-based). During this period, two forms of soil tillage were developed to tackle soil erosion: minimum tillage (MT), using low-impact soil-tillage practices such as chisel plowing; and no-tillage (NT), considered the most innovative system, which allowed sowing directly over residues from the previous crop without other soil disturbance. The NT was formally initiated in Brazil by pioneer farmers in 1972, and rapidly involved agricultural research, equipment and supplies industries and rural extension service. Then, the NT emerged as the most important means of fighting soil erosion caused by the expansion of mechanized production of soybean and wheat. In the late 1980s and early 1990s, the NT system was adapted to the Brazilian Savanna region and to small-scale farms based on draft animal power. At the same time, integrated soil and water-conservation management programs were implemented by federal and state institutions, supported by international bodies. These programs encouraged the use of MT with chisel plowing and NT with direct drilling over the straw in addition to mechanical practices such as terracing and contour farming. In the mid-1990s, the area of land under NT reached one million hectares (Mha), and has since increased and has overtaken MT as an agricultural conservation system. Data on NT in Brazil in the last 30 years have been based on estimates made by the Brazilian No-Tillage and Irrigation Farmers' Federation (FEBRAPDP), using secondary data supplied by the Rural Extension Service of Rio Grande do Sul state (EMATER-RS/ASCAR), the Agricultural Research and Rural Extension Service of Santa Catarina state (EPAGRI), the Institute of Technical Assistance and Rural Extension of Paraná state (EMATER-PR), the Coordination of Integral Technical Assistance of São Paulo state (CATI-SP), the MS Foundation for Research and Diffusion of Agricultural Technologies (MS FOUNDATION) and the Brazilian Savanna No-tillage Farmers' Association (APDC). The expansion of NT in Brazil reached such a magnitude that in 2006, for the first time, the Agricultural Census conducted by the Brazilian Institute of Geography and Statistics (IBGE) carried out a survey on the amount of area with NT in its section on soil tillage practices in AC. Therefore, more reliable data on the use of NT and other soil management systems for annual crops in Brazil were made available in 2009 after publication of the 2006 Agricultural Census. The objective of this study was to present, analyze, and discuss the types of soil tillage used in annual cropping systems in Brazil using data from special tabulations of the 2006 Agricultural Census. While the surface area of NT in Brazil was estimated as 25.6 million hectares (Mha) in 2006, the the present study indicate that NT was used on approximately 17.8 Mha of annual crops. Furthermore, MT was used on 3.8 Mha, a combination of MT and CT was used on 3.1 Mha, and CT was used on 11.8 Mha, amounting to a national total of 36.6 Mha of AC. The research also presents the total area and participation of each soil management system in AC at regional and federative unit level. Although these figures still guarantee a prominent position for Brazil in terms of NT adoption at the global scale, they show that previously the NT area in the country was overestimated. The only approach that would result in consistency between the findings of the Agricultural Census and other estimates would be to consider the total NT, MT, and mixed CT and MT areas as conservation agriculture. This would result in approximately 24.8 Mha (67.8% of AC). The methods of collecting soil conservation data could be refined for the next Agricultural Census, which will be undertaken in 2015, by providing additional details that would enable improved classification and differentiation of soil tillage practices in Brazilian agriculture.

Keywords：*No-tillage, minimum tillage, conventional tillage, conservation agriculture*

P2-37
[IDS3] Soil Information and Food Security

Advances Measuring and Monitoring Carbon in Soils of Mexico

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Mexico currently carries out exhaustive research to reduce the effect of several factors that generate uncertainty in the measurement and monitoring of carbon. These factors are:

Sampling quality. This is the factor with the greatest effect on the measurements. The sampling quality is related to the heterogeneity of sampling methodology and design among institutions, which must be harmonized in order to achieve a common monitoring baseline. It also involves the measurements of all carbon pools at the same time and in the same place, prioritize quantitative over qualitative studies, including more efficient techniques of better estimate data errors associated with the native complexity of each ecosystem. Thus, dynamic approaches should include re-sampling for different dry or wet periods and contemplate different sampling methodologies for rare or extreme events as well.

Interference satelital. Changes through their lifespan and the error due to displacements, irregularities of the geoids, cloudy days and irregular dispersion of water particles are environmental factors linked to the problem and for last the heterogeneity in the height and canopy of the plants changes the aspect of the landcover. To this regard, it is important that the units of study are compatible in format and size in order to combine the information at any level of display: parcel-state-country-continent.

Propagation methods and modeling carbon fluxes. The key issue in the mapping of carbon is the vast difference between the measured surface and the total area of representation. Considering all data obtained from soil profiles and extractions augers in the world, the known surface only 1/106 of the total area. This implies moving towards increasingly holistic methods which include change the conceptualization of thresholds, ecotones and transitional grades of soils. Any effort in which measurement is oriented to characterize the parameters which determine the behavior of the major carbon attractants, it means the carbon attractant in the final stages of transitional states depends on the initial conditions associated with land use and management. Some examples of these variables are: nitrogen-carbon ratio, type of cellulose sheets, molecular characterization clays and intensity of radiance on the soil. It is essential that the models of carbon flows consider the resilience of ecosystems in order to assess trajectories, i.e. to evaluate the status of a soil and the possibility of reversing an undesirable or degraded state.

Significant advances. At a national level, the National Forest and Soil Inventory of Mexico has obtained 225,183 samples in the last three years in order to assess the major carbon pools content in soils and biomass. Locally, the Mexican state of Aguascalientes is probably the first in the world to officially conduct forest surveys aiming to characterize the carbon distribution in its different interfaces, in order to prevent degradation and therefore reduce restoration costs.

Keywords：*information. soil. monitoring. carbon.*

P2-38

[IDS3] Soil Information and Food Security

Rationalization and Harmonization of Turkish Legacy Soil Data.rationalization and Harmonization of Turkish Legacy Soil Data: National Soil Information System (ttbs)

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Most countries completed large scale soil data over a period of time and they have a soil database that contain current, duplicate, out of date and incorrect data. The benefits of having accurate soil data is that it allows decisions to be made accurately. If it has a number of uncertainties, the level of inaccuracy is multiplied. Therefore, it has to be updated to reflect the current soil data and to be rationalized to eliminate duplicate, incorrect and unnecessary data. In Turkey, National Soil Information System (TTBS) was carry out based on legacy soil data at large scale (1:5000 - 1:25000). TTBS contains detailed information on soil chemical and physical properties, land use, parent material and land capability class. Last updated of the legacy soil maps were performed in 1987. However, main problem of national legacy data is aggregating existing properties and land use type. They need to rationalize, since they are not indicated current land use situation. In this study, digital mapping project is presented as an example of the implementation of rationalization and harmonization methodology using high resolution orthophoto and non-interpreted field survey point data.

Keywords：*Digital Mapping, Legacy Soil Map, Soil Information System*

P2-39

[IDS3] Soil Information and Food Security

Remote Sensing and Gis for Digital Land Resources Mapping of the Northwestern Coast, Egypt

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The northwestern coast of Egypt is characterized by an international interest due to its history and magnificent environment. The area was known as being the bread basket during the Greek and Roman periods. Recently, drastic changes in land use resulting in destructing many of water harvesting tools, thus diminution of the agriculture importance. Restoration of the area and planning self-sufficient communities needs to develop a sustainable land resources database for these regions. The medium scale space data provide a spatial resolution of 30 meters, in addition to multi-temporal imaging. Moreover, Geographic Information System (GIS) permits to store, merge, and manipulate the huge amounts of thematic maps and attribute data.

The study area is located in northwestern coast of Egypt. A number of 7 Landsat ETM scenes covering the whole area were acquired and merged. ENVI 4.2 software was used for image processing and analyzing. A number of 53 topographic maps at scale 1:50000 were used to input GIS thematic layers relevant to land resources, using Arc_GIS 9.2 system. Field investigation was carried out to represent different soil units and collect ground control points. Chemical and physical soil properties were determined, upon which oil classification was based. Soil map was produced including dominant geographic units and soil association. MicroLEIS system was employed to define soil suitability classes to olives, peach, wheat, beans, and sunflower crops.

The results showed that the soils are generally characterized by the presence of Calcic, Petrogypsic and Salic horizons. The identified great groups include Torripsamments, Torriorthents, Haplosalids, Petrogypsids and Haplocalcids. Soils of the alluvial fans and watershed basins are deep to moderately deep with a texture ranging between fine sand to clay loam. The salinity is relatively low (EC is +/- 2 dS/m) whereas the CaCO3 content is mostly over 8 %. Concerning the land suitability, the limiting factors found in the piedmont and coastal plains are salinity, soil depth and texture. These factors decrease the suitability classes to be between S2 and S5. It can be concluded that the digital mapping of land resources encouraged by the progress of Geographic Information System (GIS) and data provided by satellite images. Such approach may preserve in the investment spent in soil and other thematic mapping, as the digital maps are more granted compared with analogue ones. Updating and manipulating the digital thematic maps are accessible and economically effective. Usage of the digital maps and their attribute tables assist the decision support systems and may result in obtaining maps required for controlling sustainable development projects.

Keywords：*Soils, Space data, GIS, Digital soil mapping, Egypt*

P2-40

[IDS3] Soil Information and Food Security

Optimizing Nutrient Management Strategies for Rice-Wheat System in the Indo-Gangetic Plains and Adjacent Region for Higher Production Profitability, Nutrient Use Efficiency and Ensuring Food Security

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Rice (Oryza sativa L.)?wheat (Trititicum aestivum L.) system (RWS) in south Asia is under stress, as nutrient removals by crops are higher than their replenishment through fertilizers. We evaluated improved nutrient management strategies at 10 different locations across the Indo-Gangetic Plains (IGP) and adjacent regions during 2003-04 to 2005-06, and compared the improved practices in terms of yield gain, nutrient use efficiency and economic returns, with existing farmers fertilizer practices (FFP), and state recommended fertilizer rates by the government departments (SR). Improved N-P-K application rates were calculated by accounting for the indigenous nutrient supply (INS), yield target and crop nutrient demand as a function of the interactions between N, P and K. Compared with the current FFP, improved practices increased average grain yield from 1.37 to 3.69 t ha-1 in rice and 0.71 to 2.26 t ha-1 in wheat across the locations. It also out yielded SR in all the locations. Added net return (in US$) from improved practices over FFP and SR under RWS ranged from 219.6 to 804.9 and from 104.3 to 599 ha-1, respectively. Compared to improved practices, PFPn under SR and FFP were lower by 18.9 and 38.3% in rice, and 18.5 and 39.5% in wheat, respectively. Omission of P and K from improved nutrient management schedule resulted in yield loss of 0.6 to 2.8 t ha-1 in rice, and 0.43 to 1.84 t ha-1 in wheat, respectively. The annual removal of native P and K in the respective omission plots ranged from 21.8 to 46.1 kg P ha-1 and 158.4 to 349.1 kg K ha-1. Contrary to this, application of 26 kg P and 99 kg K ha-1 under improved practices had synergistic effect on nutrient use efficiencies viz. PFPn, AEP, AEK, REP and REK. Results suggested that optimised nutrient supplies considering crop nutrient needs and INS have potential for improving yields, nutrient use efficiency and profits in RWS. Future research must build on the present approach to develop a more practical way of achieving similar benefits across large areas without site-specific modelling and with minimum crop monitoring.

Keywords：*Nutrient supply, Nutrient use efficiency, Economic returns, Rice-wheat system, Indo-Gangetic Plain.*

P2-41

[IDS3] Soil Information and Food Security

Estimation Npp on Paddy Soils in South Korea Using Casa Model

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CASA (Carnegie-Ames-Stanford Approach) model is one of the most quick, convenient and accurate models to estimate the NPP (Net Primary Productivity) of vegetation. NPP is the amount of energy available for all consumer organisms, including human begins; it provides the basis for the maintenance and growth of an ecosystem. Therefore, it is essential to understand the global pattern of the potential NPPs of the land areas of the world. The purposes of this study are (1) to estimate NPP of the paddy soils using CASA model applied to MODIS (The MODerate resolution Imaging Spectroradiometer) products and solar radiation, and (2) to examine the spatial and temporal patterns of NPP in South Korea from 2002 to 2012. MODIS products; MYD09 for NIR and SWIR bands, MYD11 for LST, MYD15 for FPAR, respectively from a NASA web site were used. As a result, the range of mean NPP of the paddy soils from CASA model was estimated to be 262.30-347.64 gC/m2/yr. The higher NPP values over South Korea are related to the regions with higher biomass and higher annual temperature. Specifically, the higher increasing trends over the Southeastern region are likely due to the increasing productivity of paddy fields from sufficient irrigation and fertilizer use. The estimated NPP shows a closer relationship between annual rice yields, which results in maximum correlation during growth season. A better accuracy in the meterological and land use data and modeling applications will be necessary to improve the satellite-based NPP data.

Keywords：*CASA model, NPP, MODIS, biomass, rice yield*

P2-42

[IDS3] Soil Information and Food Security

Evapotranspiration Estimating in a Rice Field Using Tseb Model with Modified Soil Heat Flux Equation

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As evapotranspiration(ET) in a rice field means the amount of water consumption, its monitoring is important to establish the water management plan. The two source energy balance model (TSEB) can estimate ET using satellite imagery and meteorological data can provide information of water consumption in wide area without field measurements of flooding water depth. This model mainly has been developed for upland crop. To applying the TSEB model for a paddy field, we monitored soil temperature and soil heat flux in a paddy field, Kimje, South Korea in 2013. In a rice field, soil temperature increased by mid August. Soil heat flux had been decreased after transplanting and had been affected by flooding and LAI. Half-hourly energy flux data, including net radiation, sensible heat, latent heat (corresponding to ET), and soil heat, were acquired using eddy-covariance method. The root mean square difference values between predicted and observed latent heat flux ranged between 10% and 25% of the average observed latent heat flux. This is suggesting that the TSEB model can provide reliable ET estimation for rice fields.

Keywords：*Evaportranspiration, TSEB, rice field, soil heat flux*

P2-43

[C3.6-1] Saline and Sodic Ecosystems in the Changing World

Classification of Soil Desalination Area for Crop Cultivation Using Radarsat Imagery in Saemangeum Reclaimed Land

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This study aims to classify a soil desalination area for cultivation using relationship between plant of reclaimed land and backscattering coefficients of Radarsat-2 image. The soil salinity affects the change of plant community in reclaimed land. The Radarsat-2 has a frequency(C-band) and Synthetic Aperture Radar(SAR) with multiple polarization modes, including a fully polarmetric mode in which HH(Horizontal transmit and Horizontal receive), HV(Horizontal transmit and Vertical receive), VV(Vertical transmit and Vertical receive) and VH(Vertical transmit and Horizontal receive) polarized data are acquired. Also, we measured the soil salinity, plant height and vegetation group at 28 sites in Saemangeum reclaimed land in September 2013. Soil salinities in reclaimed land were estimated that backscattering coefficients using radar satellite imagery compared with information of filed survey. In halophyte and bare sites, there was low plant height and no relation between backscattering coefficients and vegetation group. But, in glycophyte sites, we found that the soil salinity was below 0.1% and plant hight ranged from 1.1 to 2.8m, was more than the other sites. So, we could distinguish the glycophyte sites from the halophyte sites, bare and classify the area that soil salinity was below 0.1%. This technique could save the time and labor to measure the soil salinity in large area for agricultural utilization.

Keywords：*Desalination, Radarsat, Saemangeum reclaimed land*

P2-44

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Rice Husk Biochar and Pgpr on Rice Yield, Nutrient Uptake and Nutrient Availability in Alluvial Soil

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Application of biochar has been reported to enhance plant growth by improving soil characteristics like bulk density, water holding capacity, nutrient availability, etc. and all these collectively contribute to an increased crop productivity (Rondan et al., 2007; Steiner et al., 2007; Zhang et al., 2010). However, the effects of biochar application on crop productivity have been observed to vary, depending on a number of factors such as soil fertility, biomass feed stock, and pyrolysis conditions used for biochar preparation. In addition, soil organic carbon, which is considered as the most reliable index of soil quality and sustainability of agricultural systems, has also been reported to improve with the application of biochar (Lehmann et al., 2003; Utomo, 2010). Hence, it was considered desirable to assess the effect of a locally available rice husk biochar applied with and without PGPR on crop productivity, nutrient availability and soil organic carbon content. For this purpose, a pot experiment was conducted taking rice as test crop at the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India during kharif season of 2012. The soil used for experimentation was sandy loam with bulk density 1.63 Mgm-3, pH (1:2.5) 7.6, E.C. 0.21 dsm-1, CEC 11.63 cmol(P+) kg-1, organic carbon 0.34%, available N 135 kg ha-1, available P 22.7 kg ha-1 and available K 183 kg ha-1. The experiment was designed as a factorial completely randomized design (FCRD) with three replicates. The treatments consisted of two levels of inorganic fertilizers viz., 100% of recommended doses of fertilizers (RDF) (60:30:30:12.50 mg N, P2O5, K2O and Zn kg-1 of soil, respectively) and 75% of RDF (Factor 1), four levels of biochar (BC) viz., 0, 1.8, 3.6 and 7.2 g kg-1 of soil (Factor 2) and two levels, uninoculated (PGPR0) and inoculated (PGPR1), of PGPR (Factor 3). Bulk soil (0-15cm) was collected from research farm of the aforesaid Institute. 10 kg of processed soil was filled in each polythene lined pot. The rice husk biochar was obtained from a rice mill where it was considered a waste material coming from gasifier plant under partially controlled conditions. The characteristics of biochar were bulk density 0.40 Mgm-3, particle density 1.40 Mgm-3 , pH (1:2.5) 10, porosity 71.42%, water holding capacity 218%, total carbon 45.60%, organic carbon 4.80%, N 0.1%, P 0.15%, K 0.20%, Ca + Mg 0.21% and Na 0.35%. The PGPR used for experimentation included Pseudomonas aeruginosa, Azotobacter chroococcum and Azospirillum brasilense.

Sole and combined application of biochar along with RDF (biochar×RDF) did not produce any significant effect on grain yield, straw yield and N, P, Fe and Zn uptake in rice and their availability in soil. Whereas increments caused by sole application of biochar on K uptake and organic carbon content in soil were found to be significant ($P< 0.05$). Biochar application @ 3.6 g kg-1 of soil increased K uptake in grain and straw by 7.14% and 4.27%, respectively over treatments comprising of no biochar. Sole application of biochar @ 7.2 and 3.6 g kg-1 soil increased the soil organic carbon by 6.81% and 4.90%, respectively when compared to soil receiving no biochar. Addition of biochar @ 3.6 and 7.2 g kg-1 of soil also improved water holding capacity by 4.93% and 4.15%, respectively. Combined application of biochar along with PGPR (BC×PGPR1) produced significantly higher grain yield and straw yield of rice as well as uptake of nutrients over control (BC0 ×PGPR0) and sole application of biochar, indicating thereby positive interaction between biochar and PGPR. The highest rice grain yield (40.48 g pot-1) was obtained with the treatment BC3.6 x PGPR1. Thus, biochar, when applied with PGPR, was capable of increasing yield as well as nutrient uptake of rice.

Keywords：*Rice husk biochar,PGPR,Rice yield,Soil organic carbon*

P2-45

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Evaluation of the Effect of Biochar on Greenhouse Gas Emissions from Slurry Storage and Slurry Amended Arable Soil

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Biochar has been identified as a potentially useful soil amendment for agriculture due to its stable nature which allows it to sequester carbon (C) for timescales of up to hundreds of years. Biochar application also offers other benefits to the soil environment including the potential to reduce greenhouse gas (GHG) emissions, particularly nitrous oxide (N2O) through disruption of the soil nitrogen cycle. This can also lead to reduced volatilisation of soil ammonium (NH4+-N) and leaching of nitrate (NO3--N). Although the impact of biochar on processes in the soil nitrogen cycle have been investigated in laboratory scale experiments, little work has been carried out to assess whether the observed results can be scaled up to the field environment and what viable strategies are available for application of biochar. To address these limitations we undertook a field experiment where we combined biochar with slurry and stored it for 50 days before application to arable land, accounting also for effects on GHG emissions during slurry storage demonstrated in other laboratory experiments. Post-application monitoring of soil GHG emissions was undertaken to assess whether any biochar-driven GHG mitigation processes could continue in the soil environment as well as in storage, therefore allowing GHG emissions from two stages of the biochar and slurry "lifecycle" to be measured. Potential agronomic improvements through application of biochar-amended slurry to arable systems was also assessed.

Biochar was made at the UK Biochar Research Centre from rapeseed straw pellets, a commonly available local feedstock, at a pyrolysis temperature of 550°C. Locally sourced cattle slurry was divided into 12 tanks, each holding 300 L of slurry. Six tanks were designated "slurry only" and six "slurry + biochar". Biochar was added to the slurry at a mass ratio of 1:2 slurry dry matter: biochar, resulting in a biochar application rate of 19 kg biochar per tank. Slurry pH, dry matter, NH4+-N and NO3--N contents were measured at the beginning and end of slurry storage. Emissions of N2O, CO2 and CH4 were measured 15 times over a 50 day period using an adapted static closed chamber methodology and gas concentrations were measured using gas chromatography. After two months the contents of the tanks were applied to field plots sown with winter wheat, at Boghall farm, Edinburgh in Spring 2013, at a rate of 41,000 L/ha giving the following four treatments (plus a no application control): slurry (surface broadcast application), slurry (trailing hose application), slurry + biochar (surface broadcast), slurry + biochar + nitrification inhibitor DCD (surface broadcast). DCD was applied at a rate of 10 kg/ha, one hour after slurry application. GHG emissions were measured frequently for a year following application from five replicate static closed chambers per plot. Other measurements included soil NH4+-N and NO3--N content, soil moisture and meteorological conditions throughout the experiment. Crop yield and crop nitrogen uptake were measured.

The results of the slurry tank storage showed lower cumulative emissions of N2O, CO2 and CH4 from the tanks containing biochar (95%, 31% and 9% lower respectively) in comparison to the tanks without biochar. The particularly large decrease in N2O emissions was consistent with the NH4+-N and NO3--N sorption capacities of biochar, as has been demonstrated by previous work, which would limit the amount of N available for transformation into N2O. The tanks containing biochar showed an increase in dry matter content (from 1.5 % to 3.1 %) and pH (from 7.3 to 7.5) in comparison to the tanks without biochar. Preliminary GHG emission results from the first few months of the field trial demonstrate limited effectiveness of DCD in reducing N2O emissions despite evidence from soil mineral N analysis showing a decrease in nitrification rates. Overall, there were no significant differences in GHG emissions between field treatments with and without biochar. However, during this period, unusual environmental conditions resulted in minimal N2O fluxes from all treatments and negligible quantitative differences in gaseous N loss. It is suggested that future work should focus on investigating whether the capacity to decrease GHG emissions from stored slurry is common to biochars made from a range of feedstocks at different pyrolysis temperatures, and to determine the mechanisms responsible and optimum rate of biochar application to achieve maximum decrease in emissions.

Keywords: *biochar, slurry, nitrous oxide, carbon dioxide, methane, arable*

P2-46

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Efficacy of Biochar in Improving Root Growth and Water Holding Capacity of Hard Setting Subsoil Layer in Coastal Plains Usa

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In the Coastal Plains region of the United States, the Norfolk soil fertility is low. In this region, the Norfolk soils are under intensive crop production that further depletes nutrients and reduces organic carbon. Furthermore, the hard setting subsoil layer of Norfolk soils results in low water holding capacity, which often impedes root development. Optimum rooting is essential for plant growth and crop productivity. Incorporation of pyrolyzed organic residues or "biochars" is an important factor in sustaining soil fertility and improving soil physical conditions. Although results have been inconsistent, biochar amendments to soil results in improved soil quality characteristics. We hypothesized that biochar additions will enhance both the level of soil fertility and soil water holding capacity. A greenhouse study was conducted to investigate the effects of biochars on root growth of winter wheat (Triticum aestivum, L) and water holding capacity in a Norfolk's hard setting subsoil layer (E horizon). Biochars were added to Norfolk's E horizon at the rate of 40 tons per hectare. The different sources of biochars were: plant-based (pine chips); animal-based (poultry litter); blended (pine chips + poultry litter); and industrial wood waste (dynamo). Biochar additions to the Norfolk's E horizon appear to improve both the root growth of winter wheat and water retention capacity. Dry root mass of winter wheat that were treated with industrial wood waste, plant-based and blended biochars was increased by 74%, 59% and 45% over the untreated winter wheat, respectively. The water holding capacity of Norfolk's E horizon that were treated with blended, industrial wood waste, animal-based and plant-based biochars when compared with the untreated soils were increased by 133%, 119%, 76% and 41%, respectively. Overall, our results showed promising significance for the Norfolk's hard setting subsoil layer since biochars did improve both root growth and water holding capacity. Research scientists at the ARS-Florence location will expand their evaluation of biochar as a soil amendment by using other biochar-types and other crops to assess the long-term effects of biochars in improving soil and crop productivity.

Keywords: *biochars, Norfolk soils water retention, E horizon, wheat*

P2-47

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Does Biochar Affect the Microbial Activity in Estuarine Sediments?

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In the search for solutions to the severe impact that climate change is already causing on our planet, a number of options to stabilize atmospheric levels of greenhouse gases, e.g. employing carbon sequestration technologies, are being explored. Enhancing natural C-sinks and their ability to capture/store carbon is an interesting and low cost alternative. The use of biochar as organic amendment has the potential to increase soil quality and carbon sequestration capacity. However, once used in soils, the physical transport of biochar to aquatic environments is inevitable, leading to a potential accumulation in estuarine and marine sediments, with unpredictable environmental consequences. The main aims of this study were: (i) to determine whether biochar is able to modify microbial activity of intertidal estuarine sediments and (ii) to analyse whether biochar can increase carbon storage in estuarine sediments. Sediments from the Mondego estuary (western coast of Portugal) were mixed with different doses of biochar obtained by pine gasification (5%, 10% and 14%). Three macroinvertebrate species were added to the sediments: the polychaete Hediste diversicolor, the isopod Cyathura carinata and the gastropod Hydrobia ulvae. The sediment-biochar-macroinvertebrate samples were immersed in water with different salinities (15, 25 and 35) during 96 hours. After that, microbial activity given by sediment respiration (SR) and biochemical oxygen demand (BOD), together with sediment water content (SWC), total organic carbon (TOC), sediment electrical conductivity (EC) and pH, were determined. The results showed that biochar did not inhibited sediment microbial activity and CO2 emissions from sediments decreased with increasing biochar doses.The high water absorption capacity of biochar, together with an rise in sediment pH and EC may have contributed to a decrease in the rate of organic matter decomposition. Our results suggest that biochar may be able to increase the carbon sink capacity of estuarine sediments.

Keywords：*biochar, sediments, CO2, BOD, carbon, coefficient of mineralization, respiratory quotient*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Carbon Mineralization Kinetics of Added Biochar in Swine Manure Compost-Treated Soils

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In this study, we evaluated the in vitro C mineralization kinetics of 2 swine manure compost-treated soils following the addition of various amounts of biochar. We hypothesized that biochar stabilizes compost organic matter and reduces C mineralization. Two soils were incubated at 25 ℃ with 0%, 0.5%, 1.0%, and 2.0% (w/w) biochar and 5% swine manure compost. Carbon mineralization was then analyzed by measuring the alkali absorption of CO2 released at regular intervals over a 434-d observation period. Our study results indicated that when adding compost to soils, applying a high amount of biochar stabilizes and prevents the rapid mineralization of swine manure compost; however, the biochar C is less stable and more easily decomposed when the biochar is applied in higher compared with lower amounts. In our studied soils, the addition of 1% biochar was the most appropriate treatment amount for compost stabilization.

Keywords：*Biochar, C-mineralization kinetics, Swine manure compost, C sequestration*

P2-49

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effects of Biochar Incorporation on Cd Bioavailability in a Cd-Contaminated Agricultural Soil

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The bioavailability of cadmium (Cd) in agricultural soils is a great health concern due to potential risks through exposure to agricultural foods produced in Cd-contaminated fields. Amendments such as zeolite and manure are often used to reduce bioavailability by immobilizing Cd into stable forms. Recently, biochar, a product of pyrolysis, has attracted tremendous research interest for sequestrating carbon in a thermally stabilized form of biomass. Biochars are known to have a highly porous structure, high pH, contain functional groups and to be effective in the adsorption of heavy metals. Therefore, incorporation of biochar into Cd-contaminated agricultural soils may be effective for reducing Cd bioavailability. However, few studies have been conducted to reveal the effects of biochar incorporation on Cd bioavailability in Cd-contaminated soils. Thus, the objective of this study was to investigate the effects of biochar incorporation on Cd bioavailability in Cd-contaminated agricultural soil.

The soil investigated was an acid sandy soil (pH 5.1) with elevated concentrations of Cd (Total Cd: 3.3 mg/kg-DW). Six kinds of biochars were produced from wood (Japanese cedar (sugi) and Japanese cypress (hinoki)), bamboo, rice husk, chicken manure and sewage sludge at 600°C for the pyrolysis temperature. Biochars were incorporated into the Cd-contaminated soil at a rate of 3% (w/w) and pot experiments with Japanese mustard spinach conducted for 28 days in a growth chamber. After pot experiments, dry weight and Cd concentrations in the above-ground portion of the plants, pH and sequential chemical fractionation of Cd in the soils were measured.

Cd concentrations in the above-ground portion of the plants were significantly decreased by the incorporation of biochars. Reduction ratios of the plant Cd concentrations with the incorporation of biochars were: Chicken manure (78%) >> sewage sludge (31%) ≒ rice husk (29%) ≒ bamboo (28%) ≒ wood (hinoki) (26%) > wood (sugi) (19%).

Soil pHs after pot experiments were significantly increased by the incorporation of biochars derived from wood (sugi), bamboo, rice husk, chicken manure and sewage sludge. Increases in the soil pHs with the incorporation of biochars as compared with the unamended soil (pH 5.4) were: Chicken manure (pH 6.8) >> sewage sludge (pH 5.7) ≒ bamboo (pH 5.6) ≒ wood (sugi) (pH 5.6) ≒ rice husk (pH 5.5).

Easily exchangeable fractions of soils after pot experiments were significantly decreased while carbonate bound fractions were significantly increased with the incorporation of biochars derived from chicken manure and sewage sludge as compared with the unamended soil. Other fractions (oxide bound, organic bound and residual fractions) were not significantly changed by the incorporation of the biochars.

These results indicate that biochars, especially chicken manure-derived biochar, can immobilize soil Cd chiefly through the precipitation reaction associated with increasing soil pH. Consequently, Cd bioavailability in Cd-contaminated agricultural soils can be decreased with incorporation of biochars.

Keywords：*Biochar, amendment, cadmium, bioavailability*

P2-50

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Growth and Yield of Cucumber under Organic Farming Practices in Arid Regions Conditions

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Organic farming, as an alternative agriculture, has not been practiced in Iraq yet. Therefore, this study was conducted to evaluate cucumber growth and yield under organic farming in arid regions. The experiment was carried out in a green house in the agricultural experimental station of the agricultural research directorate in Tewatha 20 Km south east of Baghdad. Compost of corn cob was added, as a source of organic matter, in 1, 2.5, 5, 10, and 20% of the weight of the soil to 30 cm depth. Treatments were assigned to experimental units in a Randomized Complete Block Design with three replicates. Results showed that Cucumber dry weight is to increase with the increase of level of compost addition. At 10% level of compost addition, relative dry weight of cucumber was 3 times of the fresh weight. Carbohydrate content at various level of compost addition relative to conventional farming was also increased with the increase of level of compost addition. Highest carbohydrate content was observed at 5% compost addition. Nitrogen, phosphorus and potassium content of dry matter after 45 and 75 days of planting were relatively equal at all level of compost additions. However, plant content of N, P, and K after 100 days of planting were markedly reduced at all level of organic matter addition.

Keywords：*Greenhouse, Carbohydrate, fresh weight, Dry weight, Nitrogen, Phosphorus, Potassium*

P2-51

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effects of Different Biochars on Amelioration of Acid Soil in the South of China

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We have conducted a series of experiments to study the effects of different sources of biomass materials, carbonized temperature, carbonized time, particle size of raw materials and addition rates of biochar on the content of biochar basic group and amelioration of acid soil in the South of China. The results show that different sources of biomass materials have great effects on the content of biochar basic group. We carbonized four kinds of typical local agricultural waste materials, basic group content of biochar from swine manure was the highest, 0.90mmol/g. The contents of biochar from cassava and eucalyptus followed were 0.89mmol/g and 0.88mmol/g, from coir dust was the lowest, only 0.80 mmol/g. Acid soil applied with different sources of biomass materials were incubated at room temperature for 28d. The results show that all the treatments of different sources of biomass materials could increase the acid soil pH and improve the acid soil after incubation. The effect of eucalyptus source was the best, followed by swine manure source and cassava source, coir dust sources worst. However, the effect of acid soil amelioration was gradually weakened with incubation time. Experiments about the effect of carbonized temperature, show that basic group content of biochar increased with increasing carbonized time. Basic group content of biochar was 0.76 mmol/g, 0.83 mmol/g and 0.86 mmol/g under different carbonization temperature 300℃, 400℃ and 500℃, respectively. But with carbonized temperature increasing, the effects of acid soil amelioration have gradually declined. Experiments about the effect of carbonized time show that, basic group content of biochar increased with increasing carbonized time. Basic group content of 3h carbonized treatment was 0.98mmol/g and much higher than other treatments of 1h carbonized and 2hcarbonized. The effects of acid soil amelioration increased with increasing the carbonization time. Experiments about the effect of particle size of raw materials show that, the content of biochar basic group sieved by 0.25 mm was the lowest, followed by 0.25-0.5mm, by 0.5mm was maximum. The content of biochar basic group increased with increasing particle size of raw materials. All the treatments of different particle size could increase the acid soil pH and improve the acid soil, but reduced with increasing particle size of raw materials. Experiments about the effect of biochar addition rates show that biochar could increase the acid soil pH and improve the acid soil, whereas different biochar/soil ratios have different effects of acid soil amelioration, the pH content in soil solution increased with increasing rate of biochar amendment. The treatment of 1:20 biochar/soil ratios had the best effect, and the peak value of pH during the incubation period was 5.64. The effect of 1:50 biochar/soil ratios was next, and the effect of 1:200 biochar/soil ratios was worst the soil pH only rose to 4.20.

Keywords：*biochars, basic group , amelioration of acid soil*

P2-52

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Characterization of Biochar for Agricultural Use in North of Iran

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Black carbon may significantly affect nutrient retention and play a key role in a wide range of biogeochemical processes in soils, especially for nutrient cycling. Black carbon is the main component of biochar. In this study evaluated characterization of three kinds of biochars which made by stove research, under condition of slow pyrolysis at 500 °C. Also effects of this biochars on some chemical characteristics of clay soil in north of Iran measured. Therefore, after making biochars of wood, rice straw and papermill waste biomass, exchangeable Ca, Mg, Na and K, available Fe, total P and total C of biochars were measured. Analyses of biochars sample have revealed high levels of essential elements. Also, in order to evaluated the effect of these three different types of biochars on clay soil, biochars and soil passes through a 2-mm sieve and applied three different levels of biochars at a rate of 10, 20 and 30 g kg-1 soil. After 1 and 3 months the elements were measured. Results show that after one and three months addition of biochars to soil, exchangeable Ca, Mg, K and total C significantly increased almost in all treatments. Available Fe significantly decreased and exchangeable Na and total P showed varied results.

Keywords：*biochar, pyrolysis, black carbon,amendment*

P2-53

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

The Adsorption and Desorption of Phosphate-P, Ammonium-N and Nitrate-N in Cacao Shell and Corn Cob Biochars in the Presence and Absence of Soil

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The adsorption of PO4-P, NH4-N and NO3-N to cacao shell and corn cob biochars produced at 300 - 350 °C was quantified. The biochars were used; i) as received (unwashed), ii) after rinsing with distilled water and iii) following an extensive leaching process. In addition to adsorption, desorption of PO4-P from the unwashed biochars was quantified.

There was no adsorption of PO4-P to either washed biochars, but following leaching, both biochars adsorbed PO4-P and distribution coefficients (Kd L kg -1) were very similar for both materials (10 1.1 ± 0.5 for cacao shell biochar and 10 1.0 ± 0.2 for corn cob biochar). One possible explanation for the adsorption is that the BET surface area and micropore volume increased by 80 %, thus opening up previously unavailable adsorption sites. Another explanation is that PO43- ions are able to form bridge bonds using the residual charge of electrostatically attracted or ligand-bonded divalent cations such as Ca2+, Mg2+, Al3+ and Fe3+

Desorption was carried out over a period of 1440 hours and during this time 1483 ± 45 mg kg-1 and 172 ± 1 mg kg -1 PO4-P was released from the cacao shell and corn cob biochars. The release and weak adsorption could be very beneficial in the use of biochar as a fertilizer for agricultural soils.

NH4-N was adsorbed by both unwashed biochars for cacao shell biochar. NH4-N is able to bind via an electrostatic exchange mechanism with other cationic species on the surface of the biochar. The binding was weak with Kd values around 10 2 L kg-1 and this suggests that biochar could retain N fertilizers and then release them when needed.

There was no significant release or adsorption of NO3-N from or to either of the biochars.

In addition, the effect of biochar amendments on the retention and availability of macro nutrients and aluminium in acidic tropical soils was studied. Seven different soils from Indonesia and Zambia were used. No significant increases in NH4+ concentration with additions of biochar were detected in any of the soils except for one. However, concentrations of NO3--N were significantly higher (ttest 0.05 confidence level) in the majority of the samples with 5 and 10 % biochar addition compared to the soil without biochar. The biochar itself contained NO3--N and therefore mechanism one is the most probable explanation for the increase in NO3- concentration.

The Gaines Thomas selectivity coefficient was used to assess cation exchange of NH4+. Coefficients were reduced in the presence of biochar when compared to the soil alone, and the coefficients were smaller for the biochar than for the soil or the mixtures.

Both soils, with and without the presence of biochar were able to sorb PO4-P, but to variable degrees.

When considering other macronutrients, the concentrations of K+ and Mg2+ were significantly increased (ttest at the 0.05 confidence level) following the addition of biochar to the soils. The opposite trend was apparent for the concentration of Mn2+, where the addition of biochar to the soil decreased the concentrations significantly (ttest confidence level 0.05). The concentration of Al3+ in the soil decreased significantly (ttest confidence level 0.05) following the amendment of biochar. Dissolved Al decreased exponentially with increasing pH, the latter due to biochar additions.

Keywords : Biochar, nutrients, soil

P2-54

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Ameliorating Physical and Chemical Properties of Two Contrasting Texture Ultisols with Wastewater Sludge Biochar

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Abstract

This paper deals with the influences of wastewater sludge biochar (WSB) on the physicochemical properties of strongly acid Ultisols with contrasting texture. The soils were mixed with WSB at the rate of 0, 10, 20, and 40 g biochar kg-1 soil and incubated for 240 d at 70% field water capacity. Results indicate that WSB amendments significantly decease soil pH, exchangeable H+ and Al3+, and increase exchangeable Ca2+ and Mg2+ content, compared with the control. WSB application increased macroaggregate contents and aggregate stability, and decreased water retention and tensile strength of clayey soil. However, WSB increased the water retention capacity of sandy soil. Overall results suggest that WSB can improve soil fertility of strongly acid Ultisols.

Introduction

The conversion of wastewater sludge by pyrolysis to produce biochar is a safe and beneficial treatment way. The wastewater sludge biochar (WSB) can be used as soil amendments for improving soil properties and increase crop yield. Many works investigated the beneficial effects of biochar produced from green biomass feedstock and organic manures on the crop yield and soil fertility. However, understanding of agricultural effects of WSB is very limited. Our objectives were to evaluate the effects of WSB on the physicochemical properties of highly acid Ultisols with contrasting texture.

Materials and Methods

Two texture soils (sandy and clayey soil) were collected from the A horizon (0-20 cm) of Ultisols in the Eastern China. The biochar used in this study was obtained from a commercial producer who uses wastewater sludge and slow pyrolysis to produce biochar. The WSB was carefully mixed with the soils at the rate of 0, 10, 20, and 40 g biochar kg-1 soil by dry weight. Three replicates per treatment were incubated at a room temperature and 70% field water capacity. After 240 d incubation the biochar-amended soils were collected for further physicochemical properties measurements. Soil analysis was carried out using routine methods. The measurements included soil pH, exchangeable H+, Al3+, Ca2+, Mg2+, aggregate size distribution, water retention capacity, and tensile strength of soils.

Results and discussion

Pot incubation results indicated biochar significantly ($p<0.05$) increased the pH of two soils. The effect of biochar on soil pH increased with increased addition level, especially for sandy soil. Biochar significantly ($p<0.05$) decreased the exchangeable H+ and Al3+ content of two soils, and increased soil exchangeable base cations compared with the control. The magnitude of changes was roughly proportional to the rate of biochar application. WSB application resulted in higher amounts of >2 mm macroaggregate and lower amount of <0.106 mm microaggregate compared with the control treatment. The calculated mean weight diameter

(MWD) increased with the addition of WSB amendments to the soil. The soil water release characteristic (SWRC) indicated that addition of WSB into soil changed soil water retention capacity, the effect being variable among different texture soils. The WSB reduced the water content of clayey soil at -0.33, -0.5, -1 and -2 bar matric potential while water content of sandy soil was increased. The effect of biochar application on water retention capacity is related to the high porosity and large inner surface area of biochar, and the soil aggregation improved by biochar. Tensile strength test indicated that tensile strength of the two soils decreased with increasing rate of biochar application. However, significant reduction ($p<0.05$) was only observed at the application rate of 4% biochar in the clayey soil. No significant effects of biochar on tensile strength were detected on sandy soil.

Conclusion

Our pot experiment results indicated significant changes in soil quality in WSB-amended soil, such as increases in pH, exchangeable cations, and aggregate stability as well as reduction in exchangeable acidity and tensile strength, suggesting the potential effectiveness of the WSB as a soil amendment. These results indicated that WSB effectively improved poor soil characteristics in highly acid Ultisol.

Acknowledgements

This research was supported by the National Key Basic Research Support Foundation of China (973) (2011CB100502).

Keywords：*Biochar, Ultisol, water retention, tensile strength, aggregate, pH.*

P2-55

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Reduction of Rice and Wheat Cd Uptake via Biochar Amendment in Contaminated Paddy Soil

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A field experiment was conducted on the effect of biochar amendment on Cd uptake by rice and wheat in a contaminated paddy in 2009 to 2011. BC was applied in soil as an amendment before rice transplantation in 2009 at rates of 0, 10, 20, 40t ha^{-1}. The biochar amendment significantly increased soil pH by 0.15-0.38 units and decreased $CaCl_2$ extracted Cd in soil by 32.0%-57.0% from 2009 to 2011. Under BC amendment, rice and wheat grain Cd concentration was observed to be reduced by 16.8%- 61.9% and 10.0% to 57.0% from 2009 to 2011. Bioachr improved soil properties and reduced the Cd bioavailability and plant uptake.

Keywords：*Biochar; Cd; Rice; Wheat; Heavy metal contamination; Soil amendment*

P2-56

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effects of Pyrolysis and Htc Chars Produced From Sewage Sludge in the Plant-Soil System: Results From A 3 Year Field Experiment

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Significant amounts of carbon and plant nutrient rich human waste and sewage sludge are waiting for sustainable treatment and recycling options. These materials can be included in strategies that rely upon the biochar concept for climate change mitigation and soil amelioration. In the course of the production of so called 'sewchars' by pyrolysis and hydrothermal carbonization (HTC) the conservation or transfer of nutrient elements in plant available speciation is of major importance. The objective of the presented study was to examine the influence of pyrolysis and HTC sewchars produced under different temperature and time regimes on plant and soil performance. Results from a three year field experiment are presented.

Within the experiment two different concentrations of pyrolysis and HTC sewchars and their feedstocks were used in a sandy soil with and without additional mineral fertilizer application. The following crops were used: y1-spring barley; y2-rape and y3-yellow clover. Plant biomass was determined and micronutrients and heavy metals were detected by ICP-OES (Ca, Fe, K, Mn, Mg, Na, P, S), ICP-MS (As, Cd, Co, Cr, Cu, Ni, Pb, Zn) and AAS (Hg). In addition, total organic carbon (TOC) and nitrogen (TN) contents of plant and soil samples as well as the pH and effective cation exchange capacity (CECeff) of substrates were detected.

Phytotoxic effects of high amounts of HTC sewchars and the feedstock (sewage sludge) occurred only in the first year of the field experiment. On the contrary, the plant growth was significantly increased in the following crops. This led to an increase of the shoot biomass of rape (86%) and yellow clover (35%) compared to the fertilized controls. A lower application rate by a factor of 10 of the HTC sewchars did not influence plant growth and was increased by sewchars only under concurrent NPK fertilization. Rape growth was neither with nor without mineral fertilization affected by pyrolysis chars.

Growth rates were in agreement with the nutrient concentrations. Analyses of shoot material of spring barley showed that various elements were provided by HTC sewchars in a plant available form. Besides a clear indication of the possibility to recycle plant available nitrogen, calcium and magnesium, the studies show a pronounced fertilization effect of phosphorus and sulfur through HTC sewchars. In contrast, studies of pyrolysis sewchars suggest that the anaerobic treatment of sewage sludge at temperatures above 400°C cause emissions of nitrogen and sulfur, as well as a transformation of phosphorus, calcium and magnesium into non-plant available forms.

A significant growth stimulation of yellow clover by the application of sewchars produced through LTC (thermocatalytic low temperature conversion) show, however, that high application rates of pyrolysis sewchars can have a positive effect on the growth of nitrogen fixing species. Studies of the CECeff showed that the exchange capacity of the sewage sludge was reduced both by pyrolytic and hydrothermal conversion. However, the CECeff of the sewchars were more than 60% above the endemic soil used.

In summary, the studies show that (i) nutrients remained in plant available forms during the HTC process, (ii) phytotoxic components of HTC sewchars were degraded in the field, and (iii) positive effects of pyrolysis sewchars can be developed with the addition of a mineral fertilizer. The study underlines that the application of sewchars to agricultural soils has the potential to greatly improve soil and plant performances. However, further research is needed on the effects of sewchars in the plant-soil system and, particularly, their potential for C sequestration.

Keywords : Hydrothermal carbonization (HTC), Pyrolysis, Sewage sludge, Sewchar, Biochar, Plant and soil performance, Nutrient cycling

P2-57

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

The Sewchar Concept: An Innovative Tool for Sustainable Reuse of Human Waste and Sewage Sludge in Soils

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The mitigation of climate change, the protection of natural resources and the provision of sufficient food and healthy life conditions for a growing world population are prominent challenges of our time. The presentation introduces the “sewchar concept”, which addresses this complex by combining the treatment of human waste and sewage sludge with the principles of the biochar concept. Under this approach human waste and sewage sludge are treated by thermochemical carbonization processes and are then applied to soils in the form of carbon enriched and refractory sewchars for long-term C sequestration and soil amendment.

In contrast to direct plant derived feedstocks used for the production of conventional biochars, carbonaceous materials from the wastewater sector do not face any relevant competition from alternative utilization routes. Human waste and sewage sludge usually undergo treatment and disposal at high environmental and economic costs. In many developing countries human excreta lack sufficient treatment and as a result may have negative impacts on human health and the environment. In industrialized countries concerns about the perceived risks associated with inorganic and organic contaminants has led to debate about the use of sewage sludge from conventional wastewater treatment systems as soil amendments, threatening the recycling of valuable resources such as plant available phosphorus.

While facing these challenges, thermochemical conversion by pyrolysis and hydrothermal carbonization (HTC) offer the possibility to: (i) remove pathogens; (ii) degrade organic contaminants; (iii) eliminate or demobilize inorganic pollutants; and (iv) improve the overall energy and material resource efficiency of sanitation systems. The generation of sewchars from human waste and sewage sludges can therefore provide social, economic and environmental benefits not only for climate change mitigation and soil amelioration but also for human health and environmental protection. Sewchar technologies could strengthen particularly the approach of ecological sanitation for the closure of local material flow cycles and resource conservation.

The presentation gives an overview of the quantitative and qualitative potential of sewchar systems. It presents technologies for the treatment of human waste and sewage sludges by dry pyrolysis and hydrothermal processes. Moreover, it introduces the possibility to gain synergistic effects by the use of HTC and related technologies in wastewater treatment plants and presents results of studies on the characteristics of sewchars and their effects on soils and the plant growth. Theoretical considerations and experimental investigations suggest that HTC based sewchar strategies will offer advantages with respect to the efficiency of plant nutrient recycling and energetics within sanitation systems. On the other hand, limited information is available on the stability of HTC sewchars and their capability for long term C sequestration.

Keywords：*biochar, sewchar, nutrient recycling, resources efficiency, hydrothermal carbonization (HTC), sanititation, soil carbon sequestration, soil amendment*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Short-Term Response of Bacterial Populations in Compost-Amended Soil to Additions of Biochar

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Biochar was considered as a soil amendment which could be a significant approach to stabilize soil ecology and sustain fertility. Previously, oscillations in bacterial populations (CFUs) have been demonstrated after incorporation of organic materials into soil. For this article, a pot experiment was carried out to verify whether bacterial populations and microbial activities fluctuated after additional incorporation of biochar in compost-amended soils, and whether these short-term oscillations were much weaker than compost-amended soils. CFUs of copiotrophic bacteria oscillated over time after additions of green compost (GC) or swine manure compost (SMC) into unplanted soils. The oscillations of CFUs with similar period, but smaller amplitudes were observed in GC or SMC compost-amended soil with biochar (BC). Cross-correlation analysis demonstrated that periodic fluctuations of copiotrophic CFUs in GC-BC and SMC-BC treatments did not coincide with those in amended soils without biochar but were shifted in phase. Moreover, the changes of soil chemical variables, including pH, dissolved organic carbon, and NO3?-N, and NH4+-N contents in the initial 7 days in BC treated soils were less significant than compost-amended soils. From the results of fast-growing bacteria populations, it appears that biochar could decrease the degree of short-term disturbance from nutrients inputs to soil.

Keywords：*biochar; CFUs; soil; short-term response*

P2-59

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Role of Biochar on Metal Ion Release Kinetics and Phytotoxicity Reduction in Serpentine Soils in Sri Lanka

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Soil derived from serpentinite rock weathering may release elevated concentrations of heavy metals such as Ni, Cr, Mn and Co into the environment due to the natural abundance. Hence, agricultural activities in the ultramafic surroundings may of particularly concern, due to the possibility of accumulating toxic metals in plants as well as phytotoxic effects. The objectives of this research were to investigate the potential of woody biochar as a soil amendment to immobilize bioavailable toxic metals and reduce the phytotoxicity of heavy metals. Biochar (BC) used in this study was obtained from a Dendro power plant, a byproduct of energy generation, at Thirappane, Sri Lanka. Biochar used in the study was characterized by proximate and ultimate analysis. Batch adsorption experiments were carried out to investigate the release kinetics and mechanisms of Ni and Mn in BC amended/unamended serpentine soil. A pot experiment was conducted using tomato plants (Lycopersicon esculentum L.) to evaluate the effect of biochar on reducing phytotoxicity in serpentine soil. Plants were harvested after 9 weeks from the germination of tomato seeds and the dry weight of harvested plants was obtained. Three biochar applications, 1.0, 2.5 and 5.0 % (w/w) were used in both batch adsorption and pot experiments. Results obtained from batch adsorption experiments revealed that both Ni and Mn from BC amended as well as unamended serpentine soil leach rapidly during first 60 minutes and the equilibrium reaches after 120 minutes, releasing a maximum amount of Ni and Mn in the range of 4.5-11.0 and 0.35-0.80 mg kg-1 respectively. Removal percentage of Ni in BC unamended serpentine soil, 1.0, 2.5 and 5.0 % biochar was 0.17, 0.15, 0.10 and 0.08 % and that of for Mn was 0.033, 0.026, 0.023 and 0.012 % respectively, which shows the release amount of both Ni and Mn is significantly decreased with the increasing BC application in the order of 1 > 2.5 > 5 %. The time dependent data also revealed that the release of both Ni and Mn from serpentine soil is better described by the simple Elovich model indicating a heterogeneous diffusion of metals through chemisorption mechanisms. There was a marked effect of biochar amendments on the growth of plants in the pot experiment and the biomass of plants was shown an increase with the increase of biochar application. The least dry weight was observed in the plants of unamended serpentine soil which was about 40 fold lesser than the average dry weight of the 5 % biochar treatment. Our results suggest that the use of biochar as a soil amendment could be an alternative and economically viable strategy to immobilize bioavailable toxic metals and reduce the phytotoxicity of heavy metals in serpentine soils in Sri Lanka.

Keywords：*Metal immobilization, Black carbon, Translocation, Bioavailability, Phytotoxicity*

P2-60

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Biochar on Nitrogen Mineralization of a Green Manure Legume Residue

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The use of green manure legumes (GML) has the potential to improve soil fertility of degraded infertile soils low in organic matter. Apart from organic matter addition, GML also contributes to biological nitrogen (N) fixation into the cropping system and upon decomposition, the N is released to the soil through mineralization. Biochar on the other hand has gained widespread attention as an amendment to boost soil fertility although several studies have indicated that biochar may have properties that could infringe on soil N availability. In view of this fact, a laboratory incubation study was conducted to determine the effect of biochar application rates on N mineralization of lablab (Lablab purpureus cv Rongai) green manure legume residue in a low fertility sandy soil. Soils were sampled from the surface 20 cm layer, and passed through a 2-mm sieve. Treatments consisted of four rates (0, 5, 10 and 20 t ha^{-1}) of biochar application and lablab green manure residue. 500 g soil was placed in plastic bags (50 μ thickness) and cover crop residue was added to the soil at the rate equivalent to 8 t ha^{-1}. Biochar was then added to the mixture of soil and crop residues at the stated rates, mixed thoroughly and the moisture content brought to about 60% water holding capacity (WHC) with distilled water before incubating the soil in the dark at room temperature. A polyethylene "breather tube" (0.5 cm in diameter) was placed in the opening of each bag, and the top of the bag was wrapped around the tube to allow air to diffuse in and out of the bag. Each residue treatment was replicated three times and laid in in a completely randomized design. Every week, the soil was weighed and distilled water was added to bring the soil moisture to its original level. Destructive sampling of the bags was done at 2, 5, 10 and 15 weeks from the onset of incubation in order to determine NH_4^+-N and NO_3^--N levels. Ten grams of soil from each bag was removed and extracted with 100 mL of 2N KCL. The NH_4^+-N and NO_3^--N was then analyzed by auto-analyzer (Automated Segment flow analyzer). Using completely randomized design, data at each sampling time was analyzed using the General Linear Model (GLM) procedure of the Statistical Analysis Software (SAS Institute Version 9.3). There were no differences observed in NH_4^+ and NO_3^- levels among the treatments at all sampling dates during the 15-week incubation period. NH_4^+ levels remained more less constant up to the 5th week and thereafter declined gradually. Values ranged from 70.2 – 83.6, 73.4 – 75.3, 47.7 – 66.1 and 1.49 – 1.96 mg kg^{-1} at 2, 5, 10 and 15 weeks, respectively, after onset of incubation. Nitrate levels increased gradually from the onset of incubation with the exception of the control which showed a slight decline in the 10th week and thereafter increased up to the 15th week. At the end of the 15 week incubation, cumulative NO_3^- produced were 30.0, 30.1, 31.8 and 34.2 mg kg^{-1} for the 0, 5, 10 and 20 kg ha^{-1} biochar application rates, respectively. The results obtained from this study indicate that biochar did not impact on the $NH_4^+$to NO_3^- conversion as compared to the control. Possibly the biochar was neutral with respect to decomposition implying that there was a lot of C groups as aromatic. This may be related to the quality of the feedstock used to make the biochar. There is need therefore to conduct further studies on the effect of biochars made from different feedstock on N mineralization of green manure legumes.

Keywords：*Ammonium, Nitrate, Incubation, Infertile soils, N availability.*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Salt Leaching in the Saline Soil Added with Different Rates of Biochar

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Background and aims Biochar as a pyrolysis product of biomass has special characteristics of high carbon concentration, porous structure, high specific surface area and various functional groups. It can be used as a soil conditioner. A significant number of data have shown that biochar can improve soil fertility, increase crop yield, reduce nutrient leaching and stimulate microbial activity, and store organic C in soil. But few data are available about the impacts of biochar on salt leaching in saline soil. The aim of this study, therefore, was to investigate the effect of biochar on leaching of salt and ions from a saline soil collected from Inner Mongolia China.

Methods A series rates of mushroom medium biochar (0%, 2%, 5%, 10%, w/w) were added into 0-20 cm surface soil in a sulfate saline soil column collected from Hetao Inner Mongolia. Continuously washing with deionized water, the eluent was collected and measured for electrical conductivity (EC) and main ions. At the end of the leaching, the contents of main ions were measured in the different layers.

Results The eluent from biochar-amended soil columns appeared much earlier, by 5~36 days ahead, than the control column. The days for EC reduction to lower than 5ms/cm was shortened by 41~100 days due to biochar addition. The higher the biochar added, the earlier the eluent was collected, and the sooner the EC was reduced to lower than 5ms/cm. It was thus obvious that the biochar could shorten salt leaching time and strengthen salt leaching as well. However, biochar addition had not significant effect on the leaching order and rate of the salt ions.

The tested soil contained very high salts. After leaching, the salt content significantly decreased in the whole soil profile. The concentrations of Na^+, Cl^- and SO_4^{2-} in surface soil decreased by 65%, 86% and 95% respectively. However, the contents of CO_3^{2-} and HCO_3^- were found to be higher in the Biochar-amended soil. The content of K^+ had an increase by 16-115% in the control soil and low biochar-added soil, which might be explained as the K^+releasing from clay minerals during washing.

Conclusion Biochar addition to saline soil could significantly accelerate salts leaching and shorten leaching time. The more the biochar added, the higher the salt leaching efficiency was detected. But biochar addition had not significant effect on the leaching order and rate of the salt ions. Considering the benefit of biochar in improving soil physical, chemical and biological properties, there is a potential value to use biochar for improving saline soil fertility.

Keywords：*Saline soil, Soil columns, Biochar, Salt-leaching*

P2-62

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Understanding the Soil Physics Of Biochar Amendments: A Glasshouse Experiment

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Understanding the Soil Physics of Biochar Amendments: a glasshouse experiment

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High nutrient amendments to soil are known to change the physical and chemical properties of the soil over time. Previously, the impact of biochar amendment on soil physics has only been addressed with the use of bulk density measurements. Processing biochar amended soils is difficult using traditional soil physics methods and is one of the major reasons that soil physics has not been undertaken in previous biochar work. Here we present the results of a series of soil and biochar combinations on a range of soil physical properties. The properties measured included bulk density, and total porosity, and particle size analysis (PSA). The PSA was measured using lazer diffraction analysis in a mastersizer. A glasshouse experiment was established using a randomised split plot design. A yellow podzollic from the southern tablelands of NSW Australia was used in this study. Three biochars were selected for use in this study; a woody construction material (WC), this woody construction material combined with sewage sludge (WC+SS), and, greenwaste (GW). These biochars were manually mixed with the soil at three application rates (by volume); i.e , a control (0%), 0.5% and 6%. The responses of several species of plants to the different additions of biochar were examined but this research focused on soil planted with Poa (Poa labillardieri). Soil samples were collected at twelve weeks and measurements of bulk density, total porosity and PSA, were taken.

The three biochars had no significant effect on bulk density or total porosity, except for WC biochar, which caused a significant decrease in bulk density. This is due to the different production methods at pyrolysis. The PSA indicated that all samples treated with biochar had significantly higher levels of macro-aggregates compared to the control, with WC biochar being significantly different to WC+SS biochar but not to the GW biochar. There was also no significant difference between the fraction classes of WC+SS and GW biochar. This indicates that the nature of the feedstock used to prepare biochars is critical in determining the physical properties of biochar treated soils, and hence in their potential use as agronomic amendments.

The results also showed that the presence of the Poa plants made no difference to the effects of the different biochars on bulk density, total porosity or PSA . The PSA indicated that there was no significant difference across sand, silt and clay fractions between the Poa and no plant samples. Even though other studies have shown that the presence of vegetation in the soil matrix will increase total porosity, the lack of any vegetation effects in the current experiments may be due to the presence of biochar in the soil matrix being the most dominant factor on soil physical properties. It could also be due to the short growth time used in this study.

The only significant variation in biochar and application rate combinations is in poa samples, with the application of GW biochar at

6% having significantly lower bulk density and higher total porosity compared to the control. Previous works have proven that GW biochar application increases plant response, which intern increases the total porosity of samples which is supported with these results. PSA did produce variation across different application rates and biochar application however the only significant variable combination being Poa samples in WC at 0.5% having a lower silt fraction percentage and greater clay fraction percentage than the control. This indicates aggregation of the soil occurring in theses samples. However there is no consistent trend across the other applications of biochars.

This research presents preliminary results on physics of biochars and the effect on soil physics once amended. Soil physics has been a largely neglected area in agronomic investigations of biochar. This research finds that the relationship between biochar type and application rate on the physics of soils amended with biochar is complex and further investigation is needed, along with investigation into relationship between plant response and soil physics with biochar application.

Keywords：*Biochar, soil physics, glasshouse experiment*

P2-63

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Vegetation Response to Biochar Amendments: A Glasshouse Experiment

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Biochar is pyrolised organic matter that has been suggested to increase plant productivity when applied to soil. Several studies have focused on biochar application to the surface of the soil in agricultural field settings. The biochars tested are all from similar feedstocks, producing varied results. Here, the research focuses on the effect of biochar type and application rate on plant response in a controlled environment.

The experiment was established across a randomised design in two glasshouses with environmental factors controlled. Four biochar feedstocks - construction and demolition waste (CD), sewage sludge (or biosolids) (SS), urban waste (UW) and greenwaste (GW) were used to create four biochars; CD, CD+SS , UW+SS and GW biochar. Each biochar was physically mixed with soil matrix before potting at five applications rates; control (i.e. 0%/L, by volume), 0.5%/L, 1.5%/L, 3%/L and 6%/L; which are equivalent to surface applications of 2.7kg/ha, 8.1kg/ha, 16.2kg/ha and 32.4kg/ha. Three plant species; acacia pycnantha (AC), brassica oleracea (BA) and Austrodanthonia caespitose (DA), were planted and samples grown for nine weeks, at which time plant height measurements were taken.

Plant type was found to be a significant factor (p-value <.0001) in the plant response measured. BA and DA samples have a significantly higher average response than the AC samples. Biochar type and application rate have no significant variation when compared to the control samples, however different trends were apparent across changing plant and biochar type. No biochar, or application rate combination produced a significant difference from the control across all plant types.

The AC samples had an increasing response with increasing application rates for CD, CD+SS and UW+SS biochars. The BA samples had an increased response at 0.5, 1.5 and 3% application rates in CD and CD+SS biochars. The DA samples had no relationship to, or varied randomly across application rate for CD, CD+SS and GW biochars. AC and BA samples responded similarly in GW biochar with the lower application rates (0.5 and 1.5%) having a greater response than the higher application rates (3 and 6%). AC samples increase with application rate for CD, CD+SS and UW+SS biochars.

Plant type was found in this research to be the dominant factor in plant response to biochar applications. The literature does not distinguish differences in plant species, making comparison with and between published studies, difficult. Here the research found that no matter which biochar was used, plant response is indicative of the species 'normal' growth patterns. Any reactions found, differed between biochars applied and vegetation type. This indicates that different biochars cause different responses in plants, probably driven by the physiological differences in plants to certain properties of biochars. Further research is needed to strengthen this link and to establish any fundamentally positive biochar and plant type combinations.

Biochar feedstock is often discussed in the literature, focussing on different forms of greenwaste and biosolid biochars. If biochar is to be used as a means of closing the nutrient cycle in agriculture other forms of urban waste should also be utilised in the pyrolysis reaction, as in this research using urban waste feedstocks. The CD was primarily composed of waste organic matter produced on construction sites, mainly scrap wood. Biosolid biochars have been praised for their high nutrient content, while

another source of high mineral waste is landfill waste/municipal waste. The varied content and high organic component of municipal waste has the potential to fill both an agricultural and waste management need in society. While the biochar tested in this research did not have a significant result there were no negative effects of these biochars, used as soil amendments. Further investigation into new feedstocks of biochar may illuminate potential pathways of biochar use as soil amendments, not yet thought of.

This research found that under controlled glasshouse conditions biochar amendments had no significant effect on plant response. However, plant type was found to be the dominant positive factor interacting with the different biochars and applications rates tested. Further research is needed to establish best practice for field application of biochar.

Keywords：*Biochar, plant response, glasshouse experiment*

P2-64

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Impact on Methane Generation and Nitrogen Dynamics in Ruminal Fermentation

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Biochar is a porous material obtained from the carbonization of biomass such as woodchips, crop residues, or animal manures. Historical use of biochar for soil productivity enhancement dates back at least 2000 years. Recently, biochar has received much renewed interest not only as soil amendment for potential agronomic benefits but also as a remediation measure for environmental de-contamination purposes. An intense interest is also growing in using biochar as a means to sequester carbon (C) for offsetting anthropogenic carbon dioxide (CO2) emissions. This is based on the premise that biochar-C is environmentally benign, in contrast to most of the parent materials (feedstocks) that undergo natural decay within a short period of time, releasing CO2.

Here, we report an innovative use of biochar for potentially mitigating greenhouse gas (GHG) emissions from dairy cattle. Ruminants such as cattle and sheep contribute to nearly one third of the methane (CH4) emitted worldwide, and CH4 has a greenhouse potential 25 times that of CO2. Therefore ruminal methane emissions account for a significant part of the GHGs from agriculture. Based on our understanding of rumen microbial functions and nitrogen metabolism and transformations, as well as the physico-chemical characteristics of biochar, we hypothesized that biochar has the potential to reduce methane emissions and change nitrogen pathways when used as feed amendment for dairy cattle.

A series of in vitro incubations were performed to test biochar products (derived from poultry litter, corn stover, bermudagrass, woodchips, and a commercial product of activated charcoal) on fermentation pattern, microbial biomass and total and individual gas composition. Incubation trials were conducted under strict anaerobic conditions at 37 ºC, with 6 mL rumen fluid (from a lactating dairy cow) added to a serum vial containing a mixture of substrate (0.75 g of total mixed ration formulated for lactating dairy cow), McDougal's buffer (9 mL), and biochar at various rates. A syringe was inserted through the cap into the serum vial, and volume of gas production was recorded hourly for the first 10 h, 12 h, and 24 h. At the end of incubation, the syringes were collected, sealed and archived until further analysis for CO2 and CH4. The analysis was done using gas chromatography with a thermal conductivity detector, a 914 mm silica gel column at 90 °C, and helium carrier gas at 7 mL/min. The content in the serum vials was analyzed for pH and viscosity before being filtered through cheese cloth. The liquid fraction was further aliquoted for determination of ammonium-N, volatile fatty acids, and microbial biomass. The solids were analyzed for in vitro dry matter digestibility as well as microbial biomass.

Preliminary results showed that the pH of the rumen fluid was around 6.1. After 24 h, the pH of the inoculum was reduced to 4.9, showing the extent of fermentation during the incubation. Gas generation continued throughout the 24 h incubation, but the rate of gas production peaked around 4-6 h before slowing down gradually. With biochar amendment, both total and rate of gas production appeared to decrease compared to control. Cumulative CH4 production over the 24 h period decreased by 13-31% compared to the control. The apparent inhibition in CH4 generation exerted by biochar appeared to take place soon after the fermentation was initiated. Results on ammonium-N, volatile fatty acids, and microbial biomass will be reported once the analyses are completed. Together, findings from the study will help us gain insight into the potential impact of biochar on ruminal fermentation processes involving microbial community structure and functions as well as C and N metabolism and pathways. Future studies will further evaluate biochar products as feed amendment not only for its potential in mitigating methane emissions and other environmental impact associated with animal agriculture, but also for its impact (or lack of) on animal performance indicators so that animal health and productivity will not be compromised.

Keywords：*biochar, methane, ruminant, feed amendment, greenhouse gas*

P2-65

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effects of Biochar and Compost-Modified Biochar on Immobilisation of Pb in Lead Smelting Slag-Contaminated Soil, Yield And Pb Accumulation by Maize Plant

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High concentrations of lead in soil impacted by lead-laden slag is dangerous to man and the ecosystem. Biochar with strong adsorption affinity for heavy metals and soil conditioning properties has potential to render soil Pb harmless and improve plant growth. Efficiency of cashew nut shell (CNS)- and rice husk (RH)-based biochars and compost-modified biochars to immobilize Pb in lead smelting slag (LSS)-contaminated soil (Pb = 18,300mglkg) in Nigeria was assessed using CaCl2 batch leaching experiment, yield and Pb uptake by maize plant. Four rates, in the range of 0.05g-0.4g amendments/1g soil of the biochar and mixture with compost were applied. In pot experiment, maize plant was grown on the soil with minimum and optimum doses of the amendments for 6 weeks during which agronomical and chemical parameters such as plant height, number of leaves, leaf area and plant Pb uptake were measured. CaCl2-extractable Pb in the untreated soil was reduced from 61mg/kg to concentrations which ranged between ND and 3.40mg/kg in the CNS-biochar, RH-biochar, compost, CNS-biochar/compost and RH-biochar/compost amended soils. RH-biochar/compost yielded the most increased plant height, number of leaves and leaf areas and also reduced shoot Pb accumulation by 85.8%. The amendment/soil ratio and the biochar type and modification have significant effects on the immobilization of Pb in the contaminated soil as well as plant growth and Pb uptake. The application of compost-modified biochar is better than using either compost or biochar alone.

Keywords：*Lead smelting slag, soil contamination, biochar, compost-modified biochar, Remediation, plant uptake*

P2-66

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Application to Soil and its Effect on Soil Health

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Biochar, a carbon-rich byproduct of biological origin produced by pyrolysis, is progressively being promoted by scientists and policy makers for its role in carbon sequestration, reducing greenhouse gas emissions, renewable energy, waste mitigation, and as a soil amendment. Stabilizing the CO2 and other green house gas emissions is a strategy to combat global warming and use of biochar is taken as a strategy in this respect. On the other hand, fresh, partially decomposed or decomposed organic matter is considered heart of the soil and is crucial in maintaining soil health in terms of its biology, biochemistry and nutrient recycling processes. Pyrolysis of the organic materials to biochar carbon allows cycling of nutrients back into the agricultural soils and sequestering carbon in a recalcitrant form. However, the effect of biochar on soil nutrient transformations has not been adequately studied. Understanding the characteristics of biochars to avoid ecotoxicological impacts, understanding the effects of biochar on nutrient and contaminant (e.g. heavy metals) behavior and transport, the effects of pyrolysis conditions on key soil properties are some of the areas that require attention. Moreover, there are some questions that still need to be answered. The fact that soil organic matter (SOM) is the heart of the soil cannot be overlooked as it is a vital source of energy and nutrient source for the soil macro and microorganisms and plants as well. Biochar application to soil increases the absorption capacity and is likely to fix the labile fractions of nutrients while the formation of “benzene type” ring structures that form due to pyrolysis are resistant to microbial attack. As a result, microorganisms do not get source for carbon and thus, mineralization rates slow down. It is thus pertinent to look into the facts how biochar affects the soil nutrients vis-a-vis the traditional method of maintaining soil nutrients by application of fresh or partially decomposed organic matter.

Three different sources of biomasses viz., rice straw, rice husk and sawdust and their corresponding pyrolysis products i.e., biochars were incorporated into soils to observe the impacts of these treatments on the emission of CO_2, CO, VOC and PH_3 gases; on the abundance of some agriculturally important soil bacteria viz., Bradyrhizobium, Sulphate reducing and Iron oxidizing bacteria; changes in the status of pH, phytoavailable N,P,K,S and heavy metals Cd, Cu, Pb and Zn and finally on the ameliorative efficacy of biochars on As and some other heavy metals in plant uptake. Addition of biochar had significant effects ($P<0.05$) in reducing CO_2 and PH_3 emission positive but not significant effect on emanation of VOCs. However, the application of biochar could not suppress the CO emissions. Bacterial count was lower in biochar treated soils compared to the corresponding biomass treated ones, a more resilient bacteria, Bacillus badius however, prevailed in the biochar treated soil. Counts of Bradyrhizobium, Sulphate reducing and Iron oxidizing bacteria were less in the biochar treated soil indicating the fact that the material exerted negative effect on the soil microbial population and thus jeopardizes soil health. The pH, total N, phytoavailable N, P, K were substantially higher in the biochar treated soils irrespective of the incubation days compared to the biomass treated soils. Conversely, the available S contents of the biochar treated soils were lower than that of biomass treated soils. The phytoavailable Cd, Cu, Pb and Zn extracted by the 0.005M DTPA revealed the fact that biochar did not show any substantial effect on the sorption of these metals. Although, it is believed that biochars are able to complex metal ions on their surfaces and therefore, reduce bioavailability, however, in our study we found that biochar releases metals not only from their own surface areas but also from the soils after application. Finally, addition of biochar in the soil was found to have increased the plant concentration as well as the uptake of arsenic. However, the concentrations of extractable As decreased with biochar treatments. The results suggest that biochar application is not suitable as soil amelioration for arsenic (As) mitigation.

Keywords：*Biochar, Soil Health, Phytoavailability, Gas emission, Microorganism*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Peanut Shell Biochar Soil Amendment on the Performance of Peanut on Two Types of Soil in Southeast Queensland

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Biochar is a C-rich product of burning biomass in the absence of oxygen (pyrolysis). Its potential as a soil amendment to improve soil health and crop yield has been acknowledged globally. Although agronomic benefits of biochar have been widely observed, the fundamental mechanisms by which biochar affects soil properties and crop growth are poorly understood. In particular, the link between observed changes of soil properties following biochar application and physiological effects related to crop performance have not been experimentally addressed. In this study, we amended two distinct soil types using peanut shell biochar and examined the performance of peanut crop on these amended soils in a pot experiment. We particularly aimed to explore the physiological mechanisms that underpin the effect of biochar on peanut plant's performance. The soils were collected from two sites, both in southeast Queensland, the first Kingaroy which is red ferrosol with high CEC and the second Bundaberg which is a redoxi-hydrosol which is acidic sandy loam. A pot experiment was conducted with six biochar amendment treatments (0%, 0.375%, 0.75%, 1.5%, 3%, 6%, wt/wt) thoroughly mixed in to the soil. The peanut cultivar Middleton (PBR MD1-E O1224, Peanut Company of Australia Ltd., Kingaroy) was used for the study. Biochar amendment increased plant biomass and pod yield in both soils, but in different manner. In the red ferrosol, biochar amendment linearly improved the performance of peanut biomass and pod yield, with 6% biochar treatment resulting in 111% and 77% increments respectively. In the redoxi-hydrosol, biochar amendment up to 1.5% had a limited effect on peanut, while 3% and 6% biochar, respectively doubled and tripled both biomass and pod yield relative to the control. The stimulating effect on peanut performance is not attributable to the changes to soil pH despite the high pH (10.1) of peanut hull biochar, because the change of soil pH is very limited in both types of soil. Biochar amendment had trivial effects on biomass fractions and leaf N isotopic signal, so improvement of peanut performance did not seem to be caused by altered pattern of allocation or N fixation either. In the red ferrosol, the stimulating effect of biochar amendment can be partially attributed to rate of photosynthesis, as indicated by a significant correlation between biomass growth and leaf photosynthetic rate. Biochar amendment did not alter leaf maximum carboxylation rate (V_{cmax}) but increased the maximum electron transport rate (J_{max}) and thereby the photosynthetic capacity. Such improvement in photosynthesis is largely or attributable to the increment of leaf photosynthetic apparatus (capacity) i.e. leaf nitrogen and chlorophyll. In contrast, biochar did not affect peanut leaf photosynthetic properties in the redoxi-hydrosol. In both soils, amendment with peanut shell biochar increased soil inorganic nitrogen (ammonium nitrogen for the redoxi-hydrosol, and both nitrate and ammonium nitrogen for the red ferrosol) and led to more depleted soil N isotopic signal, indicating better soil nitrogen availability and preservation. Finally, peanut shell biochar amendment introduced additional mineral nutrients into the soils. This might have relieved possible nutrient limitation (boron and phosphorus for the red ferrosol, and boron, potassium, calcium and magnesium for the redoxi-hydrosol) on peanut growth. These results suggest that agronomic benefits of peanut shell biochar can be driven by various physiological mechanisms in the two different soils. Our study also highlights the possibility of transforming peanut shell (as a waste product of peanut processing industry) into biochar to boost peanut production on both fertile and poor soils in southeast Queensland. Field experiments and mechanistic studies are warranted to further explore the potential of this system.

Keywords：*biochar, Arachis hypogaea, photosynthesis, yield, growth, nutrient*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Combined Use of Biochar and Fertilizer on Maze Yield and Greenhouse Gas Emission in Calcareous Soil: 2 Consecutive Maize Growing Cycling

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Biochar application has been found to mitigate greenhouse gas (GHG) emission and improve crop yield. We conducted a 2-year consecutive field experiment in calcareous soil to investigate the effect of biochar combined with fertilizer on maze yield and GHG emission. Wheat straw biochar were used at the rate of 0 t ha-1 (C0), 20 t ha-1 (C20) and 40 t ha-1 (C40) in 2011. Fertilizers were applied at the rate of 258 kg N ha−1 with 69 kg P2O5 ha−1 as base fertilizer, and 122 kg N ha−1 kg N ha−1 as top-dressing for traditional treatment (F1). Base fertilizer were applied at 190 kg N ha−1 with127 kg P2O5 ha−1 for adjusted fertilization treatment (F2). GHG were monitored with closed chamber method at 7 days interval throughout the maize growing season. Maize yield significantly increased at F1C40, F2C20 and F2C40 in 2011, at F2C40 in 2012 compared to C0. Nitrogen use efficiency also increased at F2C20 and F2C40 in 2011, at F2C40 in 2012. N2O emission significantly decreased at C20F1 in 2011, and C20F1, C40F1, C40F2 in 2012. N2O emission, global warming potential (GWP) and carbon intensity of rice production (GHGI) decreased under biochar application with reducing nitrogen rate. GHGI decreased at all biochar treatments in 2011 and C40 in 2012. It suggested that adjust rate of N fertilizer combined with biochar application should be more effective countermeasure to improve maze yield and mitigate greenhouse gas.

Keywords：*biochar, maize yield, fertilizer, mitigate greenhouse gas emission*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Ecotypes of Brachypodium Distachyon, Improving Topsoil Hydraulic Conductivity

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Agricultural topsoil can be lost through agricultural practices. When typical Mediterranean crops are produced on sloping terrain, a process begins which leads to considerable soil loss. Permanent green top covers can be a solution to improve topsoil hydraulic conductivity $k(\theta_{0i})$. A field experiment was done to sow Brachypodium distachyon (L.)Beauv. using four ecotypes families with two seed densities and three nitrogen fertilizations. Two dependant variables were obtained from the infiltration data analysis: infiltration $I(\theta_{0i})$ and infiltrability $k(\theta_{0i})$. $I(\theta_{0i})$ ranked $0.47< I(\theta_{0i})cm<5.03$. $k(\theta_{0i}):0.68< k(\theta_{0i})cm/h<9.76$. The spatial variability of the dependant variable, $k(\theta_{0i})$, was mapped. The use of residual values deriving from statistical analyses and kriging processes ensured relations between soil infiltration and plant density per square meter as a common agricultural practice. Fertilization presented no plot infiltrability differences. The texture topsoil analysis yielded sandy loam soil and an analysis of $2.2<(\theta_v\ \%)< 8.5$; $0.67<(\rho_b(g/cm^3))< 2.9$; $0.18<$ (SOM%) <0.87 was done.One tendency noted that the infiltration velocity of the 2n=10 (D_i) taxa occupied first place in the study groups. Physiological and ecological reasons are also supported given the mountainous origin of ecotypes 2n= 10(D_i). B. distachyon ecotypes can protect soil and improve water soil infiltration.

Keywords：*Brachypodium distachyon (L.)Beauv. topsoil, Infiltration capacity. Spatial variability. Central Ibe*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of EFB Biochar on Total Phenolics and Secondary Metabolites of L.pumila Benth

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Introduction

Kacip Fatimah (Labisia pumila) which comes from the family of Myrsinaceae, is reputed to have great medical value and is popularly used by Malay women in Malaysia. L. pumila has high demand in local market compared to other 30 herbal products and were sold in the form of dry, plant, capsule, tonic and many more (Mohd Noh et al., 2006). The Malaysia market for herbal estimated to be worth at RM4.55 billion and 90 percent of the raw material are being imported (Hartinie and Azlan, 2007). Otherwise, industries related to medical plants growing rapidly but the raw material supply from natural source is scares, unreliable and unsustainable (Rezuwan, 2002).

Oil palm (Elaeis guineensis) was introduced to Peninsular Malaysia in 1870 and has been successfully commercialized during the 1900s. Biomasses from the agricultural and forestry sectors have been used for energy generation because it is a clean and renewable energy source that is environmental friendly and economical, and promotes energy security. The palm oil industry produces huge amounts of oil palm biomass such as mesocarp fibre, shell, empty fruit bunch (EFB), frond, trunk and palm oil mill effluent (POME). About 25 millions of oil palm biomass was produced as by-products in the production of 80 million tones of fresh fruit bunch (FFB). The biomass is being converted to biochar through o a thermal process known as pyrolysis that occurs at moderate temperatures in which the biomass is rapidly heated in the absence of oxygen or air (Azri et al., 2009).

Biochar has characteristics of higher stability against decomposition and excellent ability to absorb ions as compared to other forms of soil organics matters due to its greater surface area, negative surface charge and charge density (Liang et al., 2006 and Lehmann, 2007). The porous structure, bigger surface area and ability to absorb soluble organic matter, gases and inorganic nutrients of biochar are provide a suitable habitat for microbe to colonize, grow and reproduce particularly for bacteria, actinomycetes and arbuscular mycorrhizal (AM) fungi. According to Hunt J. et al. 2010, biochar has ability to increase microbial activity. It believed that soil microbial activity were strongly effect the soil function and consequently crop growth and yield. In addition, Mayam et al., 2012 reported that in other beneficial microbe-plant interaction involving arbuscular mycorhizal (AM) fungi has induced the secondary metabolite. In this experiment EFB biochar was inoculated with arbuscular mycoorhiza (AM) i) to investigate how EFB biochar and AM fungi Glomus mossae alters the chlorophyll content in three varieties of L. pumila namely var pumila, var alata and var lanceolata. The study also attempted ii) to evaluate the secondary metabolite content in leaf of three varieties of L. pumila when EFB biochar amendment inoculated with AM fungi Glomus mossae.

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Materials and methods

The experiment location was conducted at glasshouse in Ladang 2, UPM Serdang Selangor. Eight months old L. pumila Benth.varieties seedlings (var pumila, var alata and var lanceolata) were placed for a month to acclimatize in the glasshouse until ready for treatments. Two rates of EFB biochar amendment (6%) and non-amendment (control) were applied to L. pumila seedlings and inoculated with two levels of AM spores (no spores and 150 spores). Biochar produced from empty fruit bunch (EFB) of oil palm was mixed with the soilless media thoroughly with the respective rates. The AM fungal inoculums placed just 2cm below the surface of the planting media mixture. The fungus, Glomus mossae sp. are propagated in pot culture grown with Zea mays in soil: sand mixture for 75 days. The inoculum composed of mixture of mycorrhiza soil, colonized root fragments, AM hyphae and spores. This factorial experiment was arranged in a split-split plot design with EFB rates being a main plot and AM Glomus mossae as the sub plot replicated three times. L. pumila varieties seedlings were randomly arranged in sub-plot. Each combination treatments consisted of 12 seedlings giving overall 108 seedlings used in the experiment. Chicken dung was used as standard fertilizer which was applied once every two weeks to ensure the plant get sufficient nutrients. Plants were irrigated twice daily in the morning and evening. At monthly intervals, the plants were harvested and growth development parameters were determined. Total chlorophyll content was quantified by using SPAD meter meanwhile total phenolics and total flavonoids were determined according to Ibrahim M.H et al., 2011. Data obtained from the first harvest till forth harvests respectively were analyzed with the statistical package SAS version 9.1 for Windows.

Results and Discussion

Effect of EFB biochar on total chlorophyll content of L. pumila Benth. Varieties

Along the period of study from 40 DAT to 120 DAT, the seedlings of L. pumila varieties treated with EFB biochar inoculated with AM were not significantly ($P \leq 0.05$) difference (Figure 1). However, L. pumila varieties seedlings inoculated with AM Glomus mossae without EFB biochar were significantly difference at 120 DAT.

Figure 1 Change in total chlorophyll content of L. pumila seedlings as affected by EFB biochar with and without AM during 120 days of application. Data mean ± SE (standard error of differences between means) of 12 replicates

Effect of EFB biochar on total flavonoid content of L. pumila Benth. Varieties

There were significantly ($P \leq 0.05$) different on total flavonoid observed on L. pumila varieties seedling applied with EFB biochar compared to control. Meanwhile L. pumila varieties seedlings treated with EFB biochar inoculated with AM Glomus mossae gave no significant ($P \leq 0.05$) different to the total flavonoid between the other treatments (Figure 2). AT 120 DAT, L. pumila varieties seedlings treated with 6% of EFB biochar inoculated with AM Glomus mossae obtained total flavonoid value (1.545 mg rutin equivalent per kg dry weight) compared to L. pumila seedlings treated with 6% EFB biochar (1.348 mg rutin equivalent per kg dry weight) and AM only (1.213 mg rutin equivalent per kg dry weight) (Figure 2). Meanwhile control seedlings were observed lower total plant flavonoids at 1.163 mg rutin equivalent per kg dry weight. L. pumila var alata (2.171 mg rutin equivalent per kg dry

weight) obtained higher total falavonoid content followed by L. pumila var pumila (1.411 mg rutin equivalent per kg dry weight) and var lanceolata (1.054 mg rutin equivalent per kg dry weight) under 6% of EFB biochar inoculated with AM Glomus mossae.

Figure 2 Change in total flavonoid with time of L. pumila varieties seedlings as affected by different rates of EFB biochar during 120 days of amendment. Data mean ± SE (standard error of differences between means) of 9 replicate

Effect of EFB biochar on total penolics content of L. pumila Benth. Varieties

The effects of empty fruit bunch (EFB) amendment with and without arbuscular micorrhiza (AM) Glomus mossae on total phenolics of L. pumila was shown in Figure 3. After 4 months applied with EFB with and without AM Glomus mossae, the mean of total phenolics of L. pumila varieties seedlings in all treatment has significant ($P \leq 0.05$) different. By 120 DAT, the mean of total phenolics in leaf of L. pumila varieties seedlings registered under 6% of EFB biochar with AM Glomus mossae (1.458 mg GA kg-1 dry sample) was higher than the mean of total phenolics of L. pumila varieties seedlings under 6% of EFB biochar only (1.456

Keywords：*land resource management*

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Sorption of Nutrients by Three Biochars during Co-Composting with Biowastes

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INTRODUCTION: Composting of biowastes including manures and biosolids results in the release of nutrients. Biochars have a recalcitrant carbonaceous structure that may possess a micro-porous as well as reactive surface. The presence of a wide range of functional groups on the surface allows biochar to adsorb cation nutrients; while the micropores allows absorption of both the cations and anions from solution. Bamboo biochar was found to reduce emission of N and mobility of Cu and Zn while being co-composted with sewage sludge. The objective of this study was to evaluate biochars' ability to sorb nutrients from composting system.

METHODS: Three different biochars (BC), made from macadamia nut shell (bcMS), hardwood shavings (bcWS) and chicken litter (bcCL) were co-composted with chicken manure and pine sawdust. bcMS, bcWS, and bcPL had specific surface areas of 202.49, 0.35 and 12.8 m^2 g^{-1}, and pore volume of 0.0085, 0.0035 and 0.015 mL g^{-1}, respectively. The mixing ratios of feedstocks were based on C/N value and BC%. The C/N ratio of the piles on day 0 ranged from 24.9 to 29.6. All seven feedstock mixtures (piles) contained chicken manure and sawdust. The control pile contained no biochar. The other six piles were treated with biochar at two rates: 5% and 10% (w/w). The piles (125 L) were composted in spherical plastic bins (153 L). For easy sampling of composted BC (coBC), about 1 g of a BC (710 to 2360 μm) was placed in a small litterbag made from 30 μm mesh nylon textile that allowed free movement of pore solution and composting microbes; 34 litterbags were incorporated in each pile. The bins were aerated at a low rate of 0.028 L min^{-1} kg^{-1} DM; and also rotated once a week. The progress of composting was monitored by measuring temperature, DOC, Solvita emission test, NH_4^+/NO_3^- ratio, C/N ratio, and seed germination test. The composting ended on 126th day. The litterbags were harvested on 133rd day. The composted BCs were identified as cobcWS, cobcMS, and cobcCL.

Major and minor nutrients of BCs and coBCs were analysed. C and N were determined by dry combustion in an automated CN analyser. Total P, K, S, B, Ca, Mg, Cu, Mn, Mo and Zn were measured by ICP-OES after microwave digestion of 0.1 g sample with 4 mL 69% HNO_3 and 1 mL 33% H_2O_2.

RESULTS AND DISCUSSION: cobcMS had higher amount of C, N, S, B, and Cu compared to that of bcMS. Its P, K, Mo and Zn contents were lower. cobcWS had higher amount of N, P, K, S, Ca, Mo and Zn compared to that of bcWS. Its C, B, Cu and Mn

levels were lower. cobcCL had higher amount of C and N compared to that of bcCL. Its Ca and Mg contents were equivalent to that of bcCL, while Cu, Mn, Mo and Zn contents were lower.

The C content of cobcMS was higher by 12.2 to 12.5% than that of bcMS, probably because of its ability to sorb dissolved C as it had higher surface area and pore volume. The C content of cobcWS was lower by 3.3 to 6.8% than that of bcWS probably due to loss of its labile C through bio-oxidation; bcWS had very low surface area and pore volume, thus was unable sorb enough dissolved C to outweigh the loss of labile C. The C content of cobcCL was higher by 0.2 to 3.8% compared to that of bcCL, which had slightly higher surface area and pore volume than that of bcWS. Thus in the case of cobcMS and cobcCL, probably the sorption of dissolved C outweighed any loss of labile C. The N content of coBCs followed cobcMS < cobcWS < cobcCL, whereas the % increase of N in the coBCs followed cobcWS > cobcMS > cobcCL. The increase in N content of bcWS was considerably higher (>600%) despite its negligible surface area and pore volume.

CONCLUSION: Over 133 days of incubation, all the coBCs were able to increase their N content. The C content of bcMS and bcCL increased despite a strong bio-oxidative condition. In the case of bcWS, the C content decreased only slightly. This observation points to the recalcitrance of BC in composting environment.

Keywords：*Agriculture, Recalcitrance, Sorption, Nutrient, Biochar, Compost, Soil conditioner*

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Plant Nutrient Compounds In Biochar Produced From Tropical Plant Waste By Slow Pyrolysis

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Agricultural and food processing wastes require sustainable disposal options. Waste disposal can pose serious problems such as environmental pollution, greenhouse gases, spread of plant pathogens and respiratory diseases. However, we can overcome these problems and add economic value to wastes by pyrolysis of wastes to produce biochar. Benefits of producing biochar from farm and food wastes include the generation of electricity, liquid biofuels, gas biofuels, large amounts of heat and biochar. Biochar is a black carbon solid material which may be mixed into soils, where it may remain for many years providing a long term carbon sink. It may improve the physical and microbial properties of soils. Furthermore, biochar is a potential source of plant nutrients especially potassium, calcium, magnesium, phosphorus and sulfur. However, the speciation (compounds) of these elements is poorly understood and the nature of the compound will affect nutrient availability. The main objective of this study was to investigate nutrient forms and nutrient availability for biochar manufactured from wastes of several tropical plant species.

Nineteen biochars made from 14 Thai biomass wastes (soybean meal, corncob, lemon peel, sugar palm fibre, durian shell, tamarind wood, coconut fibre, coconut shell, rice husk, bamboo wood, eucalyptus wood, oil palm fruit, coffee waste and bagasse) were produced in a fixed bed reactor and by a traditional method.

Generally, the morphology of biochar particles faithfully preserved the morphology of the parent plant organ despite the radical chemical transformations that occur. During pyrolysis, elements in xylem, phloem and plant cell fluids and both organic and inorganic compounds form crystals so that minerals such as carbonates, sulfates, phosphates and chlorides occurs in biochars. The nature of these mineral components affects the availability of plant nutrients. Apatite and calcite present in biochar are only moderately soluble at the high pH of biochar so nutrients contained in these minerals (Ca, P) will dissolve slowly. Conversely, arcanite (K2SO4), kalicinite (KHCO3) and sylvite (KCl) are highly soluble and may be readily available to plants. Potassium, P, S, Ca and Mg were present at quite high concentrations in these biochars so they should be effective fertilisers. The various alkali carbonates in biochar are also effective liming agents.

Keywords：*Biochar, alkali forms, tropical waste, slow pyrolys*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Modification of Biophysical Soil Properties by Biochar Amendments

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Biochar is the carbon-rich product obtained from pyrolysed biomass. Since biochar can be produced from different types of biomass (pine, poplar, waste) and pyrolysis (slow, fast, gasification), it is essential to investigate how the raw material and the pyrolysis method may influence the performance of biochar amendments in soil. The main aims of this study were to analyse whether biochar obtained from different organic sources and types of pyrolysis, can modify soil properties in contact with water (soil-water contact angle CA, soil disaggregation, nutrient release during soil slaking). Further changes in soil basal respiration were determined after biochar amendments. Dynamic soil-water CA measured by capillary rise method was not modified by biochars, although it tended to be increased by gasified pine and decreased by slow pyrolysed sludge. In contrast, static soil-water CA's of biochars measured by sessile drop method after crushing process, showed that slow or fast pyrolysed poplar and pine are potentially hydrophobic (CA > 90°), while slow pyrolysed sludge and gasified pine are potentially hydrophilic (CA < 90°). When soil aggregates were immersed in water, its degree of stability was calculated and pH, NO3-, NH4+, K+, Ca2+ and SO42-release resulting from soil-water contact were measured. Our results showed that biochar soil amendments were able to increase water pH and nutrient release from soil to water, while the ratio between water-stable and water-unstable soil aggregates (soil AS) was decreased by slow pyrolysed sludge. Soil-water retained in soil between -0.75MPa or -1.5MPa and -30MPa was increased by slow pyrolysed sludge during drying process, after 10 minutes of soil saturation under water column. Finally, application of gasified pine and slow pyrolysed poplar and pine was able to inhibit CO2 emissions from soil at field capacity. These findings should be taken into account when choosing the biochar to be used as soil amendment.

Keywords: *biochar, pyrolysis, soil-water contact angle, aggregate stability, nutrients, slaking, respiration*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Reducing Ammonia Emissions from Poultry Litter During Composting through the Use of Biochar

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The poultry industry is rapidly growing to meet the global protein demand. However, appropriate management of litter (ie, bedding, manure, feathers etc) is required to minimise its environmental impacts. In Australia alone 1.6 million tonnes of litter is produced annually, much of which is used as an agricultural soil amendment, either applied directly or via compost. To maximize the N-nutrient value of poultry litter, we undertook a study to incorporate biochar into a composting system to reduce the volatilization of ammonium and maximize its residual fertiliser value. Biochar is a charcoal material produced from organic matter under high temperature and limited oxygen. It has adsorptive properties, and therefore may have capacity to trap nitrogen compounds (ammonium and ammonia gas) produced during composting of poultry litter, thus reducing ammonia emissions and enhancing fertilizer value of the poultry litter. This research aims at assessing the capacity of biochar made from green waste and poultry litter to reduce NH3 emission during composting of poultry litter. Green waste Biochar (GWB) and poultry litter biochar (PLB) were co-composted with raw poultry litter and sugarcane straw with a C/N ratio of 10:1 in a compost tumbler. The tumbler was closed for 20 minutes daily to capture the gases released. The gas was bubbled through a solution of boric acid in 2 M KCl and analyzed for NH3. Daily temperature was recorded throughout the 60 day composting period. Compost was tumbled to maintain aerobic condition which is necessary for increased microbial activities and compost quality. Results revealed that rate of emissions of NH3 doubled immediately after tumbling in all treatments, with nil biochar controls having statistically significant higher emissions than the PLB and GWB treatments. Cumulative flux of NH3 revealed 50% and 28% reduction of NH3 emissions from GWB and PLB treatments respectively cf. control. We hypothesise that the biochars resulted in an enhanced adsorption of NH3 or changed the compost environment to favor dissolution of NH4+. The outcome of biochar addition to the poultry litter during composting is increased N retention, and potentially higher fertiliser N value of the final product.

Keywords：*Biochar, ammonia, poultry litter, composting ,adsorptive capacity,fertilizer value*

P2-75

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Study of the Al-Soluble NPK Content of Chernozem Soil in a Long-Term Fertilization Experiment

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Chernozem soils have excellent physical, chemical and biological properties. These properties can be changed by different agrotechnical management factors used in field crop production. The NO3-N, AL-soluble P2O5 and K2O contents of chernozem soil were studied in a long-term experiment. Our long-term experiment started in 1983 and it was carried out in the eastern part of Hungary. The original physical and chemical properties were the following: humus content 2.8%, total N = 0.16%, AL-P2O5 = 140 mg kg-1, AL-K2O = 260 mg kg-1, the depth of humus layer = 0.7-0.9 m, pH value of top soil = 6.2. Different fertilizer doses were applied in the long-term experiment (1983-1996 years = control, N = 60 kg ha-1 +P2O5 = 45 kg ha-1 + K2O = 53 kg ha-1 and its 2, 3, 4, 5 folds; 1997-2013 years = control, N = 30 kg ha-1 + P2O5 = 22.5 kg ha-1 + K2O = 26.5 kg ha-1 and its 2, 3, 4, 5 folds). The test crop was winter wheat. Soil samples were taken after the harvest of wheat. Our research results proved that the NO3-N content of chernozem soil strongly increased if we used N-fertilizer doses over the optimum dose (N120 + PK) of winter wheat. The maximum NO3-N contents were 32 mg kg-1 (in 1988) and 170 mg kg-1 (in 2003), respectively. The NO3-N accumulation zone slightly moved into deeper soil layers even under dry, continental climatic conditions (in 1988 year 0.80-1.00 m, in 2003 year 1.40-2.20 m, respectively). The phosphorous and potassium fertilizers increased the AL-P2O5 and AL-K2O content of chernozem soil only in 0-0.20 m and 0.20-0.40 m soil layers. In the control treatment, after 20 years (without fertilization) there were moderated changes in the AL-P2O5 and AL-K2O content (80 mg kg-1 and 180 mg kg-1, respectively) which proves the excellent natural fertility of the chernozem soil.

Keywords：*chernozem soil, NPK content, fertilization, long-term experiment*

P2-76

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Short Term Effects of Biochar in Enhancing the Biological Nitrogen Fixation Potential of Soybean in the Semi-Deciduous Forest Zone of Ghana

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The popularity gained by the use of biochar in improving biological nitrogen fixation of soybean and curtailing soil fertility is new in the context of Ghanaian agriculture. The aim of this study therefore was to evaluate the short term effect of rice husk biochar application on the nodulation and nitrogen fixaiton in soybean. This study was carried out during the minor rainy season of 2012 (September – December). The experiment consisted of a total of 4 treatments replicated three times and laid out in a Randomized Complete Block Design. The treatments were biochar only (5 t/ha), biochar + 100% NPK (recommended rate of 90:60:60 kg/ha), biochar (5t/ha) + 50% NPK (1/2 recommended rate) and a control.

The pH of biochar amended plots decreased from 6.44 to 4.77. At harvest, soil N content of biochar (5t/ha) + 50% NPK was significantly higher than biochar only and biochar (5t/ha) + 100% NPK. Biochar only produced nodule dry weight significantly higher than the control, biochar (5t/ha) + 50% NPK and biochar (5t/ha) + 100% NPK. However, there were no significant differences in nodule number between the biochar (5t/ha) + 1000% NPK, biochar (5t/ha) + 50% NPK and biochar only. Biochar (5t/ha) + 100% NPK gave the highest amount of nitrogen fixed. Our results indicate that biochar may have the potential to reduce acidity in farmlands and also enhance biological nitrogen fixation of legumes.

Keywords：*Biochar; nitrogen fixation; nodules; legumes*

P2-77

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Use Efficiency of Some Soil Amendments and Unconventional Irrigation Water on Improving Properties and Productivity of Sodic Soil

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A sodicity phenomenon (rich in exchangeable sodium) is likely a more important problem to mange the areas prolonged to the north coast of Nile Delta, Egypt. However, a field experiment was conducted at El-Riad province close to El-Burouls Lake, Kafr El-Shiekh Governorate. The main target of this work is to evaluate the effect of soil amendments viz. gypsum at application rate of 50% of gypsum requirements (GR=10.4 t/fed), sugar lime (equivalent to GR), farmyard manure (FYM) at a rate of 20 m3/fed.), gypsum+FYM, FYM+sugar lime and a control with unconventional (reuse of agriculture drainage water ECiw 4 dS/m) or non-saline (0.82 dS/m) irrigation water on some soil properties and yields of rice and wheat in a sodic soil (pH >8.5 and ESP 43%). The obtained results showed that the application of soil amendments increased the yield of both studied crops significantly irrespective of the quality of irrigation water used. The effectiveness of the soil amendments on soil and crop improvement could be arranged in the descending order: gypsum+FYM > sugar lime+FYM > gypsum > sugar lime > FYM > control. The reused of drainage water resulted in a significantly higher yield of both crops as compared to non-saline water. A decrease in soil pH and exchangeable sodium percentage (ESP) and increase in Ca+Mg and infiltration rate values were pronounced after rice than wheat crop in rotation, particularly, when non-saline water was used.

This research demonstrate the highly magnitude of reused drainage water as a resource to meet crop water demands applied as a supplemental irrigation as well as to accelerate the improvement process in a sodic soil and rising its productivity.

Keywords：*Sodic soil, Gypsum, Sugar lime, FYM, Drainage water, Rice and wheat production*

P2-78

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar as Soil Amendment to Improve Soil Quality, Crop Yield, and Carbon Sequestration

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Biochar, a by-product of a thermochemical process called pyrolysis, which involves burning of any agricultural and animal waste (biomass) under high temperature and absence of oxygen. It is assumed that since biochar is very high in aromatic carbon, which persists in soil environment for very long time. Biochar has a porous physical nature that can be used by microorganisms; also as soil conditioner, it improves soil quality parameters such as soil compaction, infiltration rate, water holding capacity, nutrient exchange capacity (CEC), aggregation and aggregate stability, organic carbon build up, soil reaction (pH), and soil microbial ecology. In this process, soil acts as an enormous C sink, which could significantly contribute to the reduction of CO2 in the atmosphere. Our objective was to evaluate biochar application impact on soil and corn grain yield in comparison with chemical fertilizer and animal manure. Corn grain yield in 2010 and 2011 were lower than 2013 due to drought and hail damage during the growing seasons. No significant differences among treatments in regard to corn yield in 2010 and 2011. In 2013 (an optimum year), biochar treatment produced significantly lower corn grain yield than chemical fertilizer, poultry litter, and combination of biochar and poultry litter.

Keywords：*Biochar, Sequestration, Agronomy*

P2-79

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Quantifying Biochar Amendment Impacts on Global Warming Potential For Cd/pb Contaminated Paddy Soil Ecosystem: A Case Study in Tai Lake Plain, China

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It is well known that nitrous oxide (N2O), carbon dioxide (CO2) and methane (CH4) are the main biogenic greenhouse gases (GHGs) contributing to net GHGs balance of agro-ecosystems. Evaluating the impact of agriculture on climate strongly requires to predict the net exchanges of these gases in a systemic approach, as related to environmental conditions and crop management. Biochar production and application from crop straw had been proposed as one effective countermeasure to mitigate climate change. We conducted a field experiment in the cadmium (Cd) and lead (Pb) contaminated paddy field to elucidate how the biochar effects on rice production, net ecosystem exchange(NEE) and global warming potential (GWP) in 2010 year. Biochar was amendment in 2009 before rice transplanting at rate of 0, 10, 20 and 40 t ha-1, soil emission of CO2, ecosystem emissions of CH4 and N2O were monitored with closed chamber method at 7 days interval throughout the whole rice growing season in 2010 year. The results showed that biochar amendment increased soil pH, soil organic carbon and total nitrogen, but decreased soil bulk density. DTPA Cd and Pb were decreased by 25.3%, 21.3% and 48.7%; by 11.9%, 17.3% and 23.6% under biochar amendment at 10 t ha-1, 20 t ha-1 and 40 t ha-1, respectively. Seasonal total of soil CO2 emission was decreased by 16% and 24% under biochar amendment at 20 t ha-1 and 40 t ha-1, respectively. There was less relationship between seasonal total CO2 emission and DTPA Pb concentration ($p = 0.0642$). Seasonal total ecosystem of N2O emission was reduced by 11%, 33% and 50% under biochar amendment at 10, 20 and 40 t ha-1, respectively. Seasonal total ecosystem of CH4 emission was increased by 31% only under biochar amendment at 40 t ha-1. In summary, the GWP of ecosystem was decreased by 54% and 63% under biochar amendment at 20 t ha-1 and 40 t ha-1, respectively. We conclude that the biochar amendment could result in ecosystem carbon sink for our investigated contaminated paddy filed in Tai Lake plain, China.

Keywords：*biochar;carbon dioxide;methane;nitrous oxide;NEE;GWP*

P2-80

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Amendment Effects on Nitrous Oxide and Net Greenhouse Gas Balance from an Acidic Vegetable Field In Southeast China

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The beneficial effects due to biochar amendment on agricultural soil carbon sequestration and trace gases emissions have been well documented by numerous studies, especially in laboratory incubations. However, these biochar-mediated responses have not been fully elucidated in the field to exploit its longer term effects. In this study, nitrous oxide (N_2O) and net greenhouse gas balance (NGHGB) as affected by wheat biochar (WB) amendment with compound fertilizer (CF) or a mixture of urea and nitrapyrin (CP) were investigated with year-round observation from an acidic vegetable field in southeast China. Results showed that the annual rates of N_2O emission amounted to 26.1-27.9 kg N ha^{-1}. Significant decreased effects due to biochar addition ($P<0.01$) or CP application were occurred only during the period with lower efflux intensities of 1.3-2.9 kg N ha^{-1}, corresponding to the lower soil temperature ($P<0.0001$), not the whole observation period. With differential responses of soil pH, biochar application significant increased soil organic carbon content ($P<0.0001$) but not soil total nitrogen.When taking net ecosystem exchange of CO_2 and N_2O into account, following biochar application the NGHGB were increased by 39% in the WB plus CF treatment and decreased by 34% in the WB plus CP treatment. Biochar amendment in our acidic vegetable field exhibits small or negligible beneficial effects on both plant growth and greenhouse gas mitigations, which is inconsistent with previous reports on unanimously positive agronomic and environmental influences of biochar. Therefore, biochar used as a robust means to combat changing climate and ensure food production should be further examined in various ecosystems.

Keywords：*Acidic soil, Wheat biohcar, Soil heterotrophic respiration, Net primary productivity*

P2-81

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Application as a Non-Structural Bmp on Erosion Potential Using a Rainfall Simulator

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Soil erosion is a complex process with multiaspects that depends on soil properties, slope steepness, vegetation cover, rainfall intensity and management scenarios. In this regard
the management of organic amendments play a decisive role in soil erosion potential. Best management practices (BMPs) were chosen to alleviate soil erodibility and acquire the soil sustainability. Recent studies showed the potential of biochar as a non-structural BMP for improving overall soil quality. Biochar is a carbon-rich compound with high porosity
produced by the pyrolysis process of biomass at relatively low temperature,
under field conditions is costly and time consuming. Rainfall simulation provides the possibility to quantify the effects of different management scenarios on erosion and runoff potential at a smaller scale under controlled conditions. This study investigated the short term effects of biochar application on a sandy loam soil in Denmark. The field experiment was established with eight plots (four plots with and four plots without biochar application) in 2011. The clay, silt and sand contents of these plots were within range of 9-11 g 100 g-1, 12-14 g 100g-1 and 74-79 g 100g-1 respectively. The plots with biochar were established using biochar produced from birch wood at a temperature of 500 □ C (74 % of particles having a size of 4-8 mm). An amount of 2 kg m-2 where applied to the topsoil and was incorporated into the soil by harrowing back and forth (one time). From each plot a representative sample with systematic sampling from 6 points (0-20 cm depth) has obtained. In the laboratory the soil samples were analysed in relation to aggregate stability and soil organic carbon (SOC) content including total organic carbon (TOC %), total inorganic carbon (TIC %) and total carbon (TC %). Soil erosional properties including erosion rate, runoff rate, runoff coefficient and total organic carbon eroded from each plot were measured during a 3½ hour rainfall simulation tests (30 minutes time interval) using a round flume setup (outside diameter of 50 cm and an inner diameter of 10 cm) having an inclination of 10 % from the outside to the inner rim. Artificial rain was applied with a specific nozzle at a rate of 30 mm h-1. Measurements showed that biochar application into the soil was able to enhance SOC and aggregate stability. Plots with biochar application, showed significantly lower runoff rate (mm h-1) and erosion rate (g m-2 h-1) compared to the control plots due to aggregating effects of organic carbon with binding agents resulting from biochar application. The sediment concentration during rainfall simulation tests was decreased for both biochar and control plots and for plots with biochar application was lower. Moreover, the runoff coefficient (RC) in plots with biochar application was lower. Enrichment ratio (the ratio of organic carbon in the sediment to the original soil) of plots with biochar was lower than control plots. Total organic carbon eroded (g) in plots with biochar application was lower than plots without biochar application. In addition the results showed that there was difference between surface pattern of plots without biochar and plots with biochar application. On the surface of soil amended with biochar there were biochar lumps as binding proxies to form the soil aggregates and caused increase the resistance of soil surface against erosive forces. The results illustrated that biochar application already in a short term can lead to an improvement of soil aggregation thereby enhancing the aggregate stability leading to a lowering of soil erosion.

Keywords：Key words: best management practice (BMP), erosion potential, biochar, rainfall simulator, aggregate

P2-82

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Reconstructed Topsoil Using Biochar: Soil Quality after Ten Years of Cultivation

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There is growing global interest in the use of biochar as a soil amendment to improve soil quality and sequester carbon. However, most studies to date have focused on biochar amendment to topsoil and results have mostly been obtained from short-term studies under tropical conditions. A field experiment was setup in Alberta, Canada, where topsoil (30 cm) was removed to simulate topsoil stripping during oil and gas development. This was accomplished using 36 plots (2x6 m2 each) to accommodate six treatments with six replications according to a randomized complete block design. Thirty of the 36 exposed subsoil plots were rototilled to a depth of 30 cm and amended with a mix of biochar (169 Mg/ha), sawdust (45 Mg/ha), wheat straw (45 Mg/ha) and alfalfa hay (209 Mg/ha) in two halves in October 2003 and June 2004. The excavated topsoil was returned to the remaining six plots to serve as control. The amount and composition of organic amendment mix was determined so that organic carbon (OC) levels of reconstructed topsoil would be equivalent to that of the native topsoil in the long term. During the first growing season, organic amendments were allowed to settle and all plots were planted to field pea as a green manure. Between 2005 and 2008, treatments consisted of five soil management systems (native pasture (NP), agronomic pasture (AP), field pea (FP), barley (B), and fallow (F)) superimposed on the organic amendments, and a native topsoil control (TS, cultivated to native pasture). During these periods, harvested biomass was returned to the reconstructed topsoil except for the B treatment where biomass was taken off site, and F treatment, which was kept plant free. The biomass from FP treatment was tilled under. The biomass from NP and AP treatments were left on site to decompose and build the OC while the biomass from TS treatment was taken off site. Starting in 2009, all the plots were cultivated with field pea-barley rotation. The aim of the first five years of the study was to reconstruct functioning and sustainable topsoil. Data gathered during the later years was aimed at assessing the combined effects of organic amendment and soil management and ascertaining the sustainability of the reconstructed topsoil. We measured aboveground biomass in 2009, 2010, 2011 and 2012 and key soil properties of the 0-10 cm depth at the end of the growing season in 2008, 2010 and 2013. In 2008, the highest OC, total N (TN), C:N ratio, and microbial biomass N concentrations were measured in AP (OC = 15.6%, TN=0.63%) and NP (OC=13.1%, TN=0.58%) treatments while mean values for these soil properties were lower and statistically identical for FP, B, and F treatments (OC=9.7%, TN=0.47). While AP and NP treatments accumulated the greatest organic matter in 2008, data from 2010 and 2013 indicated that these treatments also exhibited the fastest decline in OC (6.7%) and TN (0.37%). Nevertheless, OC concentrations of the reconstructed topsoil, regardless of soil management type, remained significantly higher than the native topsoil control in 2013 (4.1%). Normalized aboveground biomass averaged over four years (2009-2012) was comparable to the control except for the B and FP treatments that were lower by 11% and 8%, respectively. This suggests that land management choices can affect the sustained productivity of topsoil reconstructed using a mix of biochar and other conventional organic amendments.

Keywords：*Biochar, reconstructed topsoil, subsoil, organic amendment, soil management, soil quality*

P2-83

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effects of Biochar and the Geophagous Earthworm Metaphire Guillelmi on Fate Of 14c-Catechol in an Agricultural Soil

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Soil-borne monomeric phenols occur ubiquitously in soil and are regarded as precursors of humic substances. Both biochar and earthworms can exert influence on behaviors of these chemicals in soil; however, little was known about the effects of biochar amendment, earthworm activities, and the combined effects of biochar and earthworm activities on fate of these chemicals in soil. Using 14C-catechol as a representative, the mineralization, transformation and residue distribution of phenolic humus monomer in soil amended with different amounts of biochar (0, 0.05, 0.5, and 5%) without/with the geophagous earthworm Metaphire guillelmi were investigated. The results showed biochar at amendment rate <0.5% did not affect 14C-catechol mineralization, whereas 5% biochar amendment significantly inhibited the mineralization of 14C-catechol in soil. Earthworms did not affect the mineralization of 14C-catechol in soil amended with <0.5% biochar, but significantly enhanced the mineralization of 14C-catechol in 5% biochar amended soil when they were present in soil for 9 days. When earthworms were removed from the soil, the mineralization of 14C-catechol was significantly lower than that of in earthworm-free soil indicating that 14C-catecholic residues were protected in the cast from further degradation by stabilization during their passage through earthworms gut. The relative 14C-catecholic residues distribution among humic fractions (dissolved organic matter, fulvic acids, humic acids, soluble humin, and insoluble humin) and the molecular size distribution within soil humic substances were affected by neither biochar nor earthworm. The assimilation of 14C by earthworms was low (1.2%), and was significantly enhanced by presence of biochar, which was attributed to the release of biochar-associated 14C-catecholic residues during the gut passage of earthworms.

Keywords：*Black carbon; Phenolic compounds; Mineralization; Transformation; Accumulation*

P2-84

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Added Value of Using High-Ash Biochar from Biosolids to Amend Low Fertility Pasture Soils of New Zealand

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Nutrient-rich biosolids from New Zealand urban centres are low in heavy metals and suited to use as manures for soil amendment. However, as there are zoonotic disease risks associated with the use of biosolids, an exclusion period of 6 months is required when those are used in grazed pastoral systems. Ash-rich biochar made from the same biosolids offers a safe route for direct application as amendment to grazed pasture. In New Zealand, sandy soils have low nutrient fertility, high water infiltration and are prone to both leaching and drought, challenging any management practice. However, when managed correctly, these soils could offer advantages due to ease of rooting for plant species and improve pasture grazing productivity. We designed a field trial to evaluate the agronomic benefits of biosolids compared to biochar, when applied to a sandy soil (Typic Udipsamment). The experiment started during pasture renovation (November 2011) when forage rape (Brassica Goliath) was over sown by direct drill into glyphosate treated permanent pasture. Prior to direct drilling, the farmer had applied at surface N-P-K (12.6%-14%-15%) basal fertiliser at 150 kg/ha to the whole trial area. Nutrient-rich biosolids at two rates (Bio-L, 4.5 t/ha; Bio-H, 13.5 t/ha) and biochar produced from the same biosolids at ~650°C (Char: rate of 5.0 t/ha) were precision-drilled in at 15 cm depth. The control plots received the basal fertiliser application only. All plots were replicated 12 times. Five months after forage establishment and prior to grazing, soil reflectance measurements were taken in the visible and near-infrared (Vis-NIR) range (350-2500 nm) at 1 cm intervals to 30 cm depth by using a portable field spectroradiometer. Roots were taken at 5 cm depth intervals by using 5 x 2 cm aluminium rings either directly underneath a plant, or in the mid row, to a final depth of 30 cm. Samples were used to determine bulk density, root density, total C and N, as well as mineral-N concentrations. Forage rape yield from plots treated with fresh biosolids at either dose was significantly higher ($p < 0.05$) compared with than that under Fert treatment. A marked increase in root density, as well as soil C and N content was found at 15 cm depth when the soil was amended with biochar. Subsequent pasture renovation with three different pasture mixtures (ryegrass/white clover, cocksfoot/red clover, and lucerne/white clover; $n = 6$) was unsuccessful due to severe weather conditions during 2012. Moata ryegrass was sown and effectively established in May 2013. In November 2013, soil reflectance, C and N stocks were assessed again and data are currently being processed. Information about this experiment will help to assess whether biochar has a role on the promotion of deep root growth, as well as on the stabilisation of native C and N. Besides, the application of pyrolysed biosolids in lieu of the original feedstock could offset the loss of nutrients, especially N, in soils with a high risk of leaching as is the case of sandy soils used for agriculture in New Zealand.

Keywords：*biochar, biosolids, sandy soil, Vis-NIR spectroscopy*

P2-85

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effects of Biochar Amendment on Adsorption-Desorption Behavior of Chlorpyrifos Metabolite TCP in Loamy Soils Under Saturated and Unsaturated Conditions

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TCP (3,5,6-trichloro-2-pyridinol) is an important metabolic product of organophosphate pesticide chlorpyrifos that today remains widely used, and particularly in the developing world. Compared to parent chlorpyrifos, TCP is more hydrophilic but persistent, becoming a limiting factor for the complete mineralization of chlorpyrifos in the natural environment. In this study, effects of biochar amendment on adsorption-desorption behavior of TCP in loamy entisols collected from a cropland and a orchard field in Yanting, China were investigated under saturated and unsaturated soil moisture conditions. Biochars were prepared in our lab by anaerobic pyrolysis of conventional wastes from agriculture and wood industry (e.g., wheat straw, cole straw, walnut shell and sawdust) and characterized using relevant analytical techniques. In addition to conventional batch test, an unsaturated transient flow method was applied that allowed determination of adsorption and desorption isotherms at relatively low soil water contents. The results showed an increase in the amounts of TCP adsorption as the biochar addition rate increased from 1.0 to 10 wt.%. Maximum enhancement in the adsorption was observed in the case of sawdust-based biochars that possess realtively higher surface area and more abundant oxygen-containing functional groups. In comparison, the unsaturated flow column yielded smaller Kd values than by batch method which may be more representative of realistic field conditions. Overall, the results demonstrated the potential of biochar addition to soil as an effective way to reduce the transport of TCP in soils.

Keywords：*TCP; Biochar amendment; Adsorption-desorption; Entisol; Unsaturated*

P2-86

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar as Regulator of Soil Ph Buffer Capacity

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During the last decade interest in the biochar application as soil amendment has spurred a great amount of investigations. Biochar as extremely porous, light weight and stable form of carbon had complex of physical and chemical properties which make it a potentially powerful soil amendment (Mutezo, 2013).

The major benefit of the use of biochar is to sequester carbon and transfer it into soil (Laird, 2008). At the global scale, soil organic matter is one of the largest and most dynamic reservoirs in the global carbon cycle. As soil organic matter has a trend of decreasing in European agricultural land, it is important to find possibilities to stabilize or increase soil organic matter content and quality. The availability of different functional groups (e.g. carboxylic, phenolic, acidic, alcoholic, amine, amide) allows soil organic matter to buffer over a wide range of soil pH values (Krull et al. 2004).

Loss of soil organic matter also reduces cation exchange capacity resulting in lower nutrient retention and supply capacity (Kimetu et al. 2008). On the other hand the oxidation produces carboxylic groups on the biochar surface, increases cation exchange capacity and the reactivity of biochar in soil (Glaser et al. 2001). Biochar retains nutrients in soil directly through the negative charge that develops on its surfaces, and this negative charge can buffer acidity in the soil. The findings of van Zwieten et al. (2010) suggest that while biochars may not provide a significant source of plant nutrients, they can improve the nutrient assimilation capability of plants where they are applied, by positively influencing the soil environment.

There are few investigations about the influence of biochar to soil pH buffering capacity, especially on soil types of temperate region.

The aim of current investigation was to explore the effect of biochar on soil pH buffer capacity in Estonian soils. In the experiment different kind of softwood biochars and soil types with various texture were used. The soils selection was made of Albeluvisols and Leptosols. For the experiment a series of the soil: biochar mixtures were prepared in which the biochar content ranges from 0 to 100%. The water suspension of soil: biochar mixtures was titrated with HCl solution. The titration curves were established and pH buffer capacities were calculated for the pH interval from 3.0 to 10.0. The results demonstrate the dependence of pH buffer capacity from soil type, texture, kind of biochar and biochar content in soil:biochar mixtures.

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Keywords：*pH buffer capacity, biochar, pH titration curves,*

P2-87

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Fundamental Properties of Sugarcane and Rice Residue Biochars and Their Agronomic and Environmental Functions

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Residue burning associated with harvesting is common in sugarcane and rice production. In sugarcane, approximately 70-90% of the dry matter of harvested sugarcane trash is lost through burning. This practice has caused considerable concerns over water and air quality, and soil sustainability. On the other hand, research has consistently shown decreased sugarcane yields if the combine harvest trash is not removed from the field by burning especially in the subtropical USA, due to unfavorable post-harvest climate conditions for residue management. In this study, we proposed to take a conservation approach to convert sugarcane and rice residue into biochar and applied back to sugarcane and rice fields to conserve carbon and enhance soil quality. To do so, we have investigated fundamental properties of biochars made from sugarcane and rice residues at different pyrolysis temperatures and their potential agronomic and environmental benefits. Sugarcane and rice harvest leave and straw residues and processing byproducts bagasse and rice husk were collected and converted to biochars at 450, 550, 650 and 750oC, respectively, and characterized for various properties including elemental and molecular composition, surface chemical characteristics and pore size distribution, plant-available nutrients, and water holding capacity. In addition, greenhouse and field studies were carried out to assess the effects of these biochars on agronomic functions. Experiments were also conducted to evaluate the environmental benefits of these biochars including herbicide adsorption and greenhouse gas reduction. Biochars produced at higher pyrolysis temperatures generally had lower total N and S contents but higher total P, K, Ca and Mg contents than those at lower pyrolysis temperatures. Sugarcane leave char contained more P, K, Ca and Mg than sugarcane bagasse biochar. On the other hand, rice straw biochar had more S, K Ca but less P than rice husk biochar. Available fraction of total P was generally higher than that of total K in all biochars. Pyrolysis-GC/MC analysis showed that sugarcane leave biochar converted at 450oC was dominated with various lignin derived phenols as well as non-specific aromatic compounds such as toluene and xylene whereas sugarcane bagasse biochar was more with both lignin derived phenol and poly aromatic hydrocarbon (PAH). On the other hand, rice straw char was more dominated with non-specific aromatic compounds whereas husk biochar showed similar dominance of molecular compounds as sugarcane leave char. Biochars produced at higher temperatures exhibited generally weak signals and more dominance of PAHs. FTIR analysis indicated that at 450oC, biochar surface had similar functional groups as the raw materials except for losing OH-stretching band at around 3307 cm-1, as well as aliphatic CH stretching of CH3 and CH2 at around 2890 cm-1. At 750oC, charred material was only dominated with 975 cm-1 of C-O-C of aromatic ethers while losing 1560 cm-1 band of the aromatic C=C stretching. These molecular and surface property differences likely contributed to the difference in water holding capacities observed with these biochars. Greenhouse experiments showed that soils treated with sugarcane leave biochar significantly enhanced sugarcane growth especially the root length whereas rice straw biochars produced at different pyrolysis temperatures had no significant effect on rice germination. Positive effects of biochars on sugarcane and rice yields were also observed in field trials. In addition, treating soil with either sugarcane leave or bagasse char enhanced soil adsorption capacity of atrazine, a common herbicide used in sugarcane production, and reduced greenhouse gas emission. Overall, the conversation of harvest residue to biochar for use as soil amendment has the potential to significantly improve sugarcane production as it shows both agronomic and environmental benefits.

Keywords：*Biochar, sugarcane, bagasse, rice, straw, atrazine adsorption.*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Poultry Litter Biochar to Promote Reclamation of Surface Mine Soils

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Poultry litter from confined animal operations is an environmental liability because of the potential for water and air pollution. Although poultry litter is valued as fertilizer, the cost of shipping the bulky material can be prohibitive. One potential solution is to turn the excess litter into energy through pyrolysis producing poultry litter biochar (PLB) as a byproduct. Reclaimed surface mine soils typically require fertilizer and lime amendments to promote plant growth; both of these are present in PLB. One potentially negative component in PLB is the high salt concentration. Elevated salt concentrations have the potential to inhibit germination and soil microbial processes. Our objectives were to determine 1) the effects of PLB on soil chemical properties and forage yields of seeded grasslands, 2) the effect of poultry litter biochar on the relative size of three labile carbon (C) pools; Permanganate Oxidizable C, Microbial Biomass C and Hot Water Extractable C in a replicated field experiment on a mine soil reclaimed in 1998. Separate laboratory experiments were conducted to determine the effect of PLB on soluble salt and carbon concentrations and the germination of lettuce (Lactuca sativa), rye (Secale cereal) and birdsfoot trefoil (Lotus corniculatus). PLB contained large concentrations of acid soluble Ca and P (>2,000 ppm), Na (>5,000 ppm), and K (25,000 ppm). Seed germination of trefoil was inhibited at the lowest PLB treatment (0.5% w/w). Forage yields were significantly increased (40%) in the field experiment. Data on soil carbon pools are still being analyzed. PLB has the potential to increase the productivity of established vegetation on reclaimed surface mine soils. However, because of salt effects on germination, additional experiments would be needed to evaluate plant response to PLB at seeding.

Keywords：*surface coal mining, salt effects*

P2-89

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Impact Of Swine-Manure Derived Biochar Amendment On Soil Phosphorus Species And Phosphatase Activities: A Quantitative 31p Nmr Analysis

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Biochar derived from swine manure is extensively being recognized as a superior soil nutrient source. This microcosm incubation study evaluated the dynamics of soil phosphorus (P) species and phosphatase activities with the amendment of swine – manure – derived biochar (0, 0.5%, 1.5%, w/w) into two types of soil (clay loam and silt loam) at day 0, 3, 7, 14, 28, 42, 63, 98. Quantitative 31P nuclear magnetic resonance spectroscopy technique was employed to determine various P species and contents. Compared with no biochar treatment, orthophosphate, monoesters, diesters and pyrophosphate increased greatly with amendment rates at 0.5% and 1.5% in both soils (all $P < 0.05$), this could be the introduction of high amounts of P contents of manure biochar. There was an increase of alkaline phosphatase activities but a slight decrease of acidphosphatase and neutral phosphatase activities for both soils, possibly due to the liming effect of manure biochar. This study demonstrates that swine – manure – derived biochar can be a cost – effective soil amendment when supply of nutrition P is concerned.

Keywords：*Organic Phosphorus; Manure biochar; phosphatase; NMR*

P2-90

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Influence of Charring Biomass on Soil Microorganisms under Cocao Agroforest in South Cameroon.

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Biochar a carbon rich material obtained after heating a biomass under low oxygen content has retained recently attention due its benefits as soil amendment and its contribution in mitigating climate change through carbon sequestration. In addition to benefits as soil amendments, biochar have also been shown to change soil microbial community. However it is still unclear on how does biochar affect soil microorganisms such as mycorrhizal fungi compared to its original feedstock in the absence of carbon substrate from the host plant. In order to investigate the microbial biomass produced after one year, a short incubation experiment took place in the cocoa research farm at the Institute of Agricultural Research for Development (IRAD) Nkolbisson, Yaoundé, Cameroon. Two different sources of biomass were used to produce biochar, chicken manure and wood pellet. The biomass was pyrolysed at 450°C at Lund University Sweden. Biochar and its original biomass were mixed with soil (typical ferrasols) 10 % (v/v) in the mesh bag (25µm) and incorporated into soil at 10 cm depth around 8 selected cocoa trees. Four treatments plus a control soil with an initial low amount of indigenous mycorrhizal fungi were used for this incubation experiment. Results from microbial biomass analysis shown that mesh bags with the original biomass amended gives the highest amount of arbuscular mycorrhizal fungi (AMF) NLFA 16:1ω5 compared to mesh bags amended with biochar but the difference was too low to be substantial. Chicken manure treatment had given the highest amount of NLFA 16:1ω5. All soil mesh bags amended with biochars irrespective to the type showed a decrease in abundance of all microbial soil biomarker groups (gram-positive, gram-negative, actinomycetes, fungi and protozoa) compared to treatment with their corresponding feedstock. It was shown that the proportion of actinomycetes and fungi was less than the control soil when chicken manure biochar was added to the soil while only fungi proportion was less than the control soil when adding tree pellet char. In spite of negative impact of biochar on soil microorganisms, this study also suggest a potential of biochar in suppressing or reducing soil borne diseases which could be benefit in plant pathology.

Keywords：*biochar, pyrolysis, mycorrhizae, biomarker.*

P2-91

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Assessment of P Availability in Biochar-Amended Soils and the Relation to Soil P Fractionation

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Currently, biochar amendment has been encouraged to improve soil fertility because biochar incorporation into soil was promised to increase soil pH, to enhance fertilizer-use efficiency, and to improve nutrient-retention capacity. Biochars with specific properties, which are dependent on both temperature and feedstock in the pyrolysis of conversion of biomass into biochar, should be produced in accord with soil amendment requirements. Available phosphorous (P) to plant is almost low in soils, particularly in acid soils with high P-fixation capacity. Due to the liming effect of biochar, increase of soil pH by biochar amendment will improve the availability of P in acid soils. So far the effect of biochar amendment on soil P availability was not well understood. There were few studies for assessing the feasibility of biochar characteristics for soil P management.

In this study, an acid soil Pinchen (Typic Kandiudox) was sampled from agricultural lands in Taiwan. Sawdust-based spent mushroom substrates corrected from a king oyster mushroom farm were used as feedstock to produce both biochars (BC300 and BC500) which were pyrolyzed at 300 and 500oC, respectively. Three application rates (0, 0.5, and 1%) of biochar were used to prepare biochar-amended soil samples throughout an incubation period of 30 days with soil moisture at field capacity. Further, the biochar-amended soil samples were respectively added with one of three levels of P (0, 250, and 500 mg kg-1) and then with soil moisture at field capacity underwent 30 days for stabilization. Water soluble P (WSP) and Bray 1 extractable P (B1P) were measured for assessing the P availabilities of all biochar-amended soil samples. And a modified Hedley procedure was used to extract the conceptually chemical pools of soil P in the sequential fractions (i.e. F1: soluble and exchangeable P (KCl-P), F2: Fe- and Al- bound P (NaOH-P), F3: Ca-bound P (HCl-P), and F4: residual P (HNO3/HClO4-P)). The P fractionation for all biochar-amended soil samples was conducted to investigate the alterations of soil P fractions with biochar amendment and their influences on the P availability.

In the results, the pH values of biochar amended soils were increased with increase of the biochar application rates; that is, the liming effect of biochar amendment presented significantly. BC500 amendment behaved the liming effect more obviously than did BC300 amendment. The concentrations of WSP and B1P in biochar-amended soil samples were increased significantly with increase of amounts of P addition. At higher P additions (e.g. 250 and 500 mg kg-1), the biochar application rate of 1% promoted the releases of WSP more than did those of 0 and 0.5 %; and more amounts of B1P extracted from soil with biochar application rate of 1% were found also. Compared with BC300 amendment, BC500 amendment enhanced more WSP released and B1P extracted from soil. Thus, biochar amendment prior to P application would enhance replenishment of P and increase P availability in acid soils. Moreover, total P of soil was also increased due to biochar application and compared with BC300 amendment, BC500 amendment resulted more in increase of total P. For soil P fractionation, it was observed that both fractions KCl-P and NaOH-P were significantly increased with biochar amendment. This revealed that replenishment of P and increase P availability in acid soils enhanced by biochar amendment would be related to the increase of fraction KCl-P. That is, biochar amendment prior to P application would keep more P in soluble and exchangeable statuses in biochar amended soils. However, the dominating fraction was NaOH-P in biochar amended soils, suggesting that P had a preference for Fe- and Al- bound at the expense of other fractions. In conclusion, biochar amended in acid soils could increase the available pools of soil P ether by a supplementary supply from applied biochar or by a change of P fractions with increasing soil pH.

Keywords：*spent mushroom substrate, black carbon, acid soil, liming effect, P fraction*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Can Biochar Be Used to Increase the Bioavailability of Phosphorus Immobilized in Andisols?

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A large proportion of phosphorus (P) fertilizer applied to Andisols reacts with Al reactive surfaces and becomes unavailable for plant uptake. Up to 3 tonnes/ha of P have been locked away in intensively farmed soils. In this study we explore the possibility of mobilizing P retained in these soils through the use of biochar. The specific objectives of this study were to (i) investigate the effect of biochar application to Andisols on arbuscular mycorrhizal fungi (AMF) growth and P availability; and (ii) identify other biochar-associated mechanisms that may modify soil P availability (e.g., through changes in soil pH). For this, a root study container (RSC) technique that divided the soil into three compartments - root zone, rhizosphere and hyphae zone - was used. Three types of biochar were studied: two made from chipped pine (Pinus radiata D.Don) branches at 450°C and 550°C (BP450 and BP550) and a third one from chipped willow (Salix matsudana L.) branches at 550°C (BW550). Each biochar at a dose of 4.48% (w/w, which was equivalent to a field deep-banded rate of 10 t/ha) was mixed into samples of Egmont silt loam topsoil (Andisol) that contrasted in Olsen extractable P levels (4.3 and 33.3 mg P/kg referred to as LP and HP, respectively). The various combinations of LP ± biochar or HP ± biochar were packed into either the upper root zone compartment, or the lower hyphae compartment of the RSC, or both. Lotus pedunculatus cv barsille seeds (inoculated with Rhizobium) were sown in the root zone soil. Abundant indigenous AMF were identified, and thus no external inoculum was introduced. The lotus shoots were harvested at regular intervals dry matter yield, P and N concentrations of plant shoots determined. Results obtained to present indicate that (i) the presence of BW550 in the root zone of the LP soil significantly ($p<0.05$) enhanced plant growth and P uptake; (ii) the presence of pine biochar (BP450 and BP550) in the hyphae zone of the HP soil substantially increased plant growth and P uptake ($p<0.05$). Once the experiment is finalized, AMF colonization on roots, hyphal length in the hyphae zone soil and P forms fractions in the rhizosphere soil will be determined. Information obtained from the present study will help reveal the mechanisms underlying the influence of biochar on P bioavailability in Andisols.

Keywords：*Biochar, Andisols, Root container study, Arbuscular mycorrhizal fungi*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Does Soil ^{15}n Natural Abundance with Biochar Application Provide Insights into Nitrogen Transformation?

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Biochar, defined as a stable carbon (C) rich product, is used as soil conditioner to improve soil water and nutrient retention as well as decrease greenhouse gas emission. Biochar has been used in different plant and tree crop systems. However, studies of mechanisms attributed to soil-biochar-plant interactions, particularly for nitrogen (N) cycling, are contradictory. A series of studies including both pot and field trials was undertaken in Western Australia and South-east Queensland, Australia, respectively, to examine the possible use of soil N isotope composition ($\delta^{15}N$) for improving our understanding of N dynamics in the soil-plant systems when biochar was applied. In both trials, different rates and feedstocks of biochar were investigated. The rates of biochar application in the pot trial were from 0 t ha^{-1} to 60 t ha^{-1} and those of the field trial were between 0 t ha^{-1} and 30 t ha^{-1}. Increasing rates of biochar application slightly decreased soil $\delta^{15}N$ but not so when compared to the control soil. In the field trial, despite the fact that there was no significant difference in soil $\delta^{15}N$ between biochar-treated soil and control plots, soil NO_3--N concentration was significantly enhanced by the high rates of biochar application, which may suggest an increased residence time of NO_3--N in the soil at the high rates of biochar application rather than increased microbial activity involved in the N transformation. Our studies suggest the usefulness of soil $\delta^{15}N$ to understand N dynamics in soil-biochar interaction. All studies were carried out within one year following biochar application but longer term investigation would be required.

Keywords：*Biochar, Soil fertility, Agriculture and horticulture*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Nitrogen Dynamics in a Japanese Tropical Soil Amended with Sugarcane-Bagasse Biochars

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Large proportion of nitrogen (N) from chemical fertilizers can be leached as nitrate into groundwater from many agricultural fields due to intensive precipitation and/or excessive irrigation. N leaching as nitrate has been recognized as one of the main causes for watershed pollution in many areas, especially under tropical soils because mainly of their low water holding capacity. In addition, N leaching can cause low N use efficiency of chemical fertilizers. There have been a few studies regarding on the effect of biochar amendment to soils on increased retention thus reduced leaching of soil inorganic N, and consequently reduced total N leaching. However, its effects may vary depending on different physicochemical properties of soils and biochars used. N dynamics including retention and leaching behaviors of total N in soils when biochars are amended is not well understood. Therefore, this study focused on the total N dynamics in a tropical soil amended with sugarcane-bagasse biochars (SBB) pyrolysed at two different temperatures. The specific objectives were to investigate the effect of the SBB amendment on inorganic N leaching and total N balance before and after the column leaching study.

Calcareous dark red soil and sugarcane-bagasse were collected from Okinawa, Japan. Sugarcane-bagasse was pyrolysed at 400 ℃ (SBB400) or 800 ℃ (SBB800) under limited oxygen atmosphere. A soil column (15 ㎝ diameter; 30 ㎝ height) with Japanese mustard spinach (Brassica rapa) planted was used for the leaching study in triplicate for 30 d with application of 500 ㎖ of pure water every 3 d. SBBs application rate was 2.5% (w/w). Total N (T-N) and inorganic N (NO_3^--N, NO_2^--N, and NH_4^+-N) in leachates and soils in the column after all leaching events were measured. T-N in the post-harvest plant was also measured. N balance was calculated based on changes of T-N in the column before and after the leaching study.

Cumulative T-N in leachates from the soil amended with SBB400 and SBB800, respectively, was slightly reduced compared with that from non-amended soil, but it was not significant. However, cumulative NO_3^--N in leachates with SBB400 and SBB800 amendment was significantly reduced ($p<0.05$) compared with that from non-amended soil, respectively. In addition, the T-N in the plant grown on the soil amended with SBB400 and SBB800, similarly, significantly increased compared with that on non-amended soil, respectively. Furthermore, the plant root weight in the soils amended with SBB400 and SBB800, respectively, significantly increased compared with that in non-amended soil. It appears that the SBB800 application may have caused the increase of NO_3^--N absorption by the plant, thus the reduction of the cumulative NO_3^--N leaching. After all leaching events, T-N, NO_3^--N, and NH_4^+-N left in the soils amended with SBB400 and SBB800, respectively, were significantly greater than those in non-amended soil. It appears that applying SBBs could have enhanced the retention of T-N, NO_3^--N, and NH_4^+-N in the soil, thus the reduction of inorganic and T-N leaching. T-N in the soil column before the leaching events was 7048, 7301, and 7335 ㎎ T-N in non-amended, SBB400-amended, and SBB800-amended soils, respectively. Cumulative T-N leached and plant uptake T-N were 316 (4.5%), 290 (4.0%), and 302 (4.1%) ㎎, and 30 (0.4%), 32 (0.4%), and 36 (0.4%) ㎎ T-N, respectively, from non-amended soil, SBB400-amended, and SBB800-amended soils, respectively. Then, T-N in the soil column left after the leaching events was 6264 (88.9%), 6937 (95.0%), and 6994 (94.7%) ㎎ T-N in non-amended soil, SBB400-amended, and SBB800-amended soils, respectively. Therefore, N non-accounted for in the leaching study was estimated as 437 (6.3%), 42 (0.6%), and 52 (0.7%) ㎎ T-N in non-amended soil, SBB400-amended, and SBB800-amended soils, respectively, which was due most likely to volatilization loss.

The application of SBB pyrolysed at 400 ℃ and 800 ℃ both could significantly increases the T-N remained in the soil and reduce the N leaching loss. Because of that, the application of SSBs could enhance the plant absorption of N thus plant biomass. However, further studies are needed on N mineralization, immobilization, and volatilization, and the effect of biochar application on rotational crops to further understand the effect of biochar application to soils and plants.

Keywords：*Nitrogen dynamics, Biochar, Agricultural residue, Retention, Leaching*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

An Knowledge-Based System for Plant Diseases Management

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World's economy drives on crop production as agriculture plays an important role in most of the populated countries in the world. Currently these countries are facing food shortage in each year. Farmers are trying to increase their productivity but they need specific information so that they can make right decision at right time. One of the challenges farmers are facing is plant disease, which can be defined as deviation from normal physiological functioning. The harmful plant disease is heavily correlated with soil quality, soil chemistry and soil moisture. In this paper, we propose a knowledge-based prototype called AgroKnowledgeBase that could help farmers to make informed decisions while tackling plant disease scenarios.

Disease can impact negatively on crop productivity. Automatic weather stations, soil moisture sensors, and soil sample chemical analysis can warn farmers about potential outbreaks of plant diseases. But most of the disease information is kept in various relational databases which are not easily shared and integrated as a single knowledge-based system. This proposal is based on Linked Data principles [1] where data and knowledge has been converted into the Resource Description Framework (RDF) format [2] and has been made accessible on the web through Uniform Resource Identifiers (URI) for future automated reasoning.

Similar work has been done in the context of life sciences, specifically in the medical domain such as Linked Open Drug Data, Yeast Hub, BioDash and BioGateWay. In the agricultural domain there has been some work developing expert systems around phytopathology for plant diseases [3]. For example, botrytis decision support system is a tool for generating alert for botrytis. However none of the aforementioned work has considered the concept of an open knowledge-based system.
The legacy plant disease data are collected, converted into RDF, and then stored in a triplestore called "AgroKnowledgeBase". Dynamic environmental time series data such as temperature, rainfall, and humidity, originally delivered in different file formats such as .txt, .shp, .netCDF, are also converted into RDF and stored in the triplestore for dynamic disease risk alerting. A user interface has been built on the top of the knowledge base. Finally, we integrate concepts from AGROVOC [4], the largest Agricultural linked Open Data in the world, and DBpedia [5]. This integration allows large amounts of information to be used for decision support.

We use poppy plant as case study because Tasmania is the world's largest producer of opium alkaloid for the pharmaceutical market. The poppy industry is experiencing major disease issues. To solve the problem, we have developed a prototype to provide poppy farmers with useful, contextualized information. Our proposed case study has been tested with data from the "Plants For A Future" (PFAF) [6].

AgroKnowledgeBase is an example of an open knowledge management system. This system provides farmers with continuous

disease risk assessments by integrating real-time sensor data with plant disease information. We have successfully demonstrated how AgroKnowledgeBase can be applied in poppy farming. The system can be easily extended to other crop types.

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Mitigates Negative Effect of Salinity on Growth, Physiology and Yield of Wheat

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Salinity is one of the major threats to global food security. More than 800 million ha land in the world is affected by salinity and sodicity. Therefore, research on management strategies aiming at mitigating the negative impact of salinity on crop production is crucial. Here, a pot experiment with wheat was conducted in greenhouse under three different EC levels i.e. original, 7.8 dS m-1 and 11.6 dS m-1 and two levels of biochar (0 and 5 % w/w) incorporation. Both Salinity and biochar levels were developed in an earlier experiment on potato where we irrigated the pots with tap water (served as control), 25 mM and 50 mM NaCl solutions under 0 and 5% (w/w) biochar amendment. It was hypothesized that biochar has long term effect in alleviating the negative effects of salinity on growth, physiology and yield of plants by adsorbing Na+ on its exchange site through its high sorption ability. A column leaching study was also conducted in greenhouse to analyze the Na+ adsorption efficacy of biochar. The results indicated that biochar had capability to adsorb Na+. Increase of salinity level significantly reduced seed germination, plant survival rate, root and shoot growth, photosynthetic rate, stomatal conductance, membrane stability index, number of tillers per plant, 100-grain weight and yield per pot, but no significant affect was observed on photochemical efficiency of photosystem II (PSII)). Most interestingly, at each salinity level, biochar amendment significantly improved plant growth, physiology and yield in relation to respective non biochar control. Hence, incorporation of biochar might be a good strategy in improving growth, physiology and yield of wheat under salinity stress. However, more detailed and long term field studies should be conducted in order to evaluate the full potential of biochar for improving crop production in salt affected soils.

Keywords：*Biochar, salinity, Na+, adsorption*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Pyrolysis of Swine Manure - Plant Availability of the Phosphorus

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During the last decade's the size of animal production farms has increased considerable, creating areas with high surplus of phosphorus (P) regarding to plant requirement, leading to an increased risk of P leaching. Therefore novel methods for manure processing are required to convert manure into such a form that it is economically viable to transport to areas, where P fertilization is needed. To reach this target, volume of manure needs to be depressed and pyrolysis technology is a promising method for handling materials with a high content of organic material. The end product of the process is a dry char fraction with concentrated amount of non-volatile nutrients such as P (Wang et al. 2012). The aim of this work was to determine phosphorus content and its solubility in char fraction of pyrolysed swine manure.

In this study we pyrolysed solid fraction of separated (including chemical flocculation) and pre-dried (70 °C) swine manure at temperature of 400 °C for 60 minutes in three replicate runs. The target temperature was reached with a temperature increase of 2 °C in a minute. The raw material had pH of 7.2, electric conductivity of 3.1 mS cm^{-1} and it was rich in P (46.1 g kg^{-1} dry matter).

The recovery of the char was 53.7±1.1 %. For the one of the replicates liquid fraction was collected showing recovery of 30.1 % and calculated recovery of gas was 16.2 % (100 % - recovery char –recovery liquid). Total content of P (aqua regia extraction) in the char fraction was 88.5±1.8 mg kg^{-1} that is correspondence to mineral P fertilizers. Modified Hedley fractionation scheme (Sharpley and Moyer, 2000) will be conducted to evaluate P solubility and availability for plants will be studied in a growth experiments.

References:

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Wang, T., Camps-Arbestain, M., Hedley, M. & Bishop. P. 2012. Predicting phosphorus bioavailability from high-ash biochars. Plant and Soil 357:173-178.

Keywords：*Biochar, Pyrolysis, Manure, phosphorus, Nutrient recycling*

P2-98

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Phosphorus Bioavailability of Sewage Sludge Biochar Applied to Temperate and Tropical Soils in Japan

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Sewage sludges contain an appreciable amount of phosphorus (P) among many others and are expected to be recycled as alternative P resources in agriculture. However, problems of sewage sludge application to soils may include an accumulation of heavy metals and pathogens, heavy weight and high cost for transportation, and odor. A pyrolytic conversion of sewage sludge into biochar could solve many of the relevant problems and be one of the sustainable management options for agricultural usages. However, P bioavailability of sewage sludge biochar (SSB) and its dynamics when applied to soils are not well understood.

Two SSBs (≤300 μm) pyrolysed at 800℃ (SSB800) and 300℃ (SSB300) were used in this study. Two different soils (≤2 mm) used in this study were a brown forest soil (FS) collected from temperate Tokyo (*Typic Dystrochrept*) and a reddish soil (RS) from subtropical Okinawa (*Typic Hapludult*). P fractionation was performed on each of SSBs and soils, respectively. SEM images were taken on the surface of SSBs. P adsorption isotherms were developed using each of soils without or with each of SSBs (5% w/w), respectively. P desorption isotherms were developed using each of SSBs, and each of soils without or with each of SSBs, respectively. A pot study was performed for 30 d using a Japanese mustard spinach (*Brassica rapa*) in 1 L pots on FS amended with each of SSBs at 4 different rates (w/w), respectively (0%, 0.6%, 1.2%, and 2.3% for SSB800 and 0%, 0.8%, 1.6%, and 3.2% for SSB300). The rates corresponded to one half (1/2xP), the same amount (1xP), and twice (2xP) of the recommended rates for the spinach based on 2% citric acid-extractable P concentrations in each SSB.

SSB800 and SSB300 contained 45 and 26 g kg^{-1}) of total P, and 2.2 and 1.7 g kg^{-1}) of 2% citric acid-extractable P, respectively, however contained 1% and 30% of labile P fractions within the respective total P. Seventy percent of the total P in SSB800 was in a HCl-extractable fraction. It appears that SSB300 contained more bioavailable P than did SSB800. Based on the P adsorption isotherms on two soils, FS exhibited higher maximum adsorption capacity (9997 mg P kg^{-1}) than RS did (674 mg P kg^{-1}). The application of both SSBs (5%) did not change the isotherms or the maximum adsorption capacity on either soil, except for SSB300 reducing the maximum adsorption capacity of RS to 590 mg kg^{-1}. P in SSB300 was more desorbable than that in SSB800; 27% of total P in SSB300 was desorbable while 2% of total P in SSB800 desorbed. Partition coefficient (*Kd*) calculated from the P desorption isotherm on the soil amended with the SSB indicated that P sorbed on surface of FS became more desorbable when SSB300 was applied at specific solution equilibrium P concentrations. It appears that P desorbability in the soil amended with SSB can vary and may be enhanced when SSB containing high labile P is applied to soil with low P adsorption capacity. All pots containing SSB showed an increase in dry weight of the plant compared to that of control with no application. The spinach dry weight in SSB800-amended soils increased with increasing application rates, and that with 2xP rate was equivalent to that with chemical fertilizer. The dry weight with 1xP rate of SSB300 was greatest among those with all other treatments including fertilizer. While the total plant P with all SSB300 rates was equivalent to that with fertilizer, the total P in plant with all SSB800 rates was significantly greater than that with fertilizer, and increased with increasing application rates. It appears that the spinach grew better with SSB300 application than with SSB800 because of greater P bioavailability. However, the spinach with 2xP rate of SSB300 absorbed the most P but did not grow the most due most likely to inhibiting materials such as tar and heavy metals contained more in SSB300 compared with SSB800.

It appears that some of P contained in SSB may be available and desorbable to affect the soil P adsorption capacity, and that P in an SSB pyrolysed at lower temperature may be more bioavailable than that in an SSB pyrolysed at higher temperature.

Keywords：*Waste management, Kunigami-mahji, Phosphorus balance*

P2-99

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Pyrolysis Performance and Emission Profiles for Biochar Product Commercialization

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This technical presentation focuses on pyrolysis performance and emission profiles on two different demonstration scale biochar production units including:

1) Determination of dissipative energy and generated excess energy in energy self-sustaining mode;

2) Production unit scalability based on biochar quality from lab scale and demonstration systems;

3) Comparison of flue gas emissions with relevant reference emission limits.

Literature on lab and/or pilot scale biochar production studies provide pyrolysis efficiencies and biochar quality for agricultural soil applications and estimate potential emissions for a large scale biochar production unit. However, it is critical to determine realistic and achievable pyrolysis efficiencies, biochar quality, and emission limits from a demonstration scale unit for biochar product commercialization.

Alberta Innovate - Technology Futures (AITF), Alberta, Canada operates two research demonstration biochar production units: an auger retort and a multi-hearth. These demo units have a nominal production capacity of 1.0 tonne biochar/24 hours operation using clean biomass feedstocks containing ~20 % moisture content on a wet basis. This technical evaluation used these two units to evaluate pyrolysis performance and emission profiles through the Alberta Biochar Initiative (ABI) with funding from Western Economic Diversification Canada.

Through these demonstration scale biochar production evaluations, the following findings were made:

1) The auger retort and multi-hearth carbonizers produced biochar with suitable quality for agricultural soil application; however, the biochar yield (25% on a dry input basis) was lower than lab scale systems;

2) Excess heat was calculated to be 38% to 45% of input heat when the biochar production units used 20% feedstock moisture content on a wet basis. This excess heat can be used for a pre-dryer to reduce the feedstock moisture content form 50% to 20% on a wet basis (depending on drying efficiency);

3) Elemental chlorine and heavy metal analyses were conducted to select clean feedstocks for biochar production and emission control;

4) These biochar units should be classified as a “two-stage wood combustor” with biochar production. Realistic air emission limits for these two units were developed based on two-stage wood combustion.

Keywords：*Biochar Production, Biomass Pyrolysis, Biomass Carbonization, Flue Gas Emissions, Soil Amendment*

P2-100

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Characterization of Biochar and its Effect on Crops and Soil Properties

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The production and use of biochar is being highly popularised as a way to sequester C in soils and to improve soil quality and productivity (Laird, 2008; Bracmort, 2009). Biochar could influence yield of crops (Kimetu et al.,2008), alter soil microbial populations and shift functional groups (Pietikeinen et al., 2000). Non food biomass crops provide sustainable source of energy and India has great scope to explore. Characterizing different sources of biochar could pave the way for its potential use and its impact on natural ecosystem. Hence, a study was taken up to characterize biochar from seven plant species (Lantana camara , Dodonia viscose, Eichornia crassipes, Prosopis juliflora, Melia dubia, Giricidia sepium and Delonix elata) and its effect on crop growth and soil properties. The wood biomass were collected, processed and dried. The biochars were produced using slow pyrolysis at 400°C to 550° C. Results indicated that among the biochar obtained from different plant species, the physical properties viz., water holding capacity, pore space and pore volume ranged from 85.1 -191.0 % , 50- 84.6 % and 5.0 to 11.0 cc respectively. Biochar from Eichornia sp. recorded the highest CEC of 23.0 c mol (p+) kg-1 while the least was accounted by Dodonia (13.8 c mol (p+) kg-1). Biochar samples were also subjected to FTIR, SEM and analysed for CHNS. FTIR spectra could reveal the functional groups and SEM analysis indicated surface properties and metal ions present. The maximum total carbon was found in Dodonia sp. The order of carbon content was Dodonia > Prosopis > Delonix > Lantana > Gliricidia > Melia >Eichornia. The highest amount of total N and S was found in Eichornia.

Pot culture experiments with ten kilograms of 2 mm sieved soil (red sandy loam) were conducted with cotton, maize and tomato in a glasshouse with three sources of biochar (Melia sp., and B3 – Prosopis sp.) and five levels (L1- Control, L2-2.5 t ha-1, L3-5.0 t ha-1, L4-7.5 t ha-1and L5-10.0 t ha-1) in three replications in Factorial Completely Randomized block Design. Initial soil analysis of three experiments revealed that soil EC ranged from 0.03-0.15 dSm-1, pH ranged from 7.85 to 8.47, Available N, P, K and organic carbon ranged from 161 to 191 kg ha-1, 8.3 to 9.03 kg ha-1, 130 to 223 kg ha-1 and 5.52 to 6.94 mg kg-1 respectively. Results of pot experiments revealed that the grain and stover yield of maize ranged from 41.6 to 56.7 g plant-1 and 20.7 to 31.7 g plant-1 respectively. The highest dry matter production and grain yield of maize was recorded with the application of biochar @10.0 t ha-1 which was on par with 7.5 t ha-1.The highest response ratio was achieved in application of biochar derived from Eichornia species @ 10.0 tha-1. In cotton, seed cotton and stalk yield ranged from 10.3 to 14.80 g plant-1 and 30.20 to 42.2 g plant-1 respectively. Among the levels of biochar, 7.5 and 10.0 t ha-1 significantly influenced the seed cotton yield and however was on par with each other. The highest response ratio was achieved by the application of biochar derived from Eichornia sp. @ 10.0 tha-1. Fruit yield of tomato ranged from 416.5 to 555.6 g plant-1. The highest fruit yield was recorded by the application of biochar derived from Prosopis species @ 10.0 tha-1. The highest response ratio (86.7) was achieved in application of biochar derived from Prosopis species @ 10.0 tha-1. The over all response was increased upto 7.5 t ha 1 beyond that increment in yield and response ratio was less. The increase in yield and response ratio may be due to the enhanced use efficiency of nutrients P (Beaton et al., 1960) and ammonium (Lehmann et al., 2002) which can increase the use efficiency of phosphorus. Biochar acts as direct source of soluble P salts and exchangeable P. It promotes microbial activity and P mineralization (Tom et al., 2009). The result revealed that the source of biochar could not influence the yield of crops statistically but the levels of biochar could influence the yield and dry matter production. Hence, biochar can be used as a potential source of soil amendment rather than source of nutrient.

Keywords：*Biochar, charecterisation, crop growth, soil properties*

P2-101

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Chicken Manure-Derived Biochar Reduces the Bioavailability of Copper Contaminated Soils

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Biochar (BC) is a fine-grained and porous material produced by slow pyrolysis of biomass at low to medium temperatures (300 to 700°C) under oxygen-limited conditions. The BC production from various biomass sources has attracted research interest because BC added to soils leads to agronomic benefits by improving physical, chemical and biological properties and also has the ability to remediate soils contaminated with metals. However, to date the BC application to contaminated soil systems has not been systematically investigated. Therefore, the objective of this study was to evaluate the copper (Cu) immobilizing impact of chicken manure biochar, and its effectiveness in promoting plant growth in Cu contaminated soils.

Chicken manure-derived biochar (CM) was produced by pyrolysing at 500°C, and was analyzed for physical (e.g., BET surface area, pore volume, pore size), chemical (e.g., pH, CEC, carbon and nutrient contents) and surface (e.g., functional groups) characteristics. This material was applied to a contaminated soils sampled from a Mediterranean ecosystem near Ventanas smelter (Puchuncaví Valley, Valparaíso, Central Chile) at 5 and 10% w/w levels. In addition, increasing Cu levels (100 and 500 mg Cu kg-1) were applied to these soils and the metallophyte, Oenothera picensis was used to grow in this medium for three months under greenhouse conditions. Pore water samples were collected using the rhizon samplers at 1, 2, 3, months after the establishment of the pot experiment, and analyzed for Cu using a flame atomic absorption spectroscopy. After harvesting plants, shoot biomass production, metal content in plant, microbial activity and Cu fractionation in soils was measured.

The BC application resulted in a significant increase in pH (up to 3 units of magnitude) of the interstitial water, with a concomitant decrease in Cu concentration in soil solution. Similalry, soil pH, EC and basal respiration were higher in soils treated with BC. Plants grown in BC amended soils produced 8 fold more dry biomass than that in control soils. The biochar-induced increase in dry matter production may be attributed to the reduction in toxicity of metals and increased availability of nutrients such as P and K. The biochar significantly reduced Cu accumulation by O. picensis, and the reduction increased with increasing amount of biochar application. Metal sequential fractionation data indicated that biochar treatments substantially modified the redistribution of Cu from the easily exchangeable phase to less bioavailable organic bound fraction.

These preliminary results suggest that biochar application was effective in metal immobilization, thereby reducing the bioavailability and phytotoxicity of heavy metals and therefore could be a good alternative for the implementation of phytoremediation programs.

This study was supported by Fondecyt Project 3130390

Keywords：*metal contaminated soils, phytoremediation, amendment*

P2-102

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Characterization: Evaluating their Potential as Sources of Stable C And Inorganic Nutrients

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Biochars are the residue of pyrolyzed biomass. These materials contain stable C as condensed aromatic structures, which may require hundreds to millions of years to decay. Depending on the feedstock and pyrolysis conditions, biochars may also have elevated amounts of inorganic compounds because of their greater thermal stability relative to most organic compounds. Biochars may act as sources of stable C and nutrients in depleted lands, and are thought as attractive amendments to reclaim C-depleted, impounded mine tailings. This research assess two biochar characteristics - stable C structures and concentrations of inorganic compounds - in 13 biochars produced in large-scale pyrolysis units from 7 different feedstocks and using 7 pyrolysis conditions. Feedstock consisted of softwood, hardwood, grass, and a mixture of poultry manure and wood chips. The pyrolysis conditions included slow pyrolysis, fast pyrolysis under vacuum and a traditional carbonization method at temperatures ranging from 370 to 500 °C.

Differences in potential stability of C structures between biochars were assessed using X-ray powder diffraction (XRD), H/organic carbon (OC) ratios from elemental analysis, volatile and fixed matter from proximate analysis (ASTMD1762-84). XRD detected ordered structures such as cellulose and turbostratic crystalline C (loosely ordered array of condensed aromatic structures). H/OC and proximate analysis data reflect changes in chemical composition in that aromatic structures formed during pyrolysis have less H compared to carbohydrate and aliphatic structures in feedstock, and more stable organic compounds are likely combusted at higher temperatures during proximate analysis. Greatest contributions from signals attributed to crystalline cellulose were observed in the biochar carbonized at the lowest temperature (370-425 °C). These signals were not as prominent in the biochars carbonized at 400 oC or greater. Compared to the low-temperature biochars, those produced at higher temperatures in the range of 400 to 500 °C had greater contributions from turbostratic crystalline C, which is considered more stable against degradation. However, for biochars generated between 400 to 500 °C using the same feedstock, a 50 °C increase in pyrolysis temperature did not correspond to increased contributions from turbostratic crystalline C. Besides the limitations of XRD to detecting loosely ordered structures, this may be due to overlap between signals from the mineral phase and the broad signal from OC-structures. In contrast, there was a slight response in H/OC ratios, % volatile, and % fixed matter to a 50 °C difference in pyrolysis temperature. The H/OC ratios and weight % volatile material were lower, while the weight % fixed material were higher in biochars produced at higher temperatures. H/OC and proximate analyses suggest that for the same feedstock, greater contributions from more stable C structures may be formed with a 50 °C increase in pyrolysis temperature.

Total element contents of biochars were determined using inductively coupled plasma - atomic emission spectroscopy (ICP-AES) and ICP-mass spectrometry (MS) following microwave digestion with aqua regia. The main inorganic phases associated with biochars were also identified using XRD. Except for the switchgrass-derived biochar, where Fe was the main inorganic element, Ca dominated the inorganic profile of most biochars, and K and P were abundant in poultry manure biochar. Differences in the types and concentrations of inorganic elements were feedstock-specific. From XRD, Ca was mainly found as carbonates, Fe as

oxides and K as KCl. Signals from silicates were also observed. Scanning Electron Microscopy (SEM) coupled with Energy Dispersive X-ray Spectroscopy (SEM-EDS) showed that minerals occurred on biochar surfaces and in crevices and pores.

Overall, pyrolysis conditions appear the key determinant in the production of stable OC-structures, whereas feedstock is important in determining the types and concentrations of inorganic nutrients found in biochars. Results from this characterization is the first step in selecting the most promising amendments for reclamation of nutrient-deprived, low-C impounded mine tailings. For instance, biochars with high CaCO3 contents, such as poultry manure- and willow-derived chars are likely to have high alkaline potential and be beneficial for acidic tailings. Fe oxides in switchgrass-derived biochar in turn may help to reduce the metal mobility in mine tailings, as association with Fe-oxides through formation of surface complexes is a known mechanism for metal sequestration. The availability of these minerals should be further investigated since some minerals such as CaCO3 were sometimes observed to be occluded in pores.

Keywords：*biochar, inorganic content, XRD, proximate analysis, SEM, morphology, organic phase, mineral phase*

P2-103

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Closing the Carbon Loop in Sugarcane Cultivation: Filtercake Biochar as a Value-Added Soil Amendment

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Background: In Brazil, expansion of bioenergy and other crops is driving rapid land conversion and innovative agricultural practices are urgently required to prevent soil degradation. Biochar (pyrolyzed waste biomass) has been used to enhance soil quality, nutrient availability, and productivity, and decreased leaching loss and acidification in tropical soils. Sugarcane cultivation in particular may benefit from this approach because the industry produces several residues, including bagasse, a value feedstock for many other processes, and filtercake, a heavy, nutrient-dense residue. Filtercake is typically disposed of via field application; however, it is operationally difficult to handle and likely to decompose rapidly after application, potentially leading to nutrient leaching loss. Conversion of this highly labile residue into a more stable pyrolyzed form may be an opportunity to turn a nuisance waste into a valuable soil amendment, returning both stable carbon and nutrients to the soil.

Methods: Filtercake biochar and soil (a sandy red-yellow Latosol; FAO classification) were collected from Usina Pantanal (Jaciara, MT, Brazil). Biochar was produced in a lab-scale reactor via slow pyrolysis at 575°C for 3 h under N2 and subjected to the following analyses: carbon and nitrogen analysis via total combustion (628 Series CHN Analyzer, LECO Corp.); N2-BET surface area; residual carbohydrates via acid hydrolysis and high-performance liquid chromatography (HPLC); and Raman spectroscopy using a LabRAM HR system (Horiba Scientific). Next, biochar-soil mixtures (1.25, 2.5, 5, 10% wt) were prepared and analyzed for macro- and micronutrient availability using standard laboratory methods; these data were collected again after leaching soils with 7 L of distilled water. The effect of biochar (0, 5, 10%) on soil water retention was analyzed using a WP4C Dewpoint Potentiometer. Short-term soil CO2 efflux in response to 5% dry weight of raw vs. pyrolyzed filtercake (biochar) was examined in a benchtop incubation experiment using a LI-COR 6400.

Results: Pyrolysis conditions produced a biochar product that contained 36.7% C and 1.3%N with an N2-BET surface area of 26 m2 g-1. Raman spectroscopy revealed a primarily aromatic structure typical of carbonaceous materials, although HPLC revealed small amounts of residual cellulose (2.7% wt) and hemicellulose (3.1% wt). Compared to untreated soil, biochar addition to field soil caused significant dose-dependent increases in soil pH, effective cation exchange capacity, and the availability macronutrients (P, K, Ca, and Mg), as well as micronutrients (Zn, Fe, and Mn). These effects persisted after leaching. Doses of 5 and 10% biochar mixed with oven-dried soil significantly increased soil water retention compared to an untreated soil. In the soil respiration experiment, amendment with 5% weight raw filtercake resulted in a very large but transient surge in soil CO2 efflux, indicating rapid mineralization upon incorporation into field-moist soil. In contrast, 5% wt biochar treatment resulting in a very small increase relative to untreated soil, likely due to residual carbohydrates.

Conclusions: Our analyses revealed several ways in which filtercake biochar is physicochemically distinct from more commonly used woody or herbaceous biochars, and our soil quality assays indicate that filtercake biochar may be useful as a soil carbon management tool with agronomic nutrient and water benefits in sugarcane cultivation.

Keywords: *sugarcane; filtercake; biochar; respiration; water retention; nutrient availability*

P2-104

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Combined Remediation of Pesticide Contaminated Soil Via the Application of Manure Biochar

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Biochars are produced by pyrolysis of such biological residues as wood chips, animal manure, agricultural and other natural waste under low oxygen conditions, resulting in a porous, low density carbon rich material. In recent years, biochar as a soil amendment is increasingly receiving attention due to its ability to increase the soil carbon pool and improve the soil fertility and crop productivity, especially as a climate change mitigation strategy. It can also enhance crop resistance to disease. New research is now revealing its potential to control both organic and inorganic contaminants. This study reviews the remediation of contaminated soils utilizing manure biochar as soil amendment, combining natural attenuation, bioremediation, phytoremediation, or vermi-remediation (earthworm) technology. The mechanism controlling its role during bioremediation includes the surface adsorption, partition and sequestration. The overview of the role of biochar amendments in the combined remediation techniques is demonstrated: how the biochar amendments influence the bioavailability, potential ecotoxicological impact, and environmental fate of pesticides in the earthworm-soil-plant system. In mixed-contaminated sites, such as those where organic toxins breach safe levels, duality of amendments can enhance the remediation of contaminants, offering strategic and cost-effective advantages.

Keywords：*Biochar, Pesticides, Remediation, Soil*

P2-105

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Induced Changes in Soil Stability Parameters

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Biochar amendment of agricultural field is receiving considerable attention worldwide due to empirical findings that suggest improved output and enhanced carbon sequestration from amended plots. However there is limited research that directly quantifies the underlying the physical and mechanical processes. So in this study we amended soils with different dosages of forest derived biochar and investigated the changes in the stability parameters of substrates (after 300days) at micro- and macro scales. At the microscale, amplitude sweep tests (AST) with controlled shear deformation were conducted with samples equilibrated to 0, 6 and 15kPa to determine the viscoelastic properties relating to stiffness, structural stability, and shear behaviour. At the macroscale, we determined the precompression stresses and the Mohr Coulomb shear parameters including cohesion and the angle of internal friction. These parameters were compared with those from unamended control similarly prepared. We observed that amending soils with biochar remarkably alters the particle to particle bonding and aggregate structure consequently shifting the strength parameters. Adding 2 to 5% biochar enhance aggregation of the coarse grained sand and increased the stiffness degradation. Although this was similarly noted in fine grained calcic glysol and calcic chernozems, the changes were more profound in the sand samples. When the biochar dosage was increase to beyond 5%, the magnitude of the micro-structural changes in the substrates further altered the strength attributes particularly as the soil dries out. This study demonstrates that the effects of biochar on stabilization depend on the dosage of biochar, extent of homogenization, the texture of the base soil material and the moisture content.

Keywords：*biochar, precompression stress, rheometry*

P2-106

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Changes Soil Structure and Water-Holding Capacity - A Study with X-Ray Micro-Ct

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Soil structure is the dominant influence on the movement and storage of water and gas into and within soil, with both overall porosity and pore architecture influencing their behaviour in the soil matrix. Employing x-ray computed tomography (μCT), we examined the impact on structural traits of three agricultural soils from Australia, a Vertisol, a Ferralsol and an Arenosol from amendment with an oil mallee oil mallee (E. polybractea) biochar. The hardwood was pyrolysed at a highest treatment temperature of 550^{o}C, the biochar had an internal porosity of 75.1% with a C content of 69%. Before amending soils, it was sieved to between 250 μm and 2 mm and incorporated at 0%, 1% and 5% w/w. Using a resolution of 70 μm, we assessed the impact over a 12 months incubation on porosity, mean pore radius, fractal dimension and connectivity of the pore space. Biochar addition resulted in higher μCT porosity (i.e. porosity ≥ 70 μm) in the Vertisol, averaging 7.5, 9.1 and 13.4% respectively for 0, 1 and 5% biochar and also for the Ferralsol with corresponding μCT porosities of 6.2, 6.5 and 10.9%, the differences being significant ($p < 0.05$) for both soils. Significant increases ($p < 0.05$) in connectivity of the largest pore and mean pore radius were observed in all 3 soils containing 5% biochar and also in the Arenosol with 1% biochar. For the Ferralsol containing 5% biochar, both μCT porosity ($p = 0.005$) and connectivity ($p = 0.006$) increased during the incubation. Biochar addition significantly decreased the rate of water loss through evaporation and drainage of all soils and reduced volumetric water content at field capacity in the two clay-rich soils. We will present water release curves between 0.02 and -1.5 MPa comparing controls with addition of 1% biochar. At 1% (wt/wt) oil mallee biochar increased the rate of drainage in the Vertisol clay and increased the available water content of the Arenosol sand by 20 %. It is hypothesised that the highly porous structure of biochar may have contributed to the enhanced water retention capacity of the soils under drying conditions. This study highlights the potential for oil mallee biochar to improve soil structural characteristics of contrasting soils.

Keywords：*Biochar, x-ray computed tomography, image analysis, porosity, structural change, moisture retention*

P2-107

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Compound Fertilizer as an Option to Reach High Productivity but Low Carbon Intensity in Rice Agriculture: A Field Experiment in a Rice Paddy from Anhui, China

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Abstract: Biochar from pyrolysis of biomass amended in soils to improve nitrogen use efficiency for enhancing crop productivity and mitigate climate change in agriculture has been well documented. However, application of biochar at high rates could raise an issue of cost-effectiveness for small scale household farms. In this study, a field experiment was conducted on rice crop productivity and greenhouse gas emission with biochar compound fertilizers in a rice paddy from Anhui China. Biochar compound fertilizers (BCFs) were produced by combining conventional chemical fertilizer (CCF) with biochar derived from different feedstocks respectively of manure compost, maize straw, peanut husk and municipal bio-waste in 1:3 (m:m). A same weight of these fertilizers as the conventional chemical fertilizer was applied as basal fertilizer before rice (Oryza sativa L, cv. Yliangyou2) sowing. Rice production was consistently managed with flooding and intermittent irrigation mode and with consistent crop protection practices. Grain yield was measured at rice harvest and greenhouse gas emission monitored with closed chamber at1-week interval during the whole rice growing season (WRGS). While rice yield was observed similar or higher but nitrogen agronomical efficiency was higher by 36.8-63.2 % under BCFs compared to CCF. Although there was no significant difference between BCFs and CCF in total CO2 emissions, a decline in total CH4 emissions by 25.5-50.6% and in total N2O emission by 31.0-39.4% over CCF was observed. Overall, the global warming potential (GWP) by CH4 and N2O was significantly reduced under BCFs by 29.8-42.9% and carbon emission intensity decreased by 36.4-56.5% compared to under CCF. Thus, BCF application ensured rice productivity and reduced carbon emission at a much lower rate of N application in rice agriculture. More works are necessary to explore the mechanism of BCF in regulating N dynamics and the nitrous oxide emission from the rice paddy in the future.

Keywords：*Biochar compound fertilizer; Nitrogen; Rice productivity; greenhouse gas; soil quality; rice paddy*

P2-108

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Predictive Mapping of Soil Organic Carbon Density Using Local Spatial Interpolator Models in Plain Areas

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SOC has strong spatial variability and dependency, and its impact factors are different along with the change of scales and geographical locations. Different statistical and geostatistical approaches have been used in the past to estimate the spatial distribution of soil properties at a range of spatial scales. This paper took Chahe Town which is the typical example of Jianghan Plain as the study region. The specific objectives were to (i) estimate the spatial distribution of SOC density, and (ii) compare the GWRK results with those obtained from regression kriging (RK). A total of 272 topsoil samples were collected using random sample consensus, and randomly divided into calibration (n=181, 67%) and validation (n=91, 33%) datasets. The basic statistics of SOC density showed it has significant correlations with DEM, NDMI, TRD and TCYTRA. Estimating the spatial distribution of SOC density by different local spatial interpolator models. The model parameters showed different influence of impact factors to SOC density, and the checking indexes and theory showed the prediction accuracy of GWRK model was the best than other models, for it had the minimal value of MAEE (2.432 kg/m2), RMSE (3.051 kg/m2) and MRE (0.510), and the maximal value of r (0.282). This study can provide one theoretical foundation that the GWRK model was the best simulation model of SOC density and its coefficients of model parameters showed the influence of different impact factors to SOC density in plain area.

Keywords：*spatial variation, spatial dependence, geographically weighted regression, regression kriging, soil organic carbon density, geographically weighted regression kriging*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Assessing Biochar Stability and Native Soil Carbon Stabilisation in Pasture

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Understanding the fate of biochar in soil and its interaction with various soil organic matter pools is essential for assessing its role in long-term C sequestration. However, the mechanisms controlling both biochar stability and the stabilisation of native soil and root-derived carbon under field conditions are poorly understood.

A 12-month field trial was carried out in a C_3 pasture system converted from C_4 vegetation in a subtropical climate on ferralsol. We used a ^{13}C-depleted E. saligna greenwaste biochar (produced at 450°C; -36.57‰), applied at 0 and 3% (w/w), to quantify biochar C stability and priming effects. Autotrophic and heterotrophic soil respirations were separated by the use of a novel in-field respiration chamber. Three $^{13}CO_2$ pulse labelling (99 atom % ^{13}C campaigns were employed in contrasting seasonal conditions. During each campaign, root components were labelled with enriched $^{13}CO_2$ to create a large difference in the isotopic signals of the two end members. For instance, Soil and Root in the control, or Soil + Biochar and Root in the biochar plots. Thus, in the non-pulse-labelled plots the potential impact of biochar and root interaction on $\delta^{13}C$ of the Soil + Root component can be evaluated to better quantify the contribution of biochar-C to the total CO_2 emissions. Biochar-^{13}C and root-derived ^{13}C were monitored in soil fractions to better understand the interaction between biochar stability and C stabilisation.

Based on an isotope mixing model, the extent of biochar-induced priming effect on soil was quantified, which was defined as the change in soil C mineralisation in the biochar-treated plots without plants compared with the soil C mineralisation in control without plants. Significant negative priming was observed only at the two-month sampling point following incorporation of biochar into soil. Biochar C mineralisation rates were higher in these first two months than during the following period. The total CO_2 and N_2O emissions from biochar-amended plots were also higher than control within these first two months. These emissions declined with the decrease in biochar C mineralisation rates. A two-pool exponential model was applied to estimate the mean residence time of biochar within soil matrix.

This experiment provided field-derived evidence on the mechanisms of biochar stability and stabilisation of soil native carbon. The novel respiration chamber design with statistically robust replication (n=6) improved the detection of small contribution of biochar-C to the total CO_2 emissions from a dynamic plant-soil system.

Keywords：*Biochar-C stability, ^{13}C pulse labelling, ^{13}C-depleted biochar, In-field root respiration chamber, Priming effect*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Changes in Nitrogen and Phosphorus Chemical Structure and Nutrients Release from Raw Biomass to its Converted Biochar

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Converting raw biomass into biochar makes it suitable as a soil amendment to improve soil fertility and provide long-term carbon sequestration. In this study, we assessed how the conversion of raw biomass material into biochar alters its N and P chemical composition and nutrients release. Four different types of biomass, including one leguminous green manure biomass (Sesbania roxburghii) and three non green manure biomass (mature S. roxburghii biomass, rice husk and cedar), were charred at temperatures of 300 and 500 °C. The changes of N and P chemical structure through charring process were examined by synchrotron-based near-edge X-ray adsorption fine structure (NEXAFS) and X-ray absorption near edge structure (XANES) techniques in National Synchrotron Radiation Research Center in Hsinchu, Taiwan. Laboratory incubation was also conducted to assess N and P nutrients releases of raw material and its converted biochar amended to soils or sands.

The NEXAFS and XANES spectral revealed the substantial alterations of both N and P structure along the charring process. The N structure changed from amidic N structure in raw biomass material to aromatic and heterocyclic aromatic N structures in converted biochar, and the P structure changed from organic P form in raw biomass material to inorganic P form in converted biochar. Such structural alterations had great effects on N and P nutrients releases when raw biomass material and converted biochar were amended to soils or sands. The change in N mineralization pattern between raw material and converted biochar was different among the type of biomass. For green manure biomass, the N releasing pattern shifted from a net N mineralization (positive value to control soil) in raw material to a net N immobilization (negative value to control soil) in converted biochar. However, for non green manure biomass, the N mineralization pattern became less N immobilization in converted biochar compared that in raw material. The release of P was found to be similar in four biomass, from P immobilization in raw biomass material to net P release in converted biochar.

Our study indicates that the charring process can substantially alter N and P chemical structure and nutrients release. From our laboratory incubation, we suggest that the charring process may limit green manure biochar to provide N nutrients but allow non green manure biochar to be less N immobilized. Both green manure and non green manure biochars have higher P release rate than raw biomass.

Keywords：*biochar, Nitrogen, Phosphorus, NEXAFS, XANES, incubation*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

The Effect of Urban Biochar on Phosphorus Fractions in an Acid Soil

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A laboratory experiment was conducted to determine the effect of Urban Biochar produced by pyrolysis of a 15% biosolid / 85% greenwaste feedstock on the phosphorus (P) fractions of a dairy pasture soil from Poowong East, Victoria. The soil was anacidic Brown Dermosol and samples were obtained from the top 0-10 cm from two areas of the same paddock with contrasting Olsen P status (PL, 9 mgPkg-1 and PH, 200 mgPkg-1). Soils were incubated in small containers (250 cm3) at 25oC for 45 days at constant moisture content. Biochar was mixed with the soil at levels equivalent to 0, 10, 30 and 50 tonne ha-1. At the end of the incubation the treatments were fractionated according to the Hedley method, which included H2O-P, CHCl3/NaHCO3-P, NaOH-P, HCl-P and finally residual P. The initial distribution of P differed between the soils with around 40 % (PL) and 80 % (PH) of the P in inorganic forms. The Biochar treatments were found to have a liming effect on both soils and pH increased by 0.2 and 0.26 relative to the control at 50 t ha-1. Biochar addition significantly increased the labile forms of P in PL soil. However Biochar addition significantly decreased water soluble P in PH soil. The results suggest that Urban Biochar may have a role in increasing P availability in limited environments and decreasing P availability in high environmental risk environments.

Keywords：*biochar, phosphorus fractions, acid soil*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Degradation in Vitro and in Situ

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Biochar is often recommended as a soil amendment with an almost infinite life span. Various authors assessed the residence time of charcoal in soil to range from thousands to (more recently) hundreds of years. Charcoal is formed in large quantities in forest and savannah fires all over the world, however, no significant charcoal deposits are found either on land or in the coastal areas. This is particularly curious, since the low density of this material (about 0.3 Mg/m3) should result in substantial transport and accumulation due to erosion. This suggests that conditions for charcoal preservation in some soils are unique rather than common.

In soil environments charcoal is regarded as a largely inert material. On the surface, however, the very nature of char is very reactive instead. Charcoal is spontaneously combustible within weeks from production and may ignite on contact with oxygen in the atmosphere. Subsequent oxidation and formation of oxidized organic coatings on the surfaces of coal particles results in a significant reduction of calorific value. The reductive pathway - coal gasification in mines is common and leads to significant accumulation in mines – to such an extent that the process is commercialized.

We have embarked on a range of experiments to understand some of the oxidation and reduction processes, suggesting various pathways of charcoal degradation on soil surface and in the deeper soil layers. The biochar used in this study was produced from pine sawmill waste by slow-pyrolysis (450˚C).

Oxidative degradation was established using different concentrations of H2O2 were used. The H2O2 can be catalysed to various free radicals by transition metals such as Fe3+/Fe2+, Mn2+ and Cu2+ present in the matrix of the biochar. The biochar was assumed to be exposed to a OH•-producing system due to the pH range used and the metal catalysts present in the biochar. The biochar's elemental composition (% C, H, O, and N), surface chemistry (FT-IR spectrums, surface acidity/basicity and pH) and intermediates released upon degradation were determined.

The oxidation of the biochar with H2O2 resulted in an increase in the O content, possibly due to H abstraction and C mineralization through the oxidation of aliphatics, volatile organic carbons and cleavage of benzene rings. The increase in O content can mainly be attributed to hydroxylation and carboxylation reactions.

An incubation study was conducted in closed columns installed in a laboratory at room temperature and filled with silica sand, amended by addition of 10%wt biochar. Microbial inoculation was done with a filtered suspension produced from rotting pine wood.

Gas extractions were made from the soil-airspace and the headspace of the column with 5 ml syringes and gas composition was determined using gas chromatography. Columns were kept at field capacity for the duration of the trial and leached once a month

for collection of solubilized organics. Total organic carbon (TOC) below 8μm was determined colorimetrically using the rapid oxidation spectrophotometric method

This aerobic oxidation study has clearly shown that biodegradation of biochar in aerobic conditions produces not only gaseous, but also liquid products, which were previously disregarded in biochar degradation studies. The rate and volumes of biodegradation are largely controlled by nutrient availability, particularly N and P.

An in vitro reductive degradation trial was a factorial experiment with all treatments done in triplicate. The trial was conducted at room temperature in 500 ml Erlenmeyer flasks containing 50 grams of granulated methanogenic consortium to investigate the effect of pH and increasing biochar loads (expressed as chemical oxygen demand - COD), on the biodegradation of biochar. The trial consisted of three main treatments assessed over three periods, each with increasing biochar loads. The trials were conducted at pH 5.5, 7 and 8, with N and P added to all treatments based on carbon loads at the rate of 1000:10:1 (C:N:P). Sampling was done four times within each incubation period. The substrate feed and the effluent parameters monitored with every feed included the following: COD reduction (APHA, 1998), pH, alkalinity (as CaCO3), total biogas produced and its composition.

The greatest COD removal efficiencies were attained from digesters with starting pHs of 7 and 8., Between 30 and 50% of biochar introduced into the system was gasified within a week.

Keywords：*biochar degradation oxidation reduction*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Stabilization by Organo-Mineral Associations in a Forest Soil Under Pinus Radiata in the Spanish Atlantic Area

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The application of biochar, a long-lived form of carbon, in soils is being considered a potential strategy to sequester carbon while improving both soil properties such as fertility, nutrient cycling, biomass production and water availability and microbial functions. The benefits of biochar for soil mainly depend on the properties of adsorption and stability of biochar. Further, these two properties make biochar an effective technology to tackle major environmental problems; for instance soil degradation, climate change and waste management. Considering these benefits for soil and environment, it is crucial to advance in our knowledge of stabilization mechanisms of biochar in soil, which are overall poorly understood.

Many forest soils in the Spanish Atlantic area have low contents of organic carbon, so that the amendments of these soils with biochar might be a key strategy to restore soil quality and to strength the resilience of forest ecosystems to tackle climate change. Our objective was to study the stabilization of biochar by organo-mineral interactions in a forest soil in the Spanish Atlantic area, since the formation of organo-mineral associations is a key mechanisms for the long-term stabilization of organic matter in soil. We (1) measured the rate of incorporation of biochar to organo-mineral associations after one year from the addition of biochar to the soil and (2) tested the role of mineral composition of the soil in the formation of organo-mineral associations.

The experimental field was established in a 20-year old plantation of Pinus radiata, located in the Basque Country (Spain), where the climate is humid temperate with mean annual temperature and mean annual precipitation of 8.5 ºC and 1200 mm, respectively. The soil in the field is extremely acid (pH = 4.30) with a clayey loam texture, developed in silty sandstones. The field has a completely randomized block design with 9 replicates per treatment. We worked with three treatments in this study: control (CT), biochar (BIO, 9 Mg C of biochar per hectare were added in the plots), and biochar + N (BION, 9 Mg C of biochar per hectare activated with 0.8% N were added in the plots). Biochar, produced from Miscanthus sp. by pyrolysis at 450 ºC, was added to the soil in May 2012. The difference in natural abundance of 13C between the natural vegetation in the experimental field (C3 type) and biochar from Miscanthus sp. (C4 type) allowed us to trace the fate of biochar in the soil. We collected undisturbed soil samples from 0-20-cm depth at the plots of the three treatments and we sieved through a 2-mm sieve the air-dried samples. A particle-size fractionation was then performed in soil samples by a two-step mechanical dispersion of the soil to separate organo-mineral associations of the following sizes: 2-20 μm, 0.2-2 μm, 0.05-0.2 μm, and <0.05 μm. Clay mineralogy was analyzed in each size fraction and Fe/Al oxy-hydroxides, organic C and C isotopic composition will be analyzed in the coming weeks.

The particle-size fractionation separated organo-mineral associations with contrasted clay mineralogy. The fraction 2-20 μm was mainly dominated by illite, while fractions 0.2-2 μm, 0.05-0.2 μm, and <0.05 μm were dominated by interstratified minerals with vermiculitic phases (chlorite/vermiculate and illite/vermiculite). The accumulation of vermiculitic phases and oxy-hydroxides

increased with decreasing size of fraction. The mineralogical trend was similar in the three treatments. The analyses of Fe/Al oxy-hydroxides will complete the mineralogical characterization of the soil, as they also can participate on the stabilization of biochar by the formation of organo-metal associations. The incoming results of organic C concentration and C isotopic composition of particle-size fractions will offer an overall view of the ability of different clay minerals to create biochar-mineral associations and the contribution to biochar stability in soil. Further, we intend to perform the particle size fractionation at different times within the next four years (approx. duration of the project), in order to trace the evolution of biochar in the soil and to study the long-term stability of the biochar in soil by organo-mineral associations.

Keywords：*clay minerals, oxy-hydroxydes, biochar, particle-size fractions, organo-mineral interactions, forest soil*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Sequestration of Greenhouse Gases (ghgs) for Sustainable Agriculture

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The study was conducted in two districts of Haryana state namely, Hisar and Karnal and a total number of 120 farmers were interviewed.

The result predicted that major causes of greenhouse gases were found 'high use of inorganic farm inputs' (2.88), 'intensive tillage practices' (2.75), 'mechanization of farm practices', (2.66), 'non- adoption of diversified agriculture' (2.52), 'non-adoption of crop rotation; (2.46), and 'burning of crop residue in field' (1.95) with their respective weighted mean scores.

The study further revealed that very serious losses due to greenhouse gases were found 'crop benefit ratio decreased' (1.23), 'crop damaged due to adverse climatic uncertainty' (1.07), 'crop production decreased' (0.89), 'sowing season change (0.86), 'loss in bio-diversity' (0.84), 'less income from agriculture' (0.81), 'soil water holding capacity decreased' (0.68) based on their 'Z' scores.

The other serious losses due to emissions of GHGs were 'deeper level of ground water table' (0.31) ' 'cropping pattern and cropping system changed' (0.28), 'high usages of synthetic or inorganic fertilizers' (0.23), 'soil fertility decreases' (0.13), 'degradation of forests to barren lands' (0.10), and 'soil erosion' (0.07).

Results pertaining adoption of remedial measures for sequestration of greenhouse gases for sustainable agriculture were 'evolution of new crops cultivars' (2.95), 'crop diversification' (2.90), 'use zero tillage practices' (2.81) 'integrated farming system' (2.79) 'adapting cultivars against drought, pests, diseases, resistance' (2.78), 'soil/water testing for soil status' (2.77), 'encouraging of rice varieties that emit less CH4 (2.73), 'campaigning for sequestration of GHGs (2.67)', 'growing intercrops/mixed cropping to compensate crop failure', (2.62) and 'management of natural resources soil, water and biodiversity' (2.61) considered very effective remedial measures with their mean scores, respectively.

The other remedial measures such as 'adopting soil conservation measures' (2.57), 'reduce tillage practices' (2.56), 'use Indigenous traditional knowledge (ITK) for crop production' (2.55), 'water harvesting management practices' (2.50), 'use remote sensing technologies for analysis of vegetation and soil carbon' (2.48), 'application of compost/FYM/Green manuring' (2.47), 'enhancing the area under agro –forestry and social forestry' (2.45), and 'organic farming practices' (2.42) were perceived as effective remedial measures in sequestration of GHGs.

Keywords：*GHGs Emission,Climate change Causes, Losses, Remedial Measures, Greenhouse Gases and Sustainab*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Creation of Char from Fossil Carbon Analogous to Biochar

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Biochar is char created from a biomass feedstock via a pyrolysis process, for specific use as a soil amendment. Biochar properties such as high internal surface area and porosity, high cation exchange capacity and nutrient retention capabilities have been shown to improve soil properties and increase crop yields. Based on the concept of biochar, it was envisaged that coal mine waste (coal tailings) may be used as a feedstock to create a char with some of the beneficial properties that biochars possess. Coal tailings are a waste product of the coal mining process typically consisting of fine coal particles, mineral matter; i.e. clays and quartz, and water. Coal tailings are typically disposed of in large open dams which are both an environmental concern and a major closure liability to mining companies. Hence utilising coal tailings to produce a char akin to biochar could allow for more sustainable waste management practices as well as create a soil amendment that could assist in mining land rehabilitation. The char created from coal tailings will be referred to as 'chailings'. The concept of chailings was formulated as both coal and biomass are organic substances with somewhat similar characteristics, however coal is more inert and carbon dense as it has been under immense temperature and pressure for millions of years. As such similar production methods can be used, but as coal is fossil carbon, the chailings production process would not have the same greenhouse gas emissions profile as biochar production.

This study aims to provide a novel utilisation strategy for coal tailings that will reduce tailings volumes and provide a product that will have beneficial outcomes in agricultural and mining rehabilitation scenarios. Experimental work comprised of slow pyrolysis process of coal tailings samples at temperatures of 400 to 800°C to form a variety of chailings. The chailings were then applied to soil at a number of application rates (4 - 50 t/ha) to determine their potential as a soil amendment and examine if similar results to biochar could be achieved. Findings of this study will be presented.

Keywords: *biochar, chailings, pyrolysis, char*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Evaluation of Carbon and Nitrogen Dynamics in Different Soil Types Amended with Pig Slurry, Pig Manure and its Biochar by Chemical and Thermogravimetric Analysis

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Determining the structure and components of soil and soil organic matter is very important in terms of sustainable agriculture and forestry and greenhouse gases emissions. Organic management can increase labile C and N in the short-term, and total soil C and N in the long-term, but less is known about how management practices may affect soil organic matter (SOM) quality and stability. Methods to improve the management of livestock slurries to reduce the environmental impact and carbon/nitrogen losses are gaining importance. There is a need to find the best wastes treatment which enhances soil fertility but also carbon and nitrogen sequestration, to mitigate the effects of global warming.

The objective of this study was to assess the short-term changes in soil organic C (SOC) and N pools, using raw pig slurry, the solid phase of pig slurry, and its biochar as amendment in different soil types (Regosol, Luvisol and Kastanozem). The three different amendments were applied at 5 g C kg-1 soil. An unamended soil for each type was used as control. Soils were incubated in triplicate for 60 days at 25ºC and at 55% of their water holding capacity. Samples were sampled to monitor the evolution of soil organic and inorganic carbon, total nitrogen, recalcitrant carbon, soluble carbon and nitrogen, carbon and nitrogen mineralization, SOM thermal distribution (thermogravimetric analysis - differential scanning calorimetry - quadrupole mass spectrometry), and characterization of functional groups (Fourier transform infrared spectroscopy (FTIR)). Results showed that soils amended with raw pig slurry and the solid phase of the slurry showed higher values of soluble carbon and nitrogen, and higher carbon and nitrogen mineralization rates compared to biochar application, which showed values similar to controls. SOC increased at the end of incubation with biochar and the solid phase of the slurry applications in Kastanozem and Regosol.

Thermogravimetric results showed an increased weight loss of the Regosol compared to Luvisol and Kastanozem. These results are in agreement with the studies regarding the influence of soil carbonate on the percentage of degradable components. Luvisol and Kastanozem had higher volatile compounds than Regosol, with no significant differences among treatments. Changes in total weight loss of soil among treatments were small, although endothermic and exothermic calorimetric peaks were different depending on the treatment, mainly in Regosol and Luvisol, being higher in biochar amended samples.

An increase in the relative proportion of the C-containing gas species released above 550 ºC were observed in the Regosol owing to the high content of carbonates, with significant differences among treatments. The proportion of C and N-containing gas species below 550 ºC was higher in Luvisol and Kastanozem with no differences among treatments. There was an increment in the C-containing gas species released in the incubated samples in Regosol and Luvisol compared to initial soil, with no differences in Kastanozem.

As a general pattern, FTIR absorbance intensity followed the pattern Kastanozem> Luvisol> Regosol due to the different amount

of organic matter. Areas of bands representing chemically terminal alkenes moieties at 3286 cm-1 and 3340 cm-1 in Luvisol and Kastanozem. Chemically refractory aromatic moieties at 1580 cm-1 and 1594 cm-1 in Luvisol and Kastanozem, and at 729 cm-1 and 754 cm-1 in the three types of soils. Areas of bands representing chemically terminal alkane moieties at 1359 cm-1 and 1380 cm-1, alkenyl moieties at 962 cm-1 and 975 cm-1, and alkynes at 636 cm-1 and 663 cm-1 in all types of soils. The soil samples measured before incubation presented higher absorbance intensity than at the end of incubation, indicating mineralization of organic matter with incubation. No significant alterations in the functional groups were observed with the application of the amendments in any soil. This study suggested that the application of 5 g C kg-1 soil was not sufficient to modify organic functional groups at short term. Thus, different soil types behave differently in terms of amendments applications, being the Regosol more prone to alter SOM content and stability after applications. The application of biochar promoted higher SOM concentrations and stability at the end of the incubation.

Keywords：*Pig slurry, Pig Manure, Biochar, thermogravimetric analysis, FTIR, soil respiration, soil mineraliza*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Contrasting Effect of Biochar and Clay Amendment of Coarse Textured Soil

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Enhancing readily available moisture (RAM) is critical to crop development and production. In coarse textured soils commonly found in arid and semi-arid climate, this is often difficult. Several methods had been proposed for improving RAM, but there are scanty research comparing their effect on soil microstructural development, thus our understanding of the enhanced moisture retention capacity is limited. In this study, we compared the effect of biochar and clay amendment of soil water retention function of a fine sandy soil. Biochar (forest product based), kaolinite (non-swelling clay) and montmorillonite- (swelling clay) were added at the rate of 2%, 5% and 10% by dry weight to salt free fine sand (0.13 – 0.36 mm) and prepared at to a bulk density of 1.45gcm-3 in 100cm3 stainless steel rings. Moisture retention at 0, -6, -15, -30, -50 and -1500 kPa and air permeability at -6, -15, -30, -50kPa were measured. We equally evaluated microstructural changes concomitant with the varied types and levels of amendment using rheometry techniques. The data were compared with those from unamended control. Our results indicated varied levels of in the enhancement of moisture retention, depending on the type of material used in the amendment and the degree of amendment. Microstructural changes in the new substrate help to elucidate on the observed increase in moisture retention. The study would help in decision making process on choice of materials for amendment and in the simulation of long term consequences on soil structure and pore functions of amended substrates

Keywords：*biochar, clay amendment, rheometry*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Microbial Biomass and Enzyme Activities Dynamics in Different Soil Types Amended with Pig Slurry, Pig Manure, and its Biochar

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Large amounts of pig slurries are produced in many countries such as Spain each year leading to environmental problems, such as soil and water pollution. Thus, methods to improve the management of slurry to reduce the environmental impact are getting importance in recent times. There is a need to find the best wastes treatment which enhances soil fertility but also carbon sequestration, to mitigate the effects of global warming. Biochar, feed stocked by different organic wastes, has proved to be a suitable amendment to enhance organic carbon accumulation in stable forms in soils. Nonetheless, soil type, influenced by pH, native organic content, or clay content, could differently behave after applications of the same amendments, favoring their stabilization or their mineralization.

The objective of this study was to assess, under laboratory conditions, the effect of raw pig slurry, the solid phase of pig slurry, and its biochar on carbon and nitrogen dynamics in different soil types (Regosol, Luvisol and Kastanozem) using the microbial biomass and enzyme activities as indicators. The three different amendments were applied at 5 g C kg-1 soil. An unamended soil for each type was used as control. Soils were incubated in triplicate for 60 days at 25ºC and at 55% of their water holding capacity. Samples were periodically sampled to monitor the evolution of microbial biomass carbon and nitrogen, and β-glucosidase, β-galactosidase, arylesterase, β-glucosaminidase, urease and protease enzyme activities.

Soils amended with raw pig slurry and the solid phase of the slurry showed higher values of most biochemical properties compared to biochar application, while biochar did not have significant differences with controls. The results of a two-way repeated measures ANOVA showed that all factors studied (soil type, amendment and time of incubation) significantly affected all biochemical properties ($p<0.05$). Hence, our results indicated that even though raw and the solid fraction of pig slurry increased microbial activity and thus C and N mineralization, biochar was more recalcitrant, with no short-term activation of microbial populations in any soil. Regarding the effects of the different amendments on different soil types, the measured properties from the soil with the lower organic carbon content, the regosol, were more intensely increased than luvisol and Kastanozem, indicating a more active microbial populations leading to higher mineralization of organic compounds. Thus, it seems that the transformation of pig slurry into biochar could be positively used to fight soil degradation, mitigate global warming and reduce the environmental impacts of this organic waste. Nonetheless, to determine the net effects of biochar on different soil types, long-term experiments are needed to truly clarify its potential use for long term carbon sequestration.

Keywords：*Pig slurry, Pig Manure, Biochar, Microbial biomass, enzyme activities, soil type*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Response of Soil Microbial Communities to Long-Term Biochar Application

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Biochar addition into agricultural soils can improve crop yield and contribute to climate change mitigation by C sequestration. However, biochar application to soil induces alkalinization, increases net negative charge on soil colloids and can add heavy metals and organic pollutants depending on the feedstock source and charring temperature. For such reasons there is still much debate on the long term environmental sustainability of biochar use in agriculture and its use in many EU agricultural soils is still officially not allowed. While the impact of biochar application on crop yield and soil microbial activity and microbial community composition has been widely studied on the short term at small plot and laboratory scales, knowledge on the long-term and large-scale field application of biochar in agricultural soils is still unknown.

We studied the effects of 4 years of biochar application to a vineyard soil (shallow, acid, sandy-clay-loam) in central Italy on soil microbial activity and community composition. The experimental set up consists of two amendment rates (22 and 44 t ha-1) and a control with 5 replicates arranged in a randomized block design.

The effects of biochar application was assessed by determining heavy metal total concentration and bioavailability and the soil toxicity was evaluated with the BioTox test. The impact of biochar application on the soil microbial communities structure was studied by determining the ester- linked fatty acid methyl ester (EL-FAME).

Results showed that the biochar application induced significant soil alkalinization in the first two years after the biochar application, whereas the soil pH value tended to return to its initial value but always higher than the no treated soil. The biochar application at 44 t ha-1 significantly increased the bioavailability of some heavy metals, and induced slight soil toxicity, whereas no significant changes in heavy metal bioavailability were observed at 22 t ha-1 rate. The EL-FAME analysis showed that the impact of biochar on soil properties and microbial communities depends on the rate of application and time.

Results suggest the existence of a threshold of biochar application rate below which it is possible to sustainably contribute to climate change mitigation without endangering soil communities by the alteration of soil pH and increasing the bioavailability organic pollutants and of heavy metals in agroecosystem.

Keywords：*biochar rate, biotox, EL-FAME, time*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Pyrolysis Temperature Affects Alkalinity and Inorganic Minerals Formation in Biochar Prepared from Different Crop Residues

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We have previously observed that in a highly acidic soil (pH 4.8) when rice was grown, on an average the rise in pH due to biochar application was about 0.89. These soils have problems of nutrients toxicity and availability due to low pH. Thus, addition of biochar, may improve the soil conditions in favour of better nutrients availability and productivity. The reason of increasing pH in acid soils may be attributed to the inherent high pH of the biochar which may be due to presence of several inorganic minerals in it. In this study we addressed the effect of pyrolysis temperature on biochar alkaline property by pyrolysing four crop residues i. e. Rice (RC), Wheat (WH), Maize (MA) and Pearl Millet (PM) at 400oC, 500oC and 600 oC temperatures. All 12 biochars were analysed for pH (1:20 w/v), EC (1:20 w/v), Calcium Carbonate Equivalent (CCE), Water Soluble carbonate (CO3=) and bicarbonate (HCO3-). XRD analysis was also done to investigate the inorganic minerals present in biochar. Increase in pyrolysis temperature increased the pH and EC values for all four types of biochar. In RC biochar pH value increased from 9.95 to 10.35 when pyrolysis temperature increased from 400 oC to 600 oC. Similar trend was found for WH, MA and PM biochars also. Highest biochar pH was found i.e. 10.75 when PM residue was pyrolysed at 600oC. In the contrary, RC biochar produced at 600 oC had the highest CCE valued 46.25. With increase in pyrolysis temperature carbonate (CO3=) content increased while HCO3- content decreased for all 4 biochars. Increase in alkalinity of all these biochar with pyrolysis temperature may be due to formation of more crystalline inorganic minerals like Sylvite (KCL), Calcite (CaCO3) and Dolomite (CaCO3.MgCO3) which presence were confirmed by XRD analysis. The XRD analysis was conducted by operating the Philips PW 1710 Defractometer at 40 kV and 20 mA and data were collected over a 2θ range 15 to 55. In terms of producing alkalinity of biochars, Sylvite was found to be dominating mineral which is confirmed by peaks at 3.15 and 2.22 Å in all biochars. Calcite formation was also confirmed by peaks at 2.45 and 2.28 Å. Peaks at 2.90 Å confirm the presence of Dolomite. Semi-quantitative analysis was also done to evaluate the effect of temperature on formation and crystalinity of these mineral present in biochars prepared at three temperatures.

Keywords：*Crop residues, Biochar, C sequestration, Alkalinity, Inorganic minerals*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Characterization and Evaluation for their Application as a Soil Amendments

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Biochar is an organic charcoal material that is the final product of pyrolysis, or high temperature burning of agricultural biomass without the presence of oxygen. The limitation of oxygen in the system prevents the complete burning, instead producing the charcoal that captures much more of the natural carbon from the biomaterial. The present studies taken up with the main objective of biochar characterization and evaluation for their application as soil amendments. Biochar samples were prepared from the pyrolysis process of various biological materials viz., coconut shell, sugarcane baggaase and prosopis wood. The biochars are characterized by surface area and particle size distribution by using Scanning Electron Microscope (SEM), Raman Spectroscopy and Particle size analyzer with EDAX. The carbon in the biomass is subjected to easy degradation since they contain low grade carbon. But in biochar, pyrogenic carbon is formed by pyrolysis. The biochars are differed much from each other in many characters based on the pyrolysis temperature. The physio chemical properties of biochar showed that this is very useful source of soil amendment/nutrients is one way to manage soil health and fertility. The pH (7.89, 9.05, 7.20); EC (1.35, 0.38, 0.16), Cation Exchange Capacity (18.0, 12.2, 3.7 cmol (p+) kg-1); Total organic carbon (950, 905, 6 5.0 g kg-1); Total Nitrogen (11.5, 9.3, 1.2 g kg-1); C:N Ratio (82.6, 97.3, 54.2); Total Phosphorus (1.10, 3.0, 0.6 g kg-1); Total Potassium (27.5, 10.0, 3.7 g kg-1) respectively for the biochars of Prosopis wood, Coconut shell and Sugarcane bagasse. Plant samples pyrolysed under 350°C were finely ground particles of coconut shell, sugarcane bagasse and prosopis hardwoods were 1160,900 and 968 nm respectively and clearly explained that particle size varies with all the substrate due to the kiln resident time and milling time and revolution speed (rpm). Raman shifts (cm-1) of slow pyrolysed biochar of coconut shell, sugarcane bagasse and prosopis hardwood. Peaks observed at 187, 797, 1359, 1692, 1744, 1781, 1885 cm-1 for coconut shell and 87, 289, 797, 1646, 1692, 1742, 1781, 1885, 1960 cm-1 for sugarcane bagasse. The peaks observed at 187, 651, 795, 924, 1320, 1646, 1692, 1742, 1781, 1827, 1890, 1965, 2043 and 2079 cm-1 for prosopis hardwood. Pores were presented in all the biochar with varying size (small-high), shape with disorderedness and scatter in nature under different magnifications. The sizes of surface pores are 4-155 µm, 933 nm-33µm, 2-28 µm of coconut shell, sugarcane bagasse and prosopis hardwood respectively. Boron was observed in all biochar and Carbon content varies with all the biochars 66.5, 83.8 and 74.7%. The Carbon and oxygen ratio 66.5:1, 8.91:1 and 12.8:1. research work revealed that feedstocks differ in their composition concerning elemental composition; the presence of soil and dust particles; moisture content; and lignin, cellulose, and hemicellulose content, which, in turn, affect the properties of the respective biochars after pyrolysis. Fire accelerates and biochar decelerate the carbon cycle. If biochar is made from re-growing waste biomass as an alternative to burning and used as soil amendment it can enhance biomass buildup by improving soil fertility. Crop residues in fields can cause considerable crop management problems as they accumulate. These residues are either partially utilized or un-utilized due to various constraints. Efficient use of biomass by converting it as a useful source of soil amendment/nutrients is one way to manage soil health and fertility. One of the approaches for efficient utilization of biomass involves carbonization of biomass to highly stable carbon compound known as biochar and its use as a soil amendment.

Keywords：*Biochar, Pyrolysis, Physio-chemical properties, SEM, Raman Spectroscopy, Particle size analyzer, soi*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Application Reduces Ammonia Volatilization from Soil

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Nitrogen (N) is one of the most important nutrients for plant growth and development. When N is added to the soil it undergoes various transformation processes and is subjected to loss through gaseous emission and leaching. Ammonia (NH_3) volatilization is a major loss of N from the soil. Biochar (BC) is carbon (C) rich material which is produced from thermal decomposition of various organic biomass at low temperature (around 700^oC) and in the absence of oxygen. In this work, the effects of BC on the reduction of NH_3 volatilization and increase of soil fertility were compared for soils treated with inorganic and organic nitrogen sources. These effects were determined by conducting three incubation and one greenhouse studies.

The incubation studies were undertaken using five different soils with different pH values, three different types of inorganic and organic N sources (urea, diammonium phosphate and poultry manure) and two different biochars (BC1 = poultry manure biochar, BC2 = macadamia nut shell biochar). The pyrolysis temperature of BC1 and BC2 were 450^oC and 550^oC, respectively. In the incubation study, it was observed that NH_3 volatilization from urea fertilizer increased with increasing soil pH which could be attributed to the increasing supply of hydroxyl (OH^-) ions. Among the N sources NH_3 volatilization followed the order: urea > diammonium phosphate = poultry manure. The difference in NH_3 volatilization between N sources might be attributed to the difference in their effects on soil properties. For example, urea application increased soil pH thereby causing greater NH_3 volatilization. Ammonia volatilization from urea was reduced by 70.56% and 69.96% with the application of 5% (w/w) BC1 and BC2, respectively.

The effects of biochar on plant growth and N uptake were examined using the Stanford and Dement technique in which wheat plants (Triticum aestivum) were initially grown in a sand medium and subsequently transferred to soil samples treated with urea in the presence or absence of biochar treatment for 5 weeks. The results showed that biochar addition reduced NH_3 volatilization about 70.56% as well as improved soil fertility. Biochar increased the plant dry weight by 24.24% and N uptake by 33.29%. However further research is needed to identify the biophysical mechanisms involved in biochar-induced NH_3 volatilization from soils.

Keywords：*Ammonia volatilization, Biochar, Plant growth, Urea, Diammonium phosphate, Poultry manure*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effects Of Biochar in Sorghum and Acacia Seyal Agroforestry Systems in South Sudan: Results from a Two-Year Field Experiment

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Biochar use as a soil amendment to improve soil physiochemical properties and fertility has been the focus of recent research. However, there is meagre literature published concerning the impact of biochar on clayey soils. The aim of this study was to explore the effects of biochar alone or in combination with Acacia seyal on soil physiochemical properties in South Sudan.

The experiment used a split plot design with three replications of treatment. The main factor was the agroforestry treatment: sorghum (Sorghum bicolor (L.) Moench) grown under dense or scattered Acacia seyal cover, and control (only sorghum). The 10 x 10 m plots were divided into two subplots and the sub-plot factor was biochar application (0 or 10 t ha–1). The biochar was produced by slow pyrolysis from Acacia seyal wood and applied only once in the first season 2011. Sorghum was grown for two growing seasons, 2011 and 2012. Soil sampling (0–30cm, three samples per subplot) was conducted in end of the second cropping season 2012. Easily soluble nutrients and cation exchangeable capacity were determined from a 0.1 M barium chloride extraction with ICP-OES. Total C and N were analyzed using a VarioMax CN analyzer. Ash content was determined as loss-on-ignition (550 C° for two hours). pH was determined using a standard pH meter in a suspension (1:5) of soil/char and water. Particle size distribution was analyzed by laser diffraction analysis.

Preliminary results indicated that biochar addition did not change the soil physicochemical properties compared to the effect of a dense cover of Acacia seyal. Biochar only increased Si contents while the dense Acacia seyal treatment increased soil Ca, Mg, Na, S, P, and Si contents and decreased soil Al and Fe contents compared to the scattered Acacia seyal and control treatments. The C/N ratio in the dense A.seyal treatment (14.2) was notably higher compared with scattered A.seyal (5.9) and control (1.3) treatments. No significant treatment effects were observed on soil CEC, pH and micronutrient (Co, Cu, and Mn) contents. The final results of this two-year field experiment will be presented as the work is continuing on soil physical properties and sorghum yield data.

Keywords：*Biochar, Acacia seyal, Agroforestry, Sorghum*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Studies on the Effect of Human Urine Enriched Biochar on Soil Properties, Growth and Yield of French Bean

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An incubation experiment was conducted under green house conditions at Gandhi Krishi Vignana Kendra, Bangalore to prepare enriched biochar using human urine in different ratios (1:0.75, 1:1, 1:1.25, 1:1.5, 1:1.75 and 1:2). A field experiment was conducted at farmer's field with red sandy loam soil (Alfisol) to study the effect of human urine enriched biochar on soil properties, growth and yield of French bean crop during summer 2013. The field experiment consisited of nine treatments viz., T1-recommended dose of Fertilisers and FYM as per package of practice recommendation, T2-Recomended dose of FYM alone, T3-Biochar alone on equivalent carbon basis as that of FYM, T4-Enriched biochar 1 to supply 50% recommended N + 50% N through fertilizer, T5-Enriched biochar 2 to supply 50% recommended N + 50% N through fertilizer, T6-Enriched biochar 3 to supply 50% recommended N + 50% N through fertilizer, T7-Enriched biochar 4 to supply 50% recommended N + 50% N through fertilizer, T8-Enriched biochar 5 to supply 50% recommended N + 50% N through fertilizer and T9-Enriched biochar 6 to supply 50% recommended N + 50% N through fertilizer. The treatments were replicated thrice and the design used was randomized complete block design.

The results indicated that there was increase in nutrient composition of coconut shell biochar due to addition of human urine. The total N, P and K contents (0.72 to 1.67, 0.4 to 0.55 and 1.27 to 1.7 per cent from 1:0.75 to 1:2 ratios respectively) of human urine enriched biochar were found to be more than unenriched biochar. In the field experiment, application of enriched biochar 1(1:2) to supply 50% recommended N + 50% through fertilizer (T4) recorded significantly highest vegetable yield (6604.8 kg ha-1) as compared to all the other treatments followed by the treatment T1 receiving recommended dose of fertilizers along with FYM @ 25 t ha-1 (6194.4 kg ha-1). All the other enriched biochar treatments T5 (6161.8 kg ha-1), T6 (5793.7 kg ha-1) and T7 (5677.0 kg ha-1) recorded much higher yield over FYM alone and biochar alone treatments. Significantly lowest vegetable yield (4762.6 kg ha-1) was recorded with the application of recommended dose of FYM 25 t ha-1 (T2).

Significant differences in Physical, chemical and biological properties of soil were observed except bulk density and pH of the soil. Highest content of nitrogen and phosphorus was recorded in treatment involving application of enriched biochar 1 to supply 50% N + 50% through fertilizer (T4) and lowest was recorded with FYM alone. But highest potassium content was recorded in treatment T1 which received package of practice (POP) and was on par with treatment T4.

The exchangeable calcium, magnesium, sodium and available sulphur contents of soil varied significantly due to application of different ratios of biochar. Highest exchangeable Ca, Mg, Na and S content was recorded in the treatment which received enriched

biochar 1 to supply 50% N + 50% through fertilizer (T4) and was on par with enriched biochar 2 to supply 50% N + 50% through fertilizer (T5).

DTPA-Fe and Mn content of soil differed significantly with the application of enriched biochar. But Zn, Cu and B content did not vary significantly among treatments. Highest available iron content of soil was recorded with application of enriched biochar 1 to supply 50% N + 50% through fertilizer (T4). The Mn content was highest with application of enriched biochar 3 to supply 50% N + 50% through fertilizer (T6) and lowest Fe and Mn content was recorded in FYM treatment alone.

Higher activity of enzymes like dehydrogenase, alkaline phosphatase and urease in soil was recorded in the treatment which received enriched biochar 1 to supply 50% N + 50% through fertilizer (T4) and was on par with enriched biochar 2 to supply 50% N + 50% through fertilizer (T5) and enriched biochar 3 to supply 50% N + 50% through fertilizer (T6). The findings of this study clearly showed that application of enriched biochar using human urine has resulted in better crop growth and yield of French bean, reflecting and confirming the improved nutrient availability in soil.

Keywords：*enriched biochar, human urine, French bean*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Chitosan Soil Amendment for Zinc Removal from Soil: An Environment-Friendly Approach

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The present work evaluated the effects of pure and modified chitosan beads to consider its utilization for environmental cleanup through the remediation of soils polluted with Zinc (Zn) and to estimate the bioavailability of Zn by Indian mustard (Brassica juncea L.) plants. The soil was spiked with 0 to 400 mg kg-1 of Zn and subsequently amended with pure chitosan beads (PCB), molybdenum (MoCB), iron (ICB), single super phosphate (SSPCB) and mono calcium phosphate (MCPCB) modified chitosan beads. Compared to the non-amended soils, chitosan bead amended soils have shown higher biomass of plants, reduced plant metal uptake and increased immobilization of Zn in soil and pore water. Total plant biomass was found to be in order of SSPCB > MoCB > ICB > MCPCB > PCB > without chitosan beads (WCB) at lower dose (50 mg kg-1) and PCB > MoCB > ICB > SSPCB > MCPCB > without chitosan beads (WCB) at medium dose (100 mg kg-1). There was no plant growth observed in high Zn contaminated soil (400 mg kg-1) despite after the application of modified chitosan beads. The highest decrease in the uptake of Zn by shoot was observed in MoCB amended soil, whereas lowest in PCB amended soil (7.68% and 18.92%). In contrast, the highest decrease in the uptake of Zn by root was observed in SSPCB amended soil, showed highest decrease of Zn (72%) at lower dose and PCB showed highest reduction (78%) at medium concentration, as compared to non-amended soils. Molybdenum modified chitosan beads were found to be effective in decreasing Zn concentration in pore water. The decrease in plant Zn uptake and enhanced Zn immobilization may be attributed to Zn complexation by modified chitosan beads with high surface area and cation exchange capacity (CEC). Therefore, for the soils contaminated with Zn, the application of modified chitosan beads can be significant in a decreasing the Zn bioavailability and toxicity in an environment-friendly way.

Keywords : Chitosan, Zinc, Soil, Indian mustard, Plant biomass, Immobilization, Pore water

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Characterizations of Biochars and their Influence on Plant Growth When Added to Soil

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The late Wim Sombroek, former Secretary General of the International Soil Science Society, had a primal role in bringing the Terra Preta de Indio (TP), or the Amazonian dark earth soils to the attention of the soil science community. These soils arose from the amendments by pre-Columbian Amazonians of domestic residues and of plant debris covered with soil and set to smoulder in anaerobic or minimum air conditions. The greatly enhanced fertility of the TP soils compared with adjacent ferrisols has focused worldwide attention on soil amendments using charcoal materials, or biochars. There are significant amounts of char in many of the world's most fertile soils. These chars have arisen from savannah and forest fires, or from the deliberate burning of native vegetation, such as slash and burn practices. The dark colour of the highly fertile Mollisols in the USA Midwest, is attributable as much to chars formed through long-term burning as to humified soil organic matter.

The focus was on the similarities and differences between biochars formed from the pyrolysis of lignocellulosic feedstocks and of the residuals of these following acid hydrolysis simulating second generation biorefining (SGB), and from animal and poultry manures. Temperature, time, and pressures of pyrolysis were studied and characterisations of the biochars involved surface area measurements (BET), high heating values (HHV), and C, H, and N contents; morphologies were observed using Scanning Electron Microscopy (SEM), and compositional aspects were determined by solid state 13C NMR. Volatile material was determined from weight loss on heating for 7 min at 900oC. The Ames test checked the presence of mutagenic substances. Yields of plants grown in biochar-amended soils were determined from the weights of the plants harvested at soil level, and oven dried to constant weight at 60°C.

The 13C NMR patterns elucidated compositional changes in the biochars during pyrolysis. Pyrolysis at 400ºC and at 500ºC for the times used caused biochars to retain volatile materials, mostly aliphatic-C structures. Raising the pyrolysis temperature to greater than 500ºC, and lengthening the pyrolysis time gave rise to losses of aliphatic-C moieties and an accumulation of largely poly-condensed aromatic-C structures dominated by the 130 ppm resonance. Higher heating temperatures (e.g. 600 ºC) also resulted in a significant peak shift in the aryl region, from 131 to 127 ppm, indicative of the formation of fused aromatic structures characteristic of charcoal. That signified transformations of labile components into environmentally recalcitrant forms with greater resistance to microbial transformations. The temperatures used under ambient pressures allowed the porous architecture, based on plant cell wall structures, to be retained. Our data show how such pores provide refuge from predators for arbuscular mycorrhizal fungi (AMF), and for N-fixing Rhizoctinium bacterial species. We have evidence for entry of AMF to plant roots, thereby forming a symbiotic relationship with growing plants, obtaining their energy from plant photosynthesis, while their mycelia assist the plant with the

uptake of otherwise unavailable nutrients, such as P in immobilized phosphates. However, the porous structures are degraded progressively if pressures are raised during the formation of the biochars.

Biochar formed by heating for 10 min at 400°C suppressed plant growth. Best results were obtained for biochars formed, at 600°C for 60 min, from lignocellulosic precursors and from poultry litter. These biochars accelerated seed germination and greatly enhanced plant yields after 28 days of growth. Such biochars had high porosities and surface areas, and the NMR data showed that all lignin, carbohydrate, peptide, waxes and other plant components were transformed to fused aromatic structures.

The porosity characteristics of the biochars were lost and plant growth enhancement was decreased when the plant cell architecture of the substrates was destroyed by simulated SGB, and in bovine manures.

It is inevitable that there will be regulatory requirements should biochars become traded commodities and mutagenicity is likely to be an issues. The data show that biochars formed from lignocellulosic precursors, and from bovine manures of animals fed on grass are not mutagenic, based on evidence from the Ames test. However, biochar from pig manure was found to be highly mutagenic, and that of biochars from cows fed on grains and of calves fed on milk had intermediate levels of mutagenicity.

Keywords：*Biochar, preparation and properties, mutagenicity, plant growth*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Study of Dynamics of Changes in the Moisture Content of Chernozem Soil in Maize (zea Mays L.)

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The examinations were carried out in the polyfactorial long-term experiment set up in 1983 in Hungary. The experimental soil was calcareous chernozem soil. The available water is about 50% of the field capacity (FC), the minimum field capacity (WCmin) was 275 mm in the 0-100 cm layer and 265 mm in the 100-200 cm layer. The minimum water capacity was 33.65-46 %, the water content at wilting point (WP) was 8.5-15.7 % expressed as volume percentage in the 0-200 cm layer of the soil. The ground water level was 3-5 m below soil surface, not increasing above 2 m even in rainy years.

In the irrigated treatment, the irrigation water dosages applied were as follows:

2007: 50 mm irrigation water on 4 May

50 mm irrigation water on 23 May

50 mm irrigation water on 4 June

50 mm irrigation water on 30 June

2008: no irrigation was applied as the distribution of precipitation was favourable for maize.

2009: 50 mm irrigation water on 4 May

50 mm irrigation water on 23 May

We compared the changes in the water stock of the 0-200 cm layer in the non-irrigated and irrigated plots at the plant density (60000 plants ha-1) and fertilization level (N120+ PK) applied in field practice in the crop-years of 2007, 2008 and 2009. To study the water cycle, soil samples were collected three timesduring the vegetation (at the beginning of the season, at the flowering-fertilization phenophase when the water-uptake is the highest and at the post-harvest period) from each 20 cm layer until 200 cm depth from mono-, bi- and triculture maize.

Our results showed that the water stock of the soil significantly reduced by the end of the season in all three crop rotation systems and all years in the non-irrigated plots (10-14 V/V% in 2007, 11-17 V/V% in 2009).

In the non-irrigated plots, the reduction of the water stock almost reached the wilting point in the beginning of July in monoculture (13-15 V/V% in 2007). In irrigated plots, this effect did not occur or only in a smaller extent (14-18 V/V%).

Results of 2008 showed that the water stock of the soil (25-30 V/V%) was favourable for maize in all three crop rotation systems and the wilting point (13-19 V/V%) was approached only at the end of the season. As a result of the fallen precipitation at the proper time and in proper amount, the water stock of the non-irrigated and irrigated plots was similar from April to October (non-irrigated plots 13-30 V/V%, irrigated plots 17-32 V/V%) in all threee crop rotation systems, there was no significant difference (1-2 V/V%), the curves were almost parallel due to the favourable water supply of the season. In all the crop rotation systems, the upper 60 cm layer of the soil was almost saturated to FCmin in the spring in both the non-irrigated and irrigated plots, which greatly promoted the germination and early development of maize. However, by the end of the season, the water stock in the root

zone almost reached 13-14 V/V% in the non-irrigated treatment in triculture, while the soil moisture was 17-19 V/V% in both the non-irrigated and irrigated treatments in the other two crop rotations.

In 2009, the original soil water stock at pre-sowing was similar to that of 2007 and 2008 (24-29 V/V%) in all three crop rotation systems, in both irrigation treatments. In the top 0-60 cm layer, the water stock reduced with small fluctuations in the first half of the season. By August, a reduction of 8-9 V/V % occurred. The values did not decrease significantly around harvest, but they rather stagnated (16-19 V/V%), as a remoisturization of 2-3 v % resulted from the upward movement of moisture from lower layers.

In the trends of the three experimental years, the good water management, water-holding and permeating capacity of the chernozem soil can be observed. As a result of this, it can moderate the climate effects and compensate for the unfavourable water cycle conditions to a certain extent.

Keywords：*long-term experiment, soil moisture content, cropyear, irrigation, crop rotation, maize*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Effects on Crop Yields in a Calcareous Soil

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It remains unclear if biochar applications to calcareous soils improve crop yield. To resolve this question, a long-term field experiment to determine the effect of biochar on crop yields and soil properties was established in a calcareous soil in 2009, with five treatments: (1) Straw incorporation, (2) straw incorporation with inorganic fertilizer, (3) straw incorporation with inorganic fertilizer, and biochar at 30, 60, and 90t ha-1, respectively. The annual yields of winter wheat and summer maize were not increased significantly following biochar application, whereas the cumulative yields over the first 4 growing seasons were significantly increased. Soil pH, measured in situ, was increased by a maximum of 0.35 units after 2 years following biochar application. After 3 years, soil bulk density significantly decreased while soil water holding capacity increased with 90 t biochar ha-1, alkaline hydrolysable N decreased following biochar application while exchangeable K increased, and 0.5 M NaHCO3 extractable (Olsen) P did not change compared to the treatment without biochar. The results suggested that biochar could be used in calcareous soils without yield loss or significant impacts on N availability.

Keywords：*biochar, calcareous soil, crop yield, soil pH, long-term effect*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Stability of Pyrolysis And Htc Chars from Sewage Sludge: A Respiration Study on Effects of Pre-Washings on Microbial Char Decomposition and Quantity of Newly Synthesized Soc

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The use of biochars in agriculture and forestry is gaining increasing interest in terms of mitigating the emissions of greenhouse gases like CO2 and nitrogen oxides. Due to their molecular properties and expected high stability against abiotic and biotic transformation biochars could contribute to carbon sequestration in soils. Considering further positive effects on soil bio- and physicochemical properties, biochars potentially serve as soil conditioners, supporting sustainable land use under climate change conditions. Effects of biochars in soils depend among others upon the (i) feedstocks, (ii) type and conditions of the thermochemical carbonization processes, (iii) amount of labile components of the conversion products, (iv) physical and chemical soil properties, (v) soil microbial composition and activity, and (vi) soil meso-fauna. Beside direct plant derived biomass also carbon rich human waste and sewage sludge can be included into strategies that rely upon the biochar concept. The production of so called 'sewchars' by pyrolysis processes such as thermocatalytic low temperature conversion (LTC) at temperatures around 400 °C and hydrothermal carbonization (HTC) at 180-220 °C and increased autogeneous pressures can be included into new concepts for sustainable sanitation.

The main objective of the study was to examine the stability of LTC and HTC sewchars against microbial degradation. Repeated washings with cold water (single 15 and 30 min., and one to three times 60 min.) were performed to remove labile components from sewchars and their feedstocks (primary sludge, stabilized and unstabilized activated sludge). The test materials differed in TOC (21 to 40%) and C/N ratios (6.6 to 21.6). To investigate their catabolic stability, amounts of test materials corresponding to 50mg C were added to 50g of silica sand and adjusted to 60% of the maximum water holding capacity of the sand. The samples were incubated for 35 days at 22°C under aerobic conditions in an automatic respirometer (Respicond) and the respired CO2 was measured hourly. The obtained data were fitted to a double exponential model and mean residence times (MRT) were calculated on the basis of the turnover rates. Additionally, a synthesis coefficient (η) and a first-order rate constant (k0) of the test materials was calculated on the basis of their C/N ratio and the amount of C input using the Carbon and Nitrogen Dynamic model CANDY (Franko 1989, 1995). The η-coefficient describes the amount of carbon per unit of respired substrate C that is transformed into soil organic matter. It can be used as a measure for a carbon sequestration potential of different sewchar materials in soils. The k0 parameter specifies the turnover rate.

The DOC of the water from the different washings ranged between 77 and 1700 mg/l. The C/N ratio of the feedstocks and their sewchars as well as the labile, water soluble components of the test materials correlate with the amount of respired carbon from the substrates after 35 days of incubation. After pre-washings the attenuation of respired carbon from the feedstocks and the conversion products differed, depending on the conversion type by factors of 0.8 to 258 and on the intensity of washing by factors

of 0.5 to 3. At the end of the incubation experiment 0 to 33% of the carbon of the sewchars and the feedstock material were respired. The mean residence time (MRT) of the feedstock material varied from 4 to 7 months, of the different HTC materials from 4 to 14 months, and the MRT for the pyrolysis sewchar LTC was 19 years. Apparently, 67 to 100% of the added carbon was not transformed. From the high η-coefficients as a measure of a differential humification coefficient we presume that sewchar carbon was transferred during microbial degradation into more humified soil organic carbon. The η-coefficients range between 0.86 and 0.99 with a tendency of higher values for the most intensive pre-washing of the sewchars as compared to not pre-washed materials. The corresponding k0 values between 0.13 and 0.49 per year indicate the speed of this transformation process and tend to negatively correlate with pre-washings and η-coefficients.

Keywords：*sewchar, sewage sludge, hydrothermal carbonization (HTC), pre-washing effects, , microbial char decomposition, respiration study, newly synthesized SOC*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Forms of Nutrient Elements in Ash of Tropical Plant Wastes

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Ash derived from biomass burning is generally an alkaline material with pH ranging from 9.0 to 13.5 (Khanna et al., 1994) and may contain substantial amount of plant nutrients. The aim of this study was to evaluate the properties of ash from several tropical plant wastes and incubation effect on nutrient availability.

Ash was created by burning plant materials from several plant species. Ash properties were studied by several techniques. The pH and EC was determined in a 1:5 deionized water extract. The amounts of carbon and nitrogen were determined using the Kjedahl Method. Ash color was determined using a Munsell Color Chart (Munsell Color Co., 1998). The water-soluble elements in ash were determined using Association of Official Analytical Chemistry (AOAC) standard methods (AOAC 1975). The chemical composition of ash and biochar was determined with a model PE ELAN 600 inductively coupled plasma - atomic emission spectroscopy (ICP-OES) instrument (Perkin-Elmer, Norwalk, CT, USA) after perchloric acid digestion. Conventional XRD was conducted on a Philips PW3020 diffractometer with a diffracted beam monochromator (CuKα, 50kV, 20mA). Powder samples were scanned from 4 to 70o 2θ, using a step size of 0.02o 2θ and a scan speed of 0.04o 2θ sec-1. The composition and morphology of plant ash was examined by scanning electron microscopy (SEM) and energy dispersive X-ray spectrometry (EDS) using a JEOL 6400 instrument. Samples for SEM analysis were placed on metal stubs and carbon coated before analysis. Fourier transform infrared (FTIR) spectra were obtained with a Perkin Elmer Spectrum spectrometer with samples dried at 105oC for 24 h prior to analysis.

Seven plant wastes used for the study: peanut (Arachis hypogaea) stem and shell, soybean (Glycine max), coconut (Cocos nucifera) shell and sawdust, (Corymbia calophylla), tobacco (Nicotiana), rice (Oryza sativa) husk and stem, corn (Zea mays) stem and cob, and cassava (Manihot esculenta). These are major plant wastes in Lombok, Indonesia. The plant materials were burnt in a muffle furnace for 4 h at 700oC.

Ash percentage ranges from 1.5 to 71 % indicating the variation of combustion levels of the plant materials.. The ashes are alkaline, pH ranging from 9.6 to 11.82 and EC values were high for all the ashes, indicating that the ashes contain substantial amounts of soluble salts. Minerals present in the ashes include calcite, fairchildite, nesquehonite, sylvite, lime, scolecite, quartz (dust contamination), portlandite, periclase, hydroxyl-apatite and wilkeite.Carbon is mostly present as carbonates. Burning plants usually resulted in loss of most nitrogen .

Scanning electron microscopy and associated X-ray spectra of particles in plant ashes showed diverse particle sizes, shapes and compositions present in this material. Most micron-size particles seen in the micrographs are potassium and calcite rich aggregates often with chlorine and commonly also containing a little P, Fe and S. Addition of ash to an acid soil increased the pH and EC of the soil during the incubation experiment due to the liming effect of ash and the soluble salts present.

Keywords：*Ash, soil properties, tropical plant wastes, salts mineral, liming*

P2-131

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

The Effects of Biochars Made from Agricultural Organic Residues on Soil Ph And Ec

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This study aimed at evaluating the effects of biochar made from agricultural residues on soil pH and EC. Biochars were produced from coconut shell (Cocos nucifera L.), mangosteen shell (Garcinia mangostana L.), durian shell (Durio zibethinus L.), rice husk (Oryza sativa L.), corncob (Zea mays L.), palm kernel shell (Elaeis guineensis J.), pineapple skin (Ananas comosus M.), eucalyptus wood (Eucalyptus spp.) and bamboo (Bambusa arundinacea L.). Each biochar sample of 200 mg was incubated in 450 g of 9 acid soils (pH 4-7) for one month, then the biochars were recovered for analysis (pH, EC and XRD) and the soil pH and EC were measured. Biochar pH (H_2O, 1:200) values were initially 5.9 – 9.3 and after one month in the soil, the biochar pH values were 5.6 – 7.8. The EC (1:200) values were initially 27- 512 µS/cm and were 7 – 123 µS/cm after incubation indicating that substantial dissolution of soluble salts occurred during incubation. Soil pH (H_2O, 1:5) were initially 4.8 – 6.9 and were 5.1 – 7.4 after incubation. Soil EC (H_2O, 1:5) were 35 – 151 µS/cm before incubation and were 36 – 153 µS/cm after incubation. XRD analysis of the biochars showed that they commonly contained $CaCO_3$ and other alkali salts that provided a liming effect. The biochars also contained various crystalline soluble salts (KCl, NaCl, KH_2PO_4) which presumable rapidly dissolved in the soils but did not significantly affect the soil EC values.

Keywords：*Biochar,soil pH, EC*

P2-132

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Carbon Stability and Nutrient Efficiency of Biochar from Olive Mill By-Products

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Biochar is the carbonaceous product of the pyrolysis of biomasses and organic wastes. The increasing interest in biochar derives from its potential role in the mitigation of climate changes due to its property of storing carbon for long time and sequestering CO2 from the atmosphere, mainly because of its long term stability.

Many studies have investigated the effect of biochar on soil properties and the potential use as an amendment but have not yet provided sufficient data to allow robust prediction about the variability of its contribution to soil fertility as a function of the changing pyrolysis conditions (heating temperature and residence times among the main ones).

The aim of this study is to characterize biochar samples produced under differing process conditions and to evaluate their behavior in the soil and their effects on crop nutrient uptake.

In our study biochars were produced in a reactor associated to a nitrogen flow using olive oil mill wastes (husks) as feedstock. These by-products, representing in fact a prominent source of carbon in the Mediterranean basin, are very often discarded and misused with an enormous release of C into the atmosphere.

Different samples of biochar produced combining 3 temperature levels (350-450-550°C) with various residence times (1-2-3 h) were characterized for their elemental content and H:C and O:C ratios. Concurrently, for each sample of biochar, the germination index for the determination of the possible phyto-toxicity was also determined.

The stability of the biochars was analyzed by monitoring the potential release of CO2 from the amended soil during 90 days of laboratory incubation in order to evaluate the mobility of C.

Pot experiments on tomato plants were performed to study the effect of the different biochars in affecting nutrient availability and enhancing plant growth in soils. Biochars were applied at 10 and 20 t ha-1 ratios before transplanting the seedlings; at the end of the tomato crop cycle the yield and the elemental composition of the plant biomass were analyzed.

In spite of the lack of standardized methods for biochar production, data related to its beneficial effects are rather controversial, given that the major differences reported are possibly ascribed to the different pyrolysis conditions and to the unique character of each byproduct.

Further experiments are needed for understanding how to combine pyrolysis parameters in obtaining a biochar containing large amounts of stable C and otpimized fertilization efficiency.

Keywords：*Olive Mill Waste , Biochar, Carbon Stability, Nutrient Efficency*

P2-133

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Leaching of Nutrients and Trace Elements from Temperate Agricultural Soils Amended with Different Biochars in a Micro-Lysimeter Experiment

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Biochar (BC) application to agricultural soils has been increasingly promoted worldwide. However, wide-spread BC application requires knowledge about its interactions with plant nutrients and trace elements (TEs) and resulting effects on the leaching of these substances in the soil-groundwater system. For this purpose, we studied the effects of BC application on seepage water characteristics in a greenhouse pot experiment using columns (diameter: 23.5 cm, height: 40 cm) designed as micro-lysimeters with two crops cultivated in series, i.e. mustard (Sinapis alba L.) and barley (Hordeum vulgare L.). The experiment was set up with three agricultural soils (Planosol, Cambisol, Chernozem), four different BCs from three different feedstocks (wheat straw, woodchips mixture, and grapevine pruning; each slowly pyrolyzed at 525°C, the latter also at 400°C) added at two application rates of 1 and 3 % (w/w), respectively. Soil moisture was held constant (between 17 and 24 vol-%, equaling to approx. 50% of the soils' water holding capacity); at five occasions, leachate collection was initiated by excess watering. The leachates were analyzed for their electrical conductivity (EC) and pH values, their concentrations of dissolved organic carbon (DOC), nitrate, phosphorus and potassium as well as a suite of trace elements (Al, Cd, Cu, Pb, Mn, As, B, Mo, Se).

The application of BC caused significant pH increases in the leachates of all treatments. The studied BCs supplied high amounts of leachable K but strongly decreased the leaching of nitrate (by up to 80%). Generally, anionic TEs were increasingly mobilized whereas the leaching of most cationic TEs was hardly affected by BC application. Correlation and partial correlation analyses revealed that TE leaching was primarily related to soil pH, whereas the involvement of other factors such as EC and DOC was found to be more soil and TE-specific.

In our experiment, the most important factor influencing leachate characteristics was the BC feedstock, with wheat straw BC supplying the highest amounts of leachable nutrients (notably P and K) and woodchips BC causing the most distinct reductions in nitrate leaching. Also TE leaching strongly varied among the different BC types. Wheat straw BC caused increased leachate concentrations of As, Cd, Mo and Se, whereas the application of woodchips BC resulted in enhanced leaching of B. The different BC types showed diverging effects on Cu in the leachates with decreased concentrations for wheat straw and woodchips BC, but increased concentrations for both grapevine pruning BCs. The differences between the different BC types were mainly ascribed to their original TE contents, their alkalinity and their salt content affecting soil pH and EC.

Our results demonstrate that BC application can significantly reduce nitrate leaching and may therefore be a useful strategy for groundwater protection. However, we also saw that BC application may enhance the leaching of anionic TEs, including contaminants such as As.

Keywords: *nitrate, heavy metals, leaching, biochar types, feedstocks*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Biochars on Adsorption and Desorption of Diethyl Phthalate in Soils

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Diethyl phthalate (DEP) is one of the most commonly used plasticizers. It can become a soil contaminant and enter human food chain through plant uptake. Using biochar to adsorb DEP in contaminated soil can potentially reduce the bioavailability of DEP. Therefore a laboratory study was conducted to evaluate the effect of biochar on soil adsorption and desorption of DEP. Two soils and six biochars were used in the experiment. Biochars were derived from bamboo sawdust (BB) and rice straw (SB) that were pyrolyzed at 350oC, 500oC and 650oC. Biochars were added to the soils at rates of 0.1% and 0.5% (w/w). The biochar treatments significantly enhanced the soil adsorption of DEP. Compared to the untreated low organic matter soil, the soils treated with 0.5% 650BB increased the adsorption by 19313 times. For the straw biochar treated soils, the increase of DEP adsorption followed the order 350SB>500SB>650SB. However, for the bamboo biochars, the order was 650BB>350BB>500BB. Bamboo biochars were more effective than the straw biochars in improving soils' adsorption capacity and reducing the desorption of DEP. Therefore, adding biochar to soil can enhance soil sorption of DEP, and the sorption capacity was affected by many factors such as, the feedstock materials and pyrolysis temperature of biochars, the pH value of biochar and the soil organic carbon levels.

Keywords：*Adsorption; Biochar; Contaminated soil; Diethyl phthalate; Phthalate acid esters.*

P2-135

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Impacts on Denitrification under Different Soil Water Contents

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In the Midwestern USA, agricultural soil management practices contribute about 25 to 33% of total soil N2O emissions of the entire USA. Nitrogen (N) inputs to agricultural land in the form of fertilizers, manure, leguminous crops, and crop residues contribute about 90% of N2O emissions. There is a need to develop innovative soil management practices using soil amendments including biochars which can influence the nitrogen (N) transformations and minimize N2O emissions from agricultural ecosystems. Biochars produced from fast pyrolysis of corn stover (Zea mays L.), Ponderosa pine (Pinus ponderosa Lawson and C. Lawson) wood residue, and switchgrass (Panicum virgatum L.) were applied to a Maddock soil from an eroded upper landscape position (Sandy,Mixed, Frigid Entic Hapludolls) and a Brookings soil from a depositional landscape position (Fine-Silty, Mixed, Superactive, Frigid Pachic Hapludolls) under selected soil water contents (40%, 70%, and 90% WFPS) to investigate their effect on the denitrification process in a laboratory controlled soil incubation study for a period of 120 days. This study observed the significant effect of three different biochar types and their corresponding biomass materials on denitrification enzyme activites (DEA) over time. Rate of amendment, soil type, and water content had an effect on the dynamics of the denitrification process. The results suggest that biochars have potential to be developed as a soil amendment to mitigate nitrous oxide (N2O) emissions from agricultural soils while also enhancing soil C stocks.

Keywords：*Nitrous Oxide, Eroded Soil, Soil Amendment, Biochar, Denitrification*

P2-136

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Affect of the Nutrient Supply on the Yield and the Pathological Parameters of the Sunflower Hybrids

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Sunflower is one of the agricultural plant species that is produced on the largest production areas. Modern hybrids (HO, IMI etc.) and high environmental sensitivity of sunflower more and more require to create mid tech or intensive agrotechnical models, which can be defined only by modern agrotechnical and physiological analyses. Critical factors of production technology of sunflower are fertilization, sowing technology and plant protection.

Besides climatic factors, soil type and nutrient content (especially the nitrogen) of the crop land significantly influence yield and oil content as well as resistance to fungous pathogenes of sunflower hybrids.

The research was conducted In Hungary at Látókép research station and Regional Research Institute of the University of Debrecen, Centre of Agricultural Sciences in year 2012. The soil of the research site is calcareous chernozem developed on loess with deep mould layer. The soil is semi-hard ground (KA=43) loam and is in good condition.

The depth of the fertile layer is 80-90 cm, in which 40-50 cm evenly contains humus. The average humus content is 2.76 %. CaCO3 appears in the soil profile in the transition level at 75 cm. Lime is usually visible on the soil particles as calcareous coating, in this layer the lime content ranges from 10 to 13 %. The pH (KCl) in the cultivated layer ranges between 6.3 and 6.5.

Analysing the water management characteristics of the soil of the research area, we found that typically in chernozem soils, it has favourable water management characteristics. According to Várallyay's classification, it belongs to category IV., i.e. soil with good water management and water holding capacity.

The minimum field water capacity (VKmin) ranges between 33.65 and 46 %, the non-available water (HV) ranges between 8.5-15.7 % in the 0-200 cm soil layer.

Soil water table is in 8-10 m depth, the soil can store a substantial amount of water.

In the experiment, we studied how fertility and infection condition of the sunflower hybrids changed on the six different nutrient levels we applied. Besides the control plots, we analysed the reaction of the hybrids to nutrient levels with the following difference between the levels: with N, 30 kg ha-1; with P2O5, 22.5 kg ha-1, with K2O, 22.5 kg ha-1, and with 40000 plants ha-1, 50000 plants ha-1 and 60000 plants ha-1. We examined 3 hybrids.

Results have proven that increase of nutrient content and numbers of plants per hectare increased infection caused by fungous pathogenes. The strongest level of infection by Sclerotinia, Diaporthe and head disease was reached on N120+PK and N150+PK nutrient levels. On higher nutrient levels, stalk strength parameters have worsen. Level of lodging and breaking of the stem under the flower was the lowest with the control (10.3%; 7.1%) and the N30+PK nutrient level. On N150+PK nutrient levels, values of those indicators significantly increased (18.3%; 15.2%). Stalk strength parameters showed different results with the different hybrids we examined. As for yield, the different genotypes showed remarkable discrepancies. In the average of hybrids and numbers of plants, the highest yield was observed on N30+PK nutrient level (3660 kg ha-1). With N150+PK nutrient level decrease in yield proved to be quite strong. Among the hybrids, the NK Kondi hybrid reached the highest yield in the average of analysed numbers of plants.

Keywords：*sunflower hybrids, fertilization, plant density, yield, disease infection*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Biochar and Maize Stover Mulch on the Physical Properties of a Sandy Loam Soil and Maize Yield

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Most studies on biochar as a soil amendment have focused on the modifications to the soils' chemical and biological properties, but limited quantitative studies exist on modification to the soils' physical properties. Moreover, any benefit that could otherwise have been obtained from the un-charred feedstock when used as soil amendment is hardly compared in studies with the biochar to make any informed choice between the two. We had hypothesized that: a) biochar, including charcoal, would improve yields of maize by improving the soil physical conditions that affect crop performance, b) charred maize stover would give a better nutrient and environmental management option than the raw feedstock used as stubble mulch. Field application of charcoal, maize stover biochar and maize stover mulch were conducted on a sandy loam soil (Chromic Lixisol). From the soil's status report, fertilizers were applied at the rate of 60 kg ha-1 N, P, and K, to ensure none limiting of the major nutrients. The maize stover biochar was prepared at 420 oC using muffle furnace; and at a low heating rate of 0.1 oC/second from ambient temperature. The experiment followed a randomized complete block design (RCBD) with four treatments replicated three times. The treatments were: a) 5 t ha-1 maize stover biochar; b) 14.6 t ha-1 dried uncharred maize stover mulch (stubble); c) 5 t ha-1 charcoal and d) a control plot. Each of the 12-plot size measured 7.2 m2 (3 m x 2.4 m), and a distance of 2 m was left between plots of adjacent blocks. The maize was sown at a rate of 12 plants m-2, leaving 60 cm between rows and 40 cm between plants. Mounted on an automatic weather station (AWS), a DL2e data logger from Delta-T Devices Ltd. was used to automatically record and store soil moisture (Tp), temperature (Tm) and surface temperature (Tc) data (half-hourly averages of 30 seconds) from sensors. Three analogue cards were installed giving a total of 36 differential channels to which 12 ThetaProbes – type ML2x, 12 thermistors, and 12 thermocouples were connected for the Tp, Tm and Tc respectively. One of the 12 Tp, Tm and Tc sensors was allotted to each of four treatments in triplicates, for the 12-plot experimental layout. The Tc and Tm sensors were installed at 2 cm and 10 cm respectively, and the Tp sensor installed at 10 cm depth below the soil. The stored data were downloaded by serial interface (RS 232) via a laptop for analysis. The output of the Tp was in millivolts (V), but later converted to a volumetric soil moisture unit (θv %) using the formula: θ_v=((1.07 + 6.4V -6.4V^2+ 4.7V^3)-1.6)/8.4

Data sets obtained were tested for normality, before using ANOVA from GenStatTM statistical software (13th edition) for analysis. The datasets were normally distributed. The following results were observed:

Higher moisture content ($p < 0.001$) in the maize stover mulch amended plot (UNMS) was observed. This was followed by charcoal (CH) plots ($p = 0.009$) as compared to the charred maize stover (CHMS); and CHMS plots more than ($p = 0.028$) control (CTR) plots;

UNMS amended plots were warmer at nights, but cooler during the day. On the contrary, CTR plots were cooler at nights but warmer during the day, but biochar (CH and CHMS) plots were warmer at night and cooler in the day compared to CTR;

Maize yield parameters (fresh stover, cob, de-husked cop and grain yields) were numerically higher in UNMS amended plots compared to others. This was followed by CH, then CHMS and CTR in that order.

From the observations, UNMS presents a better option in terms of the soil's environmental and nutrient management resulting in increased maize yield. However, because the feedstock readily decomposes and releases CO2 into the atmosphere, the CHMS would be a better option in terms of carbon capture and storage in the soil, on the assumption that the charred material stays longer in the soil than the feedstock.

Keywords：*Biochar; Maize stover mulch; Charred maize stover; Charcoal; Soil Physical Properties.*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

In Situ Fate, Stability and Downward Migration of Biochar and its Impact on Native Carbon Emissions or Stabilisation in Australian Pasture Systems

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Carbon (C) sequestration potential of biochar depends on its stability and stabilisation of native or added organic C in biochar-amended soil. However, the processes of biochar degradation, fate in soil organic matter pools, and downward migration in the soil profile, as well as the influence of biochar on emissions or stabilisation of native organic C sources are poorly understood under field conditions. An Eucalyptus saligna green-waste biochar (δ^{13}C -36.6‰; total C 66.8%) produced by slow pyrolysis at 450 °C was applied at 29.2 t ha^{-1} to 10-cm depth in circular (0.66-m diameter) micro-plots, encompassing three soils [Tenosol, Dermosol and Ferrosol (Australian Soil Classification); Arenosol, Planosol, Ferralsol (approximate WRB Classification] under contrasting pasture systems across New South Wales and Tasmania (Australia). The aims of this study were to (i) monitor the fate of biochar C in respired CO_2 and quantify biochar stability and stabilisation under field conditions, (ii) determine the influence of biochar on native soil C emissions, and (iii) track downward migration of the surface (0-10 cm) applied biochar to 30-cm depth over a 1-year period. The CO_2 released from micro-plots was trapped over a 24-h period in a NaOH solution placed inside static chambers. The 24-h CO_2 trapping process was repeated periodically at <1 to ~3 week intervals over the duration of the experiment, and the traps were analysed for total C and δ^{13}C. We also periodically monitored the impact of biochar on soil microbial biomass carbon (MBC) and aboveground biomass production. The biochar-amended and control soils were separated into physically-separated light and heavy C fractions and the C recovery of applied biochar C was calculated at 0−8, 8−12, 12−20 and 20−30 cm depths using the total C and δ^{13}C data, and bulk density of soils in the field.

Biochar C mineralisation rates were generally higher, albeit fluctuated widely, in the first 3 to 4 months (from December or January to April 2013) than during the later period (from May to July or August 2013) across the Tenosol, Dermosol and Ferrosol micro-plots. Over the first 7 months, the proportion of added biochar C mineralised in soils ranged between 1.4 and 5.5% and followed the sequence: Tenosol < Dermosol < Ferrosol. The mean residence time (MRT) of biochar ranged from 29 and 70 years (estimated using a two-pool exponential model). These values of MRT should be treated as highly conservative values, as they mainly reflect the MRT of relatively labile C components in biochar. The cumulative CO_2-C emission over the 7-month period from native soil and plant sources was larger in the biochar-amended Tenosol, whereas lower in the biochar-amended Dermosol and Ferrosol, relative to the corresponding controls. As the aboveground biomass production was similar between the biochar-amended and control micro-plots on most occasions during the first 7 months, the higher cumulative CO_2-C emission in the biochar versus control Tenosol may be related to positive priming of native SOC mineralisation by biochar, and/or greater belowground

allocation of plant-assimilated C, or possibly alternative effects (i.e. negative priming or lower belowground plant C allocation) in the Dermosol and Ferrosol. At 4 months, most of the applied biochar was recovered in the top 12 cm depth, with the total recovery of 72.1% in the Tenosol, 103.7% in the Dermosol and 79.2% in the Ferrosol. Biochar C was clearly migrated downward from the application depth (0−10 cm) within 4 months, particularly in Tenosol and Ferrosol, with the recovery of 4.8%, 2.7% and 12.7% in the 12−20 cm profile, and 6.0%, 1.1% and 9.1% at the 20−30 cm profile, across the Tenosol, Dermosol and Ferrosol, respectively. At 4 months, MBC was higher in the biochar-amended Tenosol and Dermosol than the corresponding controls, whereas, biochar had no effect on MBC in the Ferrosol, possibly due to its higher native organic C content cf. the other soil types. We will present the updated results, including from the 8 and 12 month gas and soil sampling at the conference.

Keywords：*biochar carbon stability, native carbon stabilisation, light fraction, heavy fraction, microbial biomass carbon, soil organic matter pools*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

The Impact of Different Extraction Methods on Black Carbon in Soil

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Currently, the research methods about Black carbon （BC) are not uniform, and the analysis results of BC contents vary greatly from different methods , even can differ by several orders of magnitude, Therefore, the current analysis on BC, especially for soil samples, is still need to carry out in-depth research, and develops a practical quantitative and qualitative criteria.

The soil collected from Tuqiang Forestry Bureau(Figure in Mohe County Tuqiang town), the Greater Khingan Mountains area in Heilongjiang province in the November 8, 2009, and the specific point is 15 km from struggle forest 3-0-2 branch a fork lane 50 meters .We studied the extraction method of black carbon, including its structure and nature. In this study, some Chemicals are used in the test for pre-treatment of the soil, in which different concentrations of HCL and HF are used to treat soil samples again and again in order to remove metal oxides and soil minerals. When removed the organic carbon in soil, the chemical oxidation method is adopted, and the oxidizing agent is a mixture of sulfuric acid and potassium dichromate. There are three methods in this study (M1,M2,M3),the specific experimental process in three stages: First, removed carbonates and silicates in soil by chemical method; Next, removed soil humus and other organic carbonaceous material by heat treatment and chemical oxidation; Finally, the carbon black is weighed and characterization analysis. The difference between the three methods is that: the difference between M1and M2 is that there is a pre- treatment with distilled water in M1; the difference between M3 and M2 is that M3 used HF (10mol / L) instead of HF (10mol / L) / HCL (1mol / L) used in M2.

Results show that: (1) The average extraction yield of black carbon with the three methods has the following relationship: M2 (0.39%) > M1 (0.36%) > M3 (0.32%). From the error lines can be seen that the M2 has the smallest error range, whose extraction yield of BC is stable, basicly in the fluctuant level of 0.4%.(2) the BC extracted from the M2,whose peak temperature is the highest whatever the mid-temperature or the high temperature exotherm, which means that its material structure is relatively complex, stability; (3) From the infrared spectrum can be seen that: the BC contains aliphatic hydrocarbons, aromatic compounds, carboxyl, carbohydrates, etc, and the ratio of 2920cm-1/1620 cm-1 reflects the proportion of aliphatic and aromatic carbon which contained in BC. They has the following size order:M3(4.32) > M2 (2.54) > M1 (2.30), indicating that a higher percentage of aromatic compounds in BC with the M1.（4）The element analysis shows that: Carbon is the main component in BC, and the elements such as H, N, O, S are also the components of BC; according to the condensation degree (H/C) and the degree of oxidation [(O+S)/C] can judge that BC contains double bond, aromatic compounds, etc, to keep the structure stable.

In conclusion, the BC extracted with M2 method has the highest extraction yield, complicated structure and strong thermal stability.

Acknowledgements：This research was performed based on the China 973 Program (2011CB100503), National Natural Science Foundation of China (41171188）

Keywords：*black carbon; chemical oxidation method; thermal analysis; IR spectroscopy;element analysis*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar, Fertiliser & Pasture: A Field Trial

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Climate change, food security and waste disposal are some of the major current global challenges. Biochar may play a role in alleviating these and hence the high interest in this field in recent years. However, few definitive conclusions have been established due the highly variable nature of biochar, soil and environmental conditions. Most studies have focused on isolated systems using soil and biochar mixtures under laboratory conditions. Therefore, we conducted a field trial using an intensive pasture system on two soil types to evaluate the effects of biochar amendment on greenhouse gas emissions, pasture biomass production and nutrient leaching.

A blue mallee biochar was incorporated into the top 10 cm of both soil types (Tenosol and Dermosol) at a rate of 0, 10 or 20 t ha-1. Fertiliser was added at 0, 50 or 100 % of the recommended rate and a mixed pasture was sown. The 12 treatments and control plots were replicated four times. Static gas chambers were placed in all biochar amended plots combined with the 100% fertiliser rate and the CO2 emission was continuously measured for the first two weeks. Subsequently, CO2, CH4 and N2O flux was measured on a monthly basis. Soil leachate was collected from the control, and plots with 0 or 20 t ha-1 biochar combined with 100% fertiliser. Pasture biomass yield data was recorded for all plots.

During the first two weeks only the biochar treatments had a significant effect on total CO2 emissions ($P=0.002$). Both biochar treatments (10 and 20 t ha-1) produced significantly higher emissions than the control in the two soils; however, the differences were non-significant between the two biochar levels. The daily CO2 flux was quite variable during the first two weeks and it ranged from 565 – 4895 mg CO2 m-2 day-1. Monthly measurements revealed that CO2 emissions from the Dermosol were significantly higher than those from the Tenosol ($P<0.001$); the interaction between soil and biochar was also significant ($P<0.001$). Interestingly, the 10 t ha-1 biochar treatment had the lowest flux on the Tenosol but the highest on the Dermosol. Across the soils flux ranged from 93-193 mg CO2-C m-2 hr-1. Methane flux was extremely variable on a sampling basis and was closely related with soil moisture. Flux in the Tenosol was significantly lower (i.e. more negative) than in the Dermosol in which there was a positive peak coinciding with a high rainfall event. There was no influence from either biochar or fertiliser rates. The average N2O flux across all treatments was 8.7 μg N2O-N m-2 hr-1. Neither soil, biochar nor fertiliser had an effect on emissions. Flux was highest during the first three months before stabilising.

Pasture biomass on the Dermosol was almost double that of the Tenosol, regardless of treatment. In both soils there was a significant interaction between biochar and fertiliser. On the Tenosol, both the 0 and 20 t ha-1 biochar treatments in combination with the 100% fertiliser significantly increased pasture biomass. Conversely, in the Dermosol, biochar with the 50% fertiliser produced the greater biomass. Within the 100% fertiliser treatment on the Tenosol biomass in the 20 t ha-1 was significantly higher than in the 10 t ha-1 treatment but neither were different to the control.

Except for P, the concentrations of all other elements in the soil solution were significantly greater in the Dermosol than the Tenosol. This is likely a reflection of the greater nutrient storage and buffering capacity of the Dermosol as compared to the Tenosol. In the Dermosol more of the P was likely to be strongly adsorbed to Fe oxides, biochar may have also increased the P sorption in this soil. All the other element concentrations were fairly similar across treatments (within in soil types) with the exception of Na in the Tenosol which was much higher in the 20 t ha-1 a biochar treatment.

The preliminary data indicate that soil type is more important in determining greenhouse gas fluxes than the addition of biochar. Biochar treatments did not produce any significant and consistent effect on pasture biomass in the two soil types. It appears that high levels of biochar do increase the concentration of some elements in soil leachate, particularly Na.

Keywords：*Biochar, field trial*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Application Effects on Humus Carbon Composition

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Biochar(Bc) plays an important role in soil carbon sequestration, whereas, nowadays, there are rarely studies on the relationship between Bc and humus carbon. This paper has studied the effect of humus quantity and composition that applied the Bc to field through field trials, embedded trials and culture experiment. Field trials used Nanjing paddy soil. Embedded trials and culture trials used dark brown soil of Heihe. They all applied with 48t•ha-1Bc, and set the control check. Soil organic carbon was measured by potassium dichromate heating method. Humus quantity and composition was measured by humus composition modification method. The research showed that after Bc was applied into the field trials, the organic carbon content increased from19.46 g•kg-1 to 38.50 g•kg-1, FA content decreased from 2.73 g•kg-1 to 2.49 g•kg-1, HA content decreased from 2.74 g•kg-1 to 2.51 g•kg-1,Hu increased from 13.92 g•kg-1to 33.48 g•kg-1.The embedded trials which has been progressed for 6 months, after Bc was applied, the organic carbon content increased from24.80 g•kg-1 to 41.28 g•kg-1,FA content decreased from 3.55 g•kg-1 to 3.29 g•kg-1,HA content decreased from 5.66 g•kg-1 to 5.62 g•kg-1,Hu increased from 8.55 g•kg-1to 23.05 g•kg-1.The embedded trials which has been progressed for 12 months, after Bc was applied, organic carbon content increased from23.99 g•kg-1 to 40.78 g•kg-1,FA content decreased from 3.74 g•kg-1 to 2.80 g•kg-1,HA content decreased from 5.63 g•kg-1 to 4.44 g•kg-1,Hu increased from 7.53 g•kg-1to 22.40 g•kg-1.After Bc was applied into the culture trials(6 months),organic carbon content increased from21.57 g•kg-1 to 32.21 g•kg-1,FA content decreased from 3.45 g•kg-1 to 3.35 g•kg-1,HA content decreased from 5.15 g•kg-1 to 4.99 g•kg-1,Hu increased from 7.96 g•kg-1to 17.24 g•kg-1.After Bc applied into the culture trials(12 months),organic carbon content increased from21.25 g•kg-1 to 32.19 g•kg-1,FA content decreased from 3.25 g•kg-1 to 2.87 g•kg-1,HA content decreased from 5.24 g•kg-1 to 4.26 g•kg-1, Hu increased from 9.97 g•kg-1to 19.76 g•kg-1.Soil organic carbon content increased, humin content increased, the soil humic acid and fulvic acid content decreased. PQ little change in field trials. PQ increases slightly in embedded trials. PQ increased with time in culture trials. This is due to Bc adsorbing the HA and FA which are contained in soil, or it promoting HA and FA decomposition, and Bc's effect on soil HA and FA are in different level. After Bc was applied into the soil, humin content increased, and adsorption of HA and FA can increase soil carbon storage. This has important implications for long-term preservation of soil organic carbon.

Acknowledgements：This research was performed based on the China 973 Program (2011CB100503), National Natural Science Foundation of China (41171188)

Keywords：*biochar;humin; humic acid; soil organic carbon*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Study on the Effects of Temperature and Residence Time in Slow Pyrolysis on Physico-Chemical Properties of Biochar Derived from Dairy Farming Waste

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Introduction

Biochar is a rich-carbon product of biomass pyrolysis in limited supply of oxygen. Derived from various feedstocks, biochar has great potential in soil amendment, carbon sequestration and climate change mitigation and adaptation. Conversion of livestock waste by pyrolysis into biochar has benefits of extremely lessening waste stream volume, high temperature elimination of pathogens and improving soil fertility, as well as enhancing crop productivity.

This study aims to generate biochar from dairy farming waste and examine the effects of temperature and residence time in slow pyrolysis on physico-chemical properties of biochar in lab-scale.

Materials and methods

Dairy farming waste sample were obtained from dairy farming in Phu Dong village, Hanoi. After being dried naturally, sample were grinding with 1 cm size.

Our lab-scale pyrolysis facilities were utilized to produce biochar at 450oC and 550oC, heating rate 15oC/ min, and various residence times 0, 1, 2, 4 and 6 hours.

The resulting biochar were characterized by elemental analysis, Brunauer-Emmett-Teller (BET) surface area, scanning electron microscopy (SEM).

Results and discussion

The yield of biochar decreased with the increase in pyrolysis temperature and residence time. The yield were highest in 450oC with residence time 0h (47.10%), and lowest in 550oC with 6h (37.50%). The total carbon content had the same trend with the yield. The maximum and minimum carbon contents were 61.82% and 54.08%, respectively.

Conversely, the pH went up with the increase in pyrolysis temperature and residence time, and fluctuated from 8.45 to 8.82. Alkalinity of biochar come from the appearance of high concentrations of several elements (K, Na, Ca, Mg) in ash. With this alkalinity, biochar will be a great material to improve degraded soil (acidic).

Similarly, the concentrations of nutrient elements rose with the increase in temperature, and slightly fluctuated with various residence times (P, K, Ca, Mg).

Although CEC values in almost samples had the same trend with carbon content, fluctuated between 46.4 and 68.0 meq/100g biochar, an abnormal increase in CEC (89.60 meq/100g biochar) were seen in 450oC with residence time 4h. Because, oxygen containing functional groups in surface of biochar are formed in this condition (450oC and 4h residence time), which leads to extraordinary high CEC. However, after rising temperature to 550oC, these functional group are ruined, which is conducive to the decreasing in CEC and CEC came back with the trend.

BET and SEM results showed that total surface area was approximately 40m2g 1 and biochar structure was porous, amorphous and honeycomb. By dint of these benifical characteristics, biochar represents a potential amendment in boosting soil fertility, immobilizing toxic organic and heavy metal, and strengthening crop productivity.

Keywords：*biochar, temperature, residence time, slow pyrolysis, dairy farming waste*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Can Mitigate Farmland Global Warming Potential and Remediate Pops Polluted Soil

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Field microcosm experiments, lab incubation, ^{15}N labeling techniques, PCR-DGGE (denaturing gradient gel electrophoresis), and quantitative polymerase chain reaction (QPCR) were used to investigate the effects of biochar addition on rice N nutrition and GHG emissions in an Inceptisol and an Ultisol, and on bioavailability of persistent organic pollutant (POP).

Biochar N bioavailability and effect of biochar on fertilizer nitrogen-use efficiency (NUE) were studied by ^{15}N-enriched wheat biochar (7.8803 atom% ^{15}N) and fertilizer urea (5.0026 atom% ^{15}N). Corn biochar and corn stalks were applied at 12 Mg ha^{-1} to study their effects on GHG emissions.

Biochar had no significant impact on rice and wheat production for 4 continuous seasons under normal fertilizer application, but significantly increased wheat production under no potassium and no phosphorus applications, and less than 2% of the biochar N was available to plants in the first season. Biochar addition increased soil C and N contents and decreased urea nitrogen use efficiency (NUE). Seasonal cumulative CH_4 emissions with biochar were similar to the controls, but significantly lower than the local practice of straw amendment. N_2O emissions with biochar were similar to the control in the acidic Ultisol, but significantly higher in the slightly alkaline Inceptisol. Carbon-balance calculations found no major losses of biochar-C. The decreased CH_4 under biochar amendments did not result from the inhibition of methanogenic archaeal growth, but from the increased methanotrophic abundances.

Hexachlorobenzene (HCB) sorption by biochar was 42 times higher than that by soil and the sorption isotherm was linear for the concentration range studied. Biochar amendments reduced HCB dissipation, volatilization and earthworm (Eisenia foetida) uptake of HCB from soil.

Low bio-availability of biochar N did not make a significantly impact on rice production or N nutrition during the first year, replacement of straw amendments with biochar could decrease CH_4 emissions and increase SOC stocks, and biochar could potentially be used in immobilizing POPs in contaminated soils

Keywords：*Biochar,GHGs, C sequestration, N nutrition, N use efficiency, rice, POPs*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Potential for Interactions Between Biochar and Mycorrhizal Fungi in Water-Deficient Soil

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Arbuscular mycorrhiza (AM) fungi are widely considered to form beneficial mutualistic symbiotic relationships with plants, and are also widely claimed to alleviate water-stress to the host plant under soil water-deficit. This is likely to occur through a variety of mechanisms including direct access of AM fungal hyphae to microsites of water/nutrients and indirectly through the enhancement of soil aggregation. Additionally, biochar in soil has been claimed to alleviate plant water stress under soil water deficit conditions. This research aimed to elucidate these claimed roles using an agricultural soil amended with biochar under soil water-deficit. A split chamber microcosm was used to investigate the effect of biochar on plant growth and AM fungal root colonisation. Each microcosm was subject to either water-stressed or well-watered conditions. One chamber held agricultural field soil with or without biochar and the adjacent chamber held the same soil after it had been irradiated in the absence of biochar. The chambers were separated by a 38μm nylon mesh to allow hyphae to penetrate, whilst blocking plant roots. Irradiation eliminated infectivity of AM fungi within the adjacent chamber and enabled observation of the spread of hyphae and subsequent AM fungi root colonisation in the response to biochar and water treatments. Jarrah (Eucalyptus marginata Sm.) derived biochar at 2% w/w was applied to the agricultural field soil to test the response of subterranean clover (Trifolium subterraneum L. 'Seaton Park'), AM fungi colonisation, and hyphal length under the water-stressed (30% field capacity) and well-watered (60% field capacity) conditions in a glasshouse environment. In the water-stressed treatment, biochar increased shoot growth (25% by day 63), hyphal spread (30% by day 49) and AM fungal colonisation (by 47% DAE 45, 26% DAE 63). However, within the well-watered conditions, there was no response to biochar application. Additionally, biochar application to the agricultural field soil compartment increased shoot growth in the adjacent irradiated field soil compartment under water-stressed conditions by 33% (at DAE 35) and 21% (at DAE 49). This was associated with a proposed development of the mycorrhizal network. This experiment is the first to demonstrate that a biochar-induced increase in AM fungi colonisation was associated with hyphal development to the benefit of the host plant under water-limited agricultural conditions.

Keywords：*Biochar, arbuscular mycorrhizal fungi, hyphal spread, drought tolerance*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effects of Long-Term Fertilization on the Acidify in Brown Soil

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Aiming at the decline of pH in Liaoning brown soil, a combination method of field testing and laboratory analysis is used to test soil acidity changes of 34 years long-term fertilization in brown soil of Shenyang Agricultural University. It has indicated that the soil pH of long–term nitrogen treatments is decreased and its exchangeable acid (exchangeable H+ and exchangeable Al3+) is significantly increased; but its base exchangeable ion and base saturation percentage is increased significantly. Long-term application of pig manure can maintain and improve the soil pH, its exchangeable acid and exchangeable aluminum are decreased to a extent of zero gradually; but its base exchangeable ion and base saturation percentage are increased. The soil pH of CK treatment is also declined, but its descends level is remarkably lower than nitrogen treatments area, and its soil exchangeable base ions and base saturation percentage are declined not significantly. So we can conclude that long-term organic fertilization can improve brown soil acidity; however, long-term application of nitrogen fertilizers is the main cause of brown soil acidification.

Keywords：*brown soil; long-term fertilization; soil acidification; pH value*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochars Influence Nitrogen Leaching and Availability to Wheat Plants

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There is currently great interest and debate over the potential agronomic benefit of biochar application to soil. However, the effects of biochar on nitrogen dynamics during crop production are limited and require further investigation. Nitrogen fertilizer can be an environmental pollutant if not managed effectively. A lysimeter study was conducted to assess the effect of biochar on leaching of nitrogen in soil amended with two types of biochar. Nitrogen was applied as 15N labelled diammonium phosphate (DAP) at 0 and 50 kg/ha with either chicken manure biochar or wheat chaff biochar which were both made at 450 oC. The biochars were applied at 0, 2.5 and 7.5 t/ha. The lysimeters were 90 cm long cylinders with a diameter of 31 cm. DAP was applied at 50 kg/ha, in 2 equal applications of 25 kg/ha. Nitrogen leaching through the soil column, grain yield and N uptake by wheat (Triticum aestivum L.) were measured. Lysimeters contained white subsoil sand (15-90 cm depth) and surface soil (0-15 cm) collected from a field site at Mingenew, Western Australia. Lysimeters were inserted into the ground at another field site at Geraldton, Western Australia where wheat was grown from June to November. Irrigation water could pass through the soil column, therefore leachate was collected after each irrigation event imposed by adding equal amounts of water to the lysimeters. Soil samples were collected at harvest from depths of 0-5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-60, 60-90 cm for monitoring movement of NO3 and NH4 in the soil profile. All plant and soil samples were analysed for 15N enrichment. Wheat grain yield and 15N uptake by grains were not significantly affected by either biochar type or by the level of biochar applied to the soil. However, 15N retention in soil was significantly increased by biochar application. It was concluded that biochar addition to this soil did not have a significant effect on plant growth even though N availability to plants was increased by a reduction in the amount of N that was leached through the soil profile.

Keywords：*Biochar, Nitrogen, leaching, wheat, lysimeter, diammonium phosphate*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Biochar on Soil Temperature in Different Layers and Rice Yield from Cold Waterlogged Paddy

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Cold waterlogged paddies usually have properties of low soil temperature, terrible soil structure, insufficient available nutrients and redundant reducing toxic substances, which resulted mainly from the long-term waterlogging condition. Low temperatures of the water and soil substantially inhibited rice growth and reduced rice yields in the cold waterlogged paddy. A field experiment was conducted to investigate the effects of exogenous organic matters - bamboo biochar (BB), rice straw biochar (RB) and rice straw (RS) on soil temperature in different layers, soil properties and rice yield from a cold waterlogged paddy in Zhejiang province, China. BB and RB tested were received from the pyrolysis of bamboo chips and rice straw at 600 ℃, respectively. RS was applied to paddy soil at 3.75 t ha^{-1}. The amounts of BB and RB applied were both based on the C contents of the biochars as the same with that of RS. Nitrogen fertilizer was applied at 150 kg N ha^{-1} for all these three treatments. A probe-type data collector was used for recording the soil temperature in the depth of 5, 10 and 20 cm every one hour from 01 Jan to 31 Oct, 2012. Results showed that all these three treatments kept soil average temperatures from too high or too low in the cold waterlogged paddy, that is reduced the differences of soil average temperature between day and night. They increased soil temperature in the depth of 5 and 10 cm at 8:00, especially during July to October, but decreased soil temperature at 14:00. RS had the most substantial effect on regulating the soil temperature in depth of 5 cm, whereas that was BB in the depth of 10 cm. The soil temperature in depth of 5 cm at 14:00 was reduced by 9.6 ℃ with RS amendment on 20 July. There were little influences on soil temperature in the depth of 20 cm on the whole among these three treatments. The bulk density of the cold waterlogged paddy soil was significantly reduced by all three treatments. RB application significantly increased soil available phosphorus and available potassium by 16.5% and 22.3%, respectively, and promoted the assimilation of potassium by 12.0% in rice straw at the harvest period. RB had the most remarkable effect on rice yield improvement among these three kinds of organic matters. This research can provide basis for agricultural management measures of promoting soil quality and crop yield in cold waterlogged paddies.

Keywords：*cold waterlogged paddy, rice straw biochar, bamboo biochar, rice straw, temperature, yield, soil property*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

The Effect of Urban Biochar on the Chemical and Physical Properties of Potting Media

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Municipal waste management is an ever-increasing problem for many cities. Biochar produced from urban biosolid and green-waste and used as a soil conditioner (urban biochar) can be a sustainable way of managing these waste streams although production and transport costs are currently prohibitive for broadscale agriculture. A more likely market for urban biochar is the horticultural industry where biochar may also have the potential to replace environmentally unfriendly substrates such as peat in growing media while simultaneously sequestering carbon. This study assessed the affect of periodic wetting and drying (over 110 days) on the chemical and physical properties of growing media amended with varying levels of urban biochar under laboratory conditions. Urban biochar was produced through slow pyrolysis (650°C) of a mixture of green waste (%) and biosolid (%). The treatments were: a mixture of coir peat (20%) and composted pine bark (control); 20, 40, 60% biochar and composted pine bark and; 100% biochar. Water retention curves were established over four sampling times using pressure plates. In a parallel experiment with the same treatments, nutrient mobility was assessed through pore water sampling and leaching loss. Chemical and physical stability of biochar in media was measured using Mid-Infrared Spectroscopy and particle size distribution. This experiment determined the optimum rate of biochar addition to potting media for best medium term stability and soil moisture supply. Biochar significantly increased water holding capacity of media at higher matric potential as compared to the control due to high surface area, high cation exchange capacity, and porous structure of biochar. Furthermore, repeated wetting and drying cycles changed the pore size distribution of media through changes in arrangement of media components and particle size of biochar, increasing microporosity due to movement of fine biochar particles into the pores of media. Nutrients present in pore water of biochar treatments were found to be higher than control, mainly through release of the inherent nutrient content of biochar and increased sorption of nutrient into biochar surface.

Keywords：*Urban Biochar, pore size distribution, watering drying cycles, water retention curves*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Improving Productivity and Sequestering Carbon Using Organic Amendments in Contrasting Soils

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There is growing interest in sequestering carbon in agricultural soils using organic amendments. Plant residues are the primary source of organic matter in agricultural soils but their transient effects on soil carbon content has prompted interest in the use of biologically and thermally stabilized materials as alternatives. A series of incubation studies were performed to examine the effects of management practices on the decomposition rate of biochar, spent mushroom substrate (SMS) compost and corn stalks in differing soils and to assess the effect of these amendments on soil fertility indicators. A soil based bioassay was also conducted to assess the impact of the aforementioned amendments on germination and early growth of lettuce (Lactuca sativa) and cucumber (Cucumis sativus). The decomposition rate of SMS compost was marginally higher than that of biochar and both were not appreciably influenced by management or edaphic factors whereas the decomposition rate of corn stalks was much higher than the aforementioned amendments and differed with application rate and soil type in the short term. SMS compost improved the broadest range of soil fertility indicators and improved the growth rate of cucumber but its high salt content negatively affected the growth of lettuce. Corn stalks had phytotoxic effects on both test species due to the production of allelopathic substances during decomposition but improved soil microbial biomass. Biochar had no impact on soil fertility apart from improving the pH of acidic soils but had the lowest phytotoxic potential among amendments. The results of this study suggests that selection of organic amendments must be tailored to soil properties and highlights the importance of considering the impact of soil amendments in a holistic manner when making management decisions

Keywords：*Soil quality, Organic amendments, Tropical agriculture, Carbon sequestration, Phytotoxicity*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Fortification of Biochar with Iron to Enhance Phosphate Adsorption

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Excessive utilization of phosphate fertilizers has increased the loss of phosphorus (P) from soils through runoffs, thereby impacting surface water quality as a result of excessive algal growth and toxin producing microorganisms. Hence, there is a need to remove excessive level of P in water bodies so as to evade eutrophication and environmental degradation. Biochar that produced through pyrolysis of biomass has been proved as a potential adsorbent for inorganic and organic contaminants and P. Our study investigated the potential of modified biochar with iron(III) oxide to increase the sorption of P from wastewaters. Chicken manure biochar (CMB) was treated with iron(III) oxide (1, 3 and 5%) and pyrolysed at 300OC for three hours under continuous nitrogen flow. The modified biochar was characterised using FTIR and SEM-EDX to investigate the surface and structural modifications. Batch adsorption experiments demonstrated that sorption of P by modified biochar was much higher than the non-modified biochar. Moreover modified biochar that was treated with 5% iron(III) oxide has shown higher sorption of P than biochars modified with 1 and 3% iron(III) oxide. The FTIR spectra showed the changes in the functional group bands and SEM-EDX analysis confirmed that iron oxide on the biochar surface play an important role in the sorption of P. The beneficial effect of modified biochar is that after sorption of P from water bodies, it can be used in agriculture as fertilizer to improve soil fertility and soil carbon.

Keywords：*sorption, phosphate, functional groups, fortification, pyrolysis*

P2-151

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Overland Flow Filtration Systems: A Carbon Filter Between Agricultural and Aquatic Systems

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Nitrogen, phosphorus, and soil losses from agricultural systems are sources of eutrophication of surface waters and continued degradation of agricultural land. This study investigates the design, installation, and efficacy of biochar overland flow filter (BOFF) systems to retain soil nutrients from runoff water, as well as their ability to adhere eroded soil particles to biochar surfaces, in preparation for nutrient- and sediment-saturated biochar application to agricultural soil. Biochar is a biomass-derived persistent form of soil carbon produced from the pyrolysis process. A number of studies have evaluated the efficacy of biochar to sequester carbon in soil and retain soil nutrients following application to soil. However, the use of biochar as an overland flow filter media preceding application to soil is novel and warrants investigation for two reasons. First, biochar has been shown to increase crop yields in certain conditions, most notably where soil carbon has been depleted, and this research involves a previously uninvestigated biochar post-production amelioration method. Second, the use of biochar for overland flow filtration prior to application of biochar to agricultural soil has environmental implications related to conservation of ecosystem services that could potentially reach far beyond the borders of a given agricultural system. BOFF systems may prove to be useful as an on-farm best management practice for filtering overland flow and tile drain effluent. The filter can also be used as a substitute for riparian buffer strips in suburban and urban areas where conventional riparian buffer strips are not practical. Additionally, BOFF systems could be installed simultaneously with the planting of riparian buffer strips in order to filter overland flow during the planting process and the subsequent period while the plants are becoming established. If nutrient-rich overland flow from non-agricultural soils can be retained using BOFF systems and applied to nutrient-deficient agricultural soils, then it may be feasible to design an agricultural system that is not only a repository for stable soil carbon, but also a sink for, rather than a source of plant-available nutrients and associated eroded soil particles. Such a system could be described as “nutrient-negative,” adapting terminology from greenhouse gas emission literature. Biochar contained within either reusable synthetic or single use biodegradable mesh containers could be used simultaneously to reduce and filter overland flow. It is essential that BOFF systems be designed to be as effective as possible for the aforementioned purposes, while minimizing the likelihood of any detrimental downstream environmental consequences. It is of the utmost importance that all component materials within BOFF systems be carefully selected for both efficacy and safety. For example, researchers have recently estimated current global black carbon (BC) losses from natural and anthropogenic sources to many of the world's rivers and expressed concern about the proposed scale up of biochar production and land application, as they found that a substantial proportion of the total BC annually produced currently flows into surface water. Biochar is typically incorporated into soil to ensure that it remains where it is applied. However, BC produced from natural fires and anthropogenic combustion is more commonly deposited on the soil surface, leaving it far more vulnerable to erosion, thus potential losses of biochar to surface waters warrants less consideration than other current sources of BC. This concern is potentially more relevant to the deployment of BOFF systems due to the BC losses that would be associated with a rupture of the permeable material containing biochar within a BOFF. If nutrient-saturated biochar were lost to surface waters from a BOFF system, then it could represent a source of rather than a sink for plant-available nutrients and eroded soil, as well as BC, and is therefore to be avoided.Forthcoming data and system design specifications to be presented include the following:(1) BOFF system efficacy assessmentsoflab-scale BOFFs exposed to simulated overland flow and simulated rainfall generated by a sprinkle infiltrometer, in order to contrast nutrient and sediment retention and release capacities of a biochar and a mineral-enhanced biochar BOFF media, (2) conventional nutrient adsorption and desorption isotherms, and (3) design specifications, rationale for materials and methods employed, and initial observations from field-scale BOFF system trial.

Keywords：*biochar, adsorption, overland flow filtration, runoff filtration, nutrient retention, nutrient-negative*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Sorption of Hydrophobic Organic Compounds to Biochars: Mechanistic Considerations

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The application of biochar, the carbonaceous material produced during the pyrolysis of biomass, to soil (agriculture, remediation, waste management) contributes positively to the mitigation of climate change, energy production, can improve the agricultural properties of soil, and aid in waste management strategies. It has been shown that biochar addition to soil alters the soil's properties, encourages microbial activity and enhances sorption of inorganic and organic compounds. The latter has recently received a significant amount of scientific and regulatory attention. However, it is not completely understood what properties of biochar and sorbate (or both) define sorption and how to explain the high variation in affinity constants observed in the literature.

Our study aims to address this by considering biochar source material and the production method. Furthermore, the study focuses on the interactions between biochar and common anthropogenic organic contaminants, such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), which are often present in the soil and sediment environment owing to legacy contamination.

The 16 biochars (activated and non-activated) from 12 different feedstocks, were produced through slow pyrolysis (i.e. 1-5 h at 250-700oC) using various laboratory and in situ equipment and via fast pyrolysis (residence time few seconds). The samples were characterized via elemental analysis, BET-N2 and CO2 surface area, 13C-NMR, R50, TGA analysis, and pore size distribution. Partition and adsorption effects were quantified via an isotherm method, with the results evaluated with respect to biochar compositions and properties.

Both PAH and PCB affinity constant for sorption to biochar Kbiochar and physicochemical properties of the sorbents show large variation. The results of our study contribute to the understanding of process underlying HOC sorption to biochar, consider the feasibility of applying biochar in remediation technologies in addition to other perspective areas yet to be explored.

Keywords：*biochar, sorption, remediation*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Reduction of Bioavailability and Phytotoxicity of Pb(ii) and Cu(ii) in Shooting Range Soils, Using Bioamendments

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Shooting range soils are reported as highly contaminated soils with heavy metals (Pb, Cu and Sb) with an increasing environmental concern worldwide due to the eventual ecotoxicity. The objectives of this research are to assessthe potential of different bioamendments in order to reduce bioavailable and phytotoxic Pb and Cu in shooting range soils. Chitin, biochar, biofilms and their combination with different ratios, were used as bioamendments to reduce the bioavailability and mobility of heavy metals. Biofilms were formed from the isolated bacteria and fungi from the soil. Incubation experiments (one month) and pot experiments (Solanum lycopersicum L.) (for three weeks) were carried out for chitin and biochar amendments to investigate different metal bound phases after the treatment through CaCl2 and sequential extraction, the reduction of phytotoxic and bioavailable heavy metals concentration. Lead and Cu were reported in high concentrations (20960, 857.2 mg/kg respectively) from the soil. Single extraction data demonstrated a maximum and minimum Pb release are from unamended soil and 2.5% biochar treatment respectively, whereas for Cu, the maximum and minimum are from 2.5% chitin, 2.5% biochar application respectively. Sequential extraction data from the incubation experiment showed that the exchangeable Pb is higher in unamended soils than the treated soils in the sequence of control soil> 2.5% chitin> 1% chitin> 0.5% biochar> 0.5% chitin> 2.5% biochar. The highest percentage of Pb bound to carbonates is observed in 2.5% chitin amended soil indirectly suggested cation exchange mechanism of Pb with Ca of chitin. Highest plant growth rate was recorded from 0.5:1% chitin:biochar mixture, and the lowest growth rate was reported from the unamended soils and 2.5% chitin added pots. The lowest growth may be due to the toxicity induced by heavy metals and increase in electrical conductivity at the high loading of chitin. Reduction of bioavailable Pb was observed after the each treatment whereas Cu was released in high loadings of chitin. Biofilm treated pot and incubation experiments will be conducted in the future and will compare the data with other bioamendments.

Keywords：*Fungal bacterial biofilm, Sequential extraction, biochar, chitin, heavy metals*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Aggregate Stability and Phosphorus Sorption in Biochar Amended Soils

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Intensive fertilization leads to high concentrations of labile phosphorus (P) in the surface soil, increasing the risk for surface runoff loss of P. Disturbance of cultivated soil by tillage weakens soil aggregate structure and increases the risk for erosion. When dispersed into water, clay-sized material can carry sorbed P in to surface waters thus inducing eutrophication of receiving waterways. In this incubation study, the aim was to find out whether biochar could be used to improve the clay soil aggregate stability and help to mitigate the particulate P loss from agricultural land. We also studied the potential of biochar to increase P sorption of three different surface soils and thus reduce loss of dissolved phosphate-phosphorus (PO_4-P) from cultivated soils.

Biochar was produced by pyrolyzing chips of spruce and pine in a continuously pressurized carbonizer (10-15 min, 550-600 ^oC). The biochar was mixed with three different surface soils (clay% 2, 38, 47) in additions corresponding to 0, 15 and 30 t ha^{-1} and placed in plastic containers. After addition of biochar, soils were gently mixed and compacted slightly (200 g cm^{-2}). After 3-week incubation, the aggregate stability was tested with wet-sieving method. In addition to the amount of water-stable aggregates, the turbidity of the water used in wet-sieving and the mass of detached soil material was measured. The effect of biochar on P sorption was studied with Q/I plot technique. One gram of soil or soil+biochar was mixed with 50 ml of P-solution containing 0; 0.5; 1; 1.5 and 2 mg PO_4-P l^{-1}. After equilibrium, the centrifuged and filtered suspensions were analyzed for PO_4-P. The amount of adsorbed or desorbed P (Q) was calculated from the difference between the PO_4-P concentrations in the solution before and after the equilibration (I). To the Q/I points obtained, a modification of the Freundlich adsorption equation was fitted.

Biochar addition did not increase P sorption in any of the incubated soils. For a coarse-textured (2% clay) soil, biochar seemed to reduce P sorption which suggests biochar induced inhibition of soil P sorption. On the other hand, this incubation study showed that biochar could have positive effects on aggregate stability in clay soils. The amount of water stable aggregates increased and the detachment of colloids during wet-sieving decreased. Better aggregate stability would be beneficial for erosion control and in reducing particulate P load from agricultural fields.

Keywords：*Biochar, Soil phosphorus, Aggregate stability*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effects of Biochar Application on Soil Nutrients and Corn Production of Sandy Soil

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In order to study the effect of biochar on sandy soil improvement, three applications of 8t/hm2, 16t/hm2 and 32t/hm2 of biochar was carried out in Xinzheng City air port in North China Wheat-maize wheel nutrition and fertilization scientific experimental station. The soil chemical and microbial indicators were determined and compared in maize small trumpet stage, blossom stage and milk stage. The results indicated that the application of biochar could significantly improve the soil water content, soil moisture content of the three applications were significantly higher than that of the control ($P<0.05$), 32t/hm2 application was the highest, and 5.4% higher than CK. Applying biochar can improve soil pH value, and showed decreased in the late time; composition of soil available nitrogen, nitrogen content was not obvious effected, but nitrate concentration decreased with the application level; application biochar dramatically increased the content of available K and significant increase soil organic matter in higher application level, but no significant effect on available P. 16t/hm2 and 32t/hm2 application level significantly increased soil fungi numbers($P<0.05$), but no obvious effect on soil bacteria number($P > 0.05$).

Keywords：*Sandy soil, biochar, chemical properties, available nutrients, microbial number*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Biochar Amendment on Major Soil Properties, Crop Yield under Saline Cropland from Central China Great Plain

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Soil salinity has been considered a brutal environmental factor decreasing crop productivity due the excessive amount of sodium salt in soil medium under arid and semi arid region of the world. This study tries to address the potential use of organic amendment (biochar poultry-manure compost) as a rich organic C material to reclaim salt affected soil in order to enhance crop productivity, soil microbial activity and nutrient enrichment in saline dry croplands. In this regards a field experiment with soil amendment of biochar-poultry manure compost (BPC) and pyroligneous solution (PS) was conducted in a moderately salt stressed Entisol from Central China for two years under wheat/maize rotational systems. The soil was amended with BPC at 12 t ha-1 following treating with diluted PS solution at 0.15 t ha-1 1 week before sowing of crop. The experiment was performed for a single year (BPC-PS1) and for two consecutive years (BPC-PS2), compared with experimental control salt-stressed soil CK. Results showed a significant improvement in soil physical properties, leaching of soluble salts, improvement in plant nutrition and soil biological properties with amendment of BPC-PS1 and BPC-PS2 over the experimental control salt-stressed cropland CK. Furthermore, wheat/maize grain yield, nitrogen, phosphorous potassium and K/Na ratio increased while sodium decreased with BPC-PS amendment in wheat/maize grain. This study indicates that organic amendments as a biochar in conjunction with pyroligneous solution greatly improved major soil properties which mostly suffered under salt-stress soil conditions. Thus, organic waste treatment of crop straw as biochar and poultry manure compost could be combined for use to alleviate salt stress and improve crop production in the vast area of arid and semi-arid regions of the world.

Keywords：*Saline soil, Biochar poultry-manure compost, Pyroligneous solution, Wheat and maize grain yield, Imp*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Thermogravimetric and Spectroscopic Characterization of Biochar Carbon

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Biochars are a pyrolysis product of organic materials. Though dependent on feedstock and pyrolysis conditions, biochars show an increase in aromatic carbon and graphitic materials which greatly increase the environmental half-life of biochars over their feedstocks. Furthermore, the high pore volume and surface area decrease soil bulk density and increase water holding capacity. Biochar also supplies cation-exchange capacity through complex organic acids, making biochar a potentially useful amendment in the rehabilitation of surface-mined soils which have intrinsically low organic carbon. This study examines the role of temperature and carbon source on the structure and physiochemical properties of a diverse suite of biochar samples. Using a diverse sample of biochars, this study characterizes biochars on for carbon type, structure and CEC.

This study examined 13 biochars, from eight source materials and eight pyrolysis conditions. Source materials included hard and softwoods, sawdust, woody waste material, poultry manure and switchgrass; pyrolysis conditions included fast and slow pyrolysis with highest treatment temperatures (HTT) ranging from 425-800C. Carbon type and structure were examined using spectroscopic methods (Fourier transform infrared (FTIR) and Raman spectroscopy), structural (X-ray diffraction (XRD), and thermogravimetric analysis (TGA) under inert (N2) and oxidative atmospheres). The spectroscopic techniques were used to quantify functional groups like aliphatic and aromatic carbon, carbonyl groups, phenols, and other acids.

For oxidative TGA, cellulose, hemi-cellulose, lignin, and graphite were used to generate standard mass-loss curves. The temperatures of onset and cessation of mass loss were used to define “labile” (cellulose and hemi-cellulose) and “recalcitrant” (lignin and graphite) forms of carbon. The environmental availability is evaluated by holding biochars at these reference temperatures; mass loss at these temperatures is used to classify the carbon within each biochar. The biochars will then be reexamined using the spectroscopic methods to quantify the structural and mineral changes which accompany each mass loss event. Inert (N2) TGA with evolved-gas capture and FTIR-gas cell analysis was used comparatively alongside oxidative TGA to further understanding of environmental recalcitrance through thermal degradation.

Preliminary results demonstrate increased recalcitrant carbon with increasing treatment temperature. Similarly, spectroscopic analyses showed increased aromatic carbon, decreased apliphatic carbon, and decreased carbonyl structures as increased treatment temperature. However, the influence of source material was significant, and chemical and structural variations occurred between materials prepared under similar pyrolysis conditions

We will evaluate CEC with a multiple step method. After rinsing out soluble inorganic minerals, an acid rinse will be used to remove accumulated calcite and other inorganic carbonates. The biochars will be stabilized at different pH values, (4-8, at pH=1 intervals), saturated with BaCl2, and the Ba2+ desorbed through MgCl2 saturation. Not only does this method provide information about available soluble minerals and liming potential of the various biochars, it provides a pH-dependent CEC curve. This is essential, as the CEC provided by biochars is from organic oxoacids, and can be expected to be highly dependent on pH. The CEC of different biochars will then be correlated with the occurrence of different carbon types, structures, and functional groups.

This suite of analyses is designed to evaluate each biochar’s suitability as an amendment in soil rehabilitation, and inform further studies in which biochars will be used to restore the organic carbon cycle for degraded soils.

Keywords：*biochar, structure, TGA/DTG, FTIR, pH-dependent CEC, XRD, Raman, mining amendments,*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effects of Biochar Amendment on CO2 And CH4 Emissions from Two Paddy Soils in Subtropical China

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Biochar is the carbon (C)-rich solid obtained from biomass pyrolysis. Recently, biochar has been reported to have important roles in carbon sequestration, increased crop yields, and greenhouse gas (GHG) emission mitigation due to its distinct physical, chemical, and biological properties. However, how will biochar amendment affect the main GHGs from paddy soils in subtropical China has not been well defined and examined. In this study, an incubation experiment was carried out to find out the effects of straw-derived biochar amendment on CO2 and CH4 emissions from two typical paddy soils (named S1 and S2 respectively) with distinct textures (the sand, silt and clay contents were 37.1%, 32.3% and 30.6% for S1, 14.7%, 50.3% and 35.0% for S2, respectively) in subtropical China. For each soil, three biochar amendment rates were designed: 0%, 1% and 2% w/w. The bare soils and biochar-amended soils were submerged with a 5-cm water layer and incubated for 180 days at 25 oC. Greenhouse gases emission rates were measured at a frequency of approximately once each seven days (gases emission rates were also determined at 0, 2 and 5 days after incubation). The soil samples were also collected at a frequency of approximately once each month during the incubation period to determine ammonium-nitrogen (N), nitrate-N, dissolvable organic C, dissolvable organic N, microbial biomass C and microbial biomass nitrogen. The results showed that biochar amendment had a positive priming effect on CO2 emissions from the two paddy soils at the beginning of the incubation (the first five days after incubation). In the subsequent incubation, biochar amendment significantly increased soil CO2 emissions compared with control treatment ($p<0.05$) with the cumulative CO2 emissions as 2058, 2468 and 2166 mg kg-1 soil for the control treatment, 1% and 2% application rate treatments respectively, in S1, while significantly reduced CO2 emissions in S2 ($p<0.05$) with the cumulative emissions of 2142, 1979 and 1994 mg kg-1 soil for the control treatment, 1% and 2% application rate treatments, respectively. Different from its effects on CO2 emissions, biochar amendment significantly decreased soil CH4 emissions in comparison with the control treatments ($p<0.05$) and more CH4 reduction were found in 2% application rate treatment than 1% application rate treatment: 4.72, 4.17 and 3.29 mg kg-1 soil in S1 and 5.63, 4.05 and 3.90 mg kg-1 soil in S2 for control treatment, 1% and 2% application rate treatment, respectively. Correlation analysis demonstrated that CH4 emissions were significantly and positively correlated with methanogenic activities ($p<0.05$), indicating that biochar amendment may reduce CH4 emissions by decreasing the methanogenic activities. Overall, biochar amendment reduced CO2 and CH4 emissions in S2, but increased CO2 emission in S1. Therefore, from the point of views of increasing soil C sequestration and reducing GHGs emissions, biochar amendment in paddy soils with a high clay content may have a larger potential of reducing GHGs emissions than its amendment in paddy soils with a relative low clay content and a relative high sand content.

Keywords：*charcoal; CO2; CH4; greenhouse gas emission; lowland*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Impacts on Soil Biological and Biochemical Properties

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In the last years there has been an increasing interest in biochar research. Soil biological and biochemical properties have a preeminent role driving nutrient cycling and can be considered as suitable indicators of soil quality due to its rapid changes following alterations in management or land use. The information on the effects of biochar addition in soil biological activities in still scarce, although an influential number of articles have appeared lately.

The aim of this work is to provide an overview of those articles dealing with the biological impact of biochar addition to soil. Studies conducted in soils in different countries differing in forming factors and fertility status are presented. The focus of this work is on how biochar interacts with soil fauna, on changes in soil biological and biochemical properties following heavy metal immobilization after biochar addition and on how these changes are important in relation to global change. Priority areas were research is needed are identified.

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Soil Fertility Status, Nutrient Uptake and Yield of Cowpea by Tender Coconut Husk Biochar Application in Ferralitic Soils

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Introduction

Biochar is a product of thermo-chemical decomposition of biomass in a zero or limited oxygen conditions by the process of pyrolysis. Its primary use is not for fuel, but for atmospheric carbon capture and storage. Biochar is much more persistent in soil than any other form of organic matter and it can remain stable in soil for hundreds to thousands of years that makes it a prime candidate for carbon sequestration. Biochar has great importance in improving soil fertility and it could act as a soil amendment to increase crop yield and plant growth by supplying and retaining nutrients than other organic matter (Lehmann, 2007).

The tender coconut husk is a biowaste which accumulates on the road sides. The best way to utilize it for crop production without environmental pollution is by converting it to biochar. The beneficial effects of biochar on soil properties have been reported by many scientists and includes chemical (Yamoto et al., 2006), physical and biological changes in soil (Rondon et al., 2007). Improvements in plant growth and yield following biochar application also has been reported for a variety of crops, such as radish, common beans (Rondon et al., 2007), soybean (Togoe et al., 2007) and maize (Yamoto et al., 2006).

Materials and Methods

Taking all the above beneficial effects of biochar into consideration, a study was conducted at College of Agriculture, Vellayani of Kerala Agricultural University, Kerala, India, to investigate the efficacy of biochar from tender coconut husk for enhanced crop production.

Biochar was produced, characterized and tested in the field at different levels of application viz. 10 and 20 and 30 t ha-1 using Yard long bean (cowpea) as the test crop during January to April. Along with biochar, other commonly used organic manures namely FYM, vermicompost and biofertilizers namely PGPR and AMF were also tested in the field. It was a RBD with 9 treatments and 3 replications. The treatments were 1. Package of practices recommendation, 2. Biochar @ 10 t ha-1 + NPK as per POP, 3. Biochar @ 20 t ha-1 + NPK as per POP, 4. Biochar @ 30 t ha-1 + NPK as per POP, 5. Biochar @ 20 t ha-1 + 75% NPK as per POP, 6. Biochar @ 10 t ha-1 + FYM @ 10 t ha-1+75% NPK as per POP, 7. Biochar @ 10 t ha-1 + vermicompost @ 5 tha-1 + 75% NPK as per POP, 8. Biochar @ 20 t ha-1 + 2 % PGPR + NPK as per POP, 9. Biochar @ 20 t ha-1 + AMF @ 200 g m-2 + NPK as per POP. Chemical Properties of the soil such as pH, EC, CEC, Organic C, available N, P, K, Ca, Mg, S, Fe, Mn, Cu and Zn were analyzed after application of treatments. The soils of the experimental site belong to the family of Loamy Skeletal Kaolinitic Isohyperthermic Rhodic Haplustult.

Results

Biochar appication improved soil fertility status, especially soil organic carbon, CEC, available P, available K, Ca, Mg and increased nutrient uptake and yield. Soil organic carbon incresed from 0.75%-1.00% (biochar and vermicompost treated). Soils

treated with biochar had consistently higher organic carbon and the yield was highest for the treatment which received biochar and vermicompost followed by biochar @ 30t/ha.

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Keywords：*biochar, tender coconut husk, organic carbon, nutrient uptake, yield*

P2-161

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Competitive Sorption of Bisphenol a and Phenol in Soils and the Contribution of Black Carbon

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The sorption behaviours of organic pollutants such as endocrine disrupting chemicals (EDCs) play an important role in concerning their fate and bioavailability in the soil environment. Biochar or black carbon (BC) was commonly in-situ produced in Asian farms and its recent amendment in soils for carbon storage, which could play an important role in organic sorption. In this study, the sorption isotherms of one EDC, bisphenol A (BPA), and phenol in two Taiwan soils, Lu-Kung (LK) soil and Chen-Chu-Llu (CCL) soil, were investigated, respectively. The sorption capacity of LK soil for these two organic pollutants is much higher than that of CCL soil due to more soil organic matter content in LK soil. And a higher fraction of black carbon (BC) was observed in LK soil than in CCL soil. Furthermore, the sorption capacity of BPA is larger than phenol due to its higher hydrophobicity. For competitive experiments, sorption of phenol in LK soil could be suppressed by BPA, but sorption of BPA could not be suppressed by phenol. The result indicated that hydrophobicity of these two compounds strongly affected their competition. The biochar derived from the carbonized rice straw, which is generally produced in Asia after the harvest, was used as the soil carbonaceous material surrogate The similar competitive adsorption behaviours of these two compounds on soil carbonaceous material surrogate were also elucidated. These findings suggested that the surface adsorption on carbonaceous materials such as biochar or BCs could play a key role in the sorption behaviors of organic compounds in soils.

Keywords：*Competitive sorption, soils, black carbon, phenol, bisphenol A*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Using Carbonized Agricultural Waste to Reduce the Uptake of Some Chlorinated Contaminants into Crops

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Organic contamination in soils such as pesticides, oil spill, underground storage leakage, and the irrigation of wastewater with or without treatment is widely found in the world. Several toxic or potential carcinogenic organic chemicals such as fossil fuels, chlorinated solvents, and industrial aromatic compounds contaminated farm soils without awareness. These agricultural products from these possibly polluted farms could pose a great risk to the health of human. In this study, the extraction methods of three chlorinated aromatic contaminants from soils and crops were established, the uptake of organics into plants was studied, and the effect of biochar on the plant uptake was evaluated. The extraction recoveries of 4-chlorophenol (4-CP), 1,4-dichlorobenzene (1,4-DCB), and 1,2,3-triclorobenzene (1,2,3-TCB) from plant tissues were more than 90% by using the ultrasonic extraction method. Brassica chinensis was chosen as a plant model to absorb these three organic compounds. These organic compounds can absorb through plant roots and then transfer to plant stems. Sorption isotherms of organic compounds by plant residuals can be described by linear model. The absorption equilibrium time for plants is around 3 hours. Biochar was produced from the agriculture waste derived from Cryptomeria japonica after thermal treatments. The properties of biochar were analyzed by elemental analysis, NMR and FTIR. The adsorption equilibrium time of organic compounds on this carbonized agriculture waste is around 1 hour. Sorption isotherms of 4-CP and 1,2,3-TCB can be described well by Langmuir equation, and 1,4-DCB by Freundlich equation on this biochar. The addition of biochar decreases the plant uptake of these organic compounds. The amendment of biochar can reduce the organic contaminant transportation into crops due to the strong sorption of organic contaminants on biochar. These findings propose a potential approach to reduce organic pollutants in crops from contaminated soils or possible polluted sites.

Keywords：*chlorinated aromatic contaminants, plant uptake, biochar, isotherm, adsorption*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

The Role of Organo-Mineral Fertilizers to Improve the Sorption Properties of Soils

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Almost all the inhabitants of the earth - both rural and urban - routinely exposed to the atmosphere , land, containing not only the components necessary for life , but also toxic substances that suppress the immune system.
It is known that one of the most promising and effective methods of purification of water and soil from a wide range of pollutants , including residues of fertilizers and pesticides , became the so-called bioremediation based on the use of biochemical potential of biological objects , especially micro-organisms (bacteria, fungi , yeast) . Developed biologic (' Environmental Shield '), which includes waste coal , clay minerals (bentonite) and micro-organisms - introducers useful part agrobiogeotsenoza .
The aim of our research was to improve the sorption properties of the soil by adding ' Environmental Shield ' - organo- mineral fertilizers produced waste processing brown coal mining complex microorganisms and study of its impact on human health .
Material and methods . ' Environmental Shield ' ' created from coal waste activated association of soil microorganisms , mixed with bentonite was used in the experimental range of 10 hectares on the territory of Syrdarya branch of Cotton Research Institute studies have been conducted with the introduction of 10 tons per 1 hectare ' Environmental Shield 'on the gray desert -oasis soils under cotton . Carried out a field (seasoned ground) experiments based on the study of the properties of soils and migration of residual mineral fertilizers on different norms ' Environmental Shield ' and without it.

Results of the study . Experience on this project was carried out on a pilot - production basis Syrdarya branch UzNIIH . Territory branch is lowered Shuruzyakskom Hungry Steppe . Shuruzyakskoe drop occupies the southwestern part of the second terrace of the Syr Darya .
The results showed that the main factor determining the characteristics of water and physical properties of soils is their mechanical structure and the nature of the parent rocks .
Adding it is promotes organic carbon content in the soil. Increased application rates it is accompanied by a corresponding increase in organic carbon in the vadose zone .
Making it on the background N200P140K100 accompanied by an increase of total nitrogen in the soil and helps to reduce the formation of nitrite and nitrate in the vadose zone that serves to prevent them leaching into groundwater , thereby improving the quality of the upper zone of aeration and reducing the risk of groundwater contamination by residual fertilizers , as evidenced by the content of mobile forms of nitrogen , phosphorus and potassium in the following soil layers.
Also , the introduction of ' Environmental shield' helps reduce the formation of nitrite and nitrate in the vadose zone that serves to prevent them leaching into groundwater . The use of this it is an effective mechanism for removing excess nitrate concentrations ¬ Comrade in the vadose zone and the accumulation of nitrogen in ammonium and organic form and contributes to its content of digestible plants forms of phosphates and, at the same time is not accompanied by their leaching into groundwater .
It should be noted that it improves the quality of the soil and reduces the risk of groundwater contamination by residual amounts of mineral fertilizers , as evidenced by the content of mobile forms of nitrogen , phosphorus and potassium in the following layers of the soil , increases the humus content , nitrogen, phosphorus and potassium in the soil , thus creating a favorable supply for plants.
Conclusion: Adding ' Environmental shield'
-helps reduce the formation of nitrite and nitrate in the aeration zone that serves to prevent them leaching into groundwater .
-improves the quality of the upper zone of aeration and reduces the risk of groundwater contamination by residual amounts of mineral fertilizers , as evidenced by the content of mobile forms of nitrogen , phosphorus and potassium in the following soil layers.
-promotes humus , nitrogen, phosphorus and potassium in the soil , thereby creating favorable food for plants

Keywords：*soil, nitrit, polution, coal, humus*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Beneficial Soil Management Practices for Yield of Maize (zea Maize) Grown in Reddish Brown Earth and Reddish Brown Latasolic Soils in Sri Lanka

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Conversion of infertile soils in to productive soils could be achieved by addressing soil fertility related constraints. Site specific nutrient management is one of the important tools to address low productivity in agricultural soils. Combined use of chemical fertilizers and organic amendments illustrate overall soil fertility development in different food crops grown in Sri Lanka. But benefits of application of organic matters such as green manures, farm yard manures usually last only for one or two growing seasons due to the rapid mineralization of organic matter under the hot, humid tropical environment. This study was conducted to test beneficial management practices selected for soils individually based on the soil physical and chemical limitations identified for the each soil on the yield of maize.

Two sites were selected from Field Crop Research and Development Institute at Mahailluppallama, in low country dry zone (DL1b) where soil is Reddish Brown Earth (RBE, Typic Rhodustalfs) and from University Experimental Station, Dodangolla, at intermediate zone mid country (IM3c) where soil belongs to Reddish Brown Latosolic soils (RBL, Rhodudalfs). Initially a composite soil sample was collected from each field at 0-20 cm depth to identify soil fertility related constraints. Soil was analyzed for pH, organic-matter (OM), cation exchange capacity (CEC) electrical conductivity (EC) and texture. Available nutrients were determined using standard procedures. Site Specific fertilizer (SF) recommendation for RBL and RBE soils were formulated using modified missing element technique by standard protocol. Treatments of SF, biochar applied at 0.5% by weight with SF (BC+SF), rock powder applied at 5% by weight with SF (RP+SF), and a soil only control (C) for RBE were selected based on the soil analysis. For RBL soil, SF, BC+SF, incubated cattle manure and saw dust applied at 1% by weight with SF (CS+F,) and C were selected as treatments. A field experiment was conducted at the two locations using maize local variety of Sampath. The experiments were arranged in randomize complete block design with four replicates. At 50% tasseling plant heights were taken. At 105 days after planting seed yield was taken and 2 plants from each plot was harvested to get the plant dry matter yield.

The chemical analysis of homogenous biochar samples showed that the pH, available N, available P and available K was 8.7, 58 mg/kg, 11.3 mg/kg and 1736 mg/kg. This indicated that biochar can provide K to the soil. The chemical analysis of rock powder showed that, 7.8, 37 mg/kg, 2.1 mg/kg and 211 mg/kg for pH, available N, available P and available K respectively. Cattle manure incubated with saw dust sample showed that the pH, available N, available P and available K was 7.8, 37 mg/kg, 15.4 mg/kg and 2456 mg/kg. Cattle manure incubated with saw dust amendment can provide K to the soil.

Initial soil parameters indicate that CEC is moderate and OM contents are comparable in both soils and soil reaction is acidic only in RBL. Texture of the RBL soil was sandy loam and RBE soil belongs to the sandy clay loam. The EC in RBE soil was 0.12 dS m-1 while that of RBL soil was 0.10 dS m-1. Both RBE and RBL soils were deficient with N, P, S, Ca, Zn and Cu. In RBL soil K

and Mn were below the optimum level but not in RBE. Significantly higher plant height observed in SF, BC+SF and CS+SF than the control in RBL where BC+SF and RP+SF showed higher plant height than other treatments in RBE soil. With the addition of soil amendments plant height increased significantly in both soils at 50% tasselling. In RBL and RBE soils plant dry weights significantly increased in amendment +SF compared with the control but no significant difference was observed between amendment treatments and SF only treatment. Significantly highest grain yield was observed for BC+SF treatment than the other treatments in RBL soil where in RBE soil both BC and RP added with SF increase the grain yield significantly than other treatments. This indicates that biochar with adequate nutrient increase the soil fertility and sustains production for RBL soil. Where for RBE soil both biochar and rock powder improves the soil constraints resulting in high yield. Therefore site specific beneficial management practices are necessary to improve soil fertility in low productive lands.

Keywords：*Beneficial management practices, low productive, site specific, yield*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar and Arbuscular Mycorrhizal Fungi: An Alternative to Contributing to Agroecosystem Sustainability

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The agriculture activities produced an important amount of residues and in the agroecosystems of South Chile the burning of these is a widely practiced management causing some problems such as air pollution and nutrients lost mainly soil organic matter. Indeed, the transformation and reutilization of agricultural wastes by the pyrolysis methods obtaining a product called biochar (BC) could be a feasible solution to contribute to maintain soil quality, since the BC application on soils improves the physical, chemical and biological properties as well as increase crops yields. In the same way, the activity of arbuscular mycorrhizal (AM) fungi plays an important role in the soil fertility, cycling of nutrients and plant health nutrition. In fact, some studies indicate that biochar and mycorrhizal associations are potentially important in various agroecosystems services provided by soil. The aim of this work was to evaluate the early effect of the BC application on wheat root colonization by native AM fungi, glomalin content and some soil properties and production of wheat biomass in an Andisol and Ultisol of Southern Chile. For the above, Two BCs were produced using oat hulls (OBC) and pine bark (PBC) processed at 300 °C and 2 h of pyrolysis. The BCs produced were physico-chemical characterized and then we evaluated their phytotoxic effect through a germination test. After that, doses of 5, 10 and 20 Mg ha-1 of BC were incorporated into 0-5 cm depth on Andisol and Ultisol, using a treatment without BC application as a control. In wheat, AM root colonization, root and shoot biomass were determined, whereas in soil pH, electrical conductivity (EC), bulk density, porosity, water holding capacity (WHC), water stable soil aggregates (WSA) and glomalin (GRSP; glomalin related soil protein) content were also measured. The results showed that OBC have higher nutrients content and better values in the physical parameters (BET, pore volume and pore size) compared with PBC. The germination test showed a non-toxic effect of the BCs on the wheat seeds. The AM fungi colonization of wheat increased with the use of OBC, reaching values by 48.7% and 44.2%, while the colonization values obtained with the use of PBC ranged between 39.3% to 36.4% in Andisol and Ultisol respectively. GRSP content responds to of higher BC doses in both soils, increasing its contents mainly with the use of OBC compared with the PBC and control treatment. An increase in the production of shoot (45% and 23%) and root (70% and 37%) biomass related with the use of highest doses of BCs in the Andisol and Ultisol studied. Improves in the soil pH, EC, WHC, and WSA were also observed with the application of both OBC and PBC compared with the control. No differences were observed in bulk density and porosity. Our results have shown that the use of biochar as amendment in agriculture soil can be an effective alternative of soil management in order to stimulate root colonization by AM fungi and increase GRSP contents as well as improve soil properties, thus promoting a higher sustainability of agricultural systems.

Acknowledgements: This study was supported by FONDECYT Project 3120213

Keywords：*Biochar, Arbuscular mycorrhizal fungi, Glomalin related soil protein, Chile*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Phosphorus Sorption Behavior in Manure Impacted Soil Amended with Biochar

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Phosphorus (P) loss from manure-impacted sandy soils resulting in eutrophication of water bodies has been a major concern for the past several years. Various attempts have been made that could potentially alleviate the problem of P loss resulting from surface applied or incorporated fertilizer or manure in any animal and/or agricultural systems. The effect of biochar addition to soil for agronomic and environmental benefits is well-discussed and established research in current time. However, very few studies have been conducted on the effect of application of biochar on P-sorption and release characteristics relative to its chemical properties. High adsorption and slow release capacities of biochar may allow use as potential sustainable soil amendments, particularly in heavily manure impacted soils. Our hypothesis for the study was that there is a potential for adding biochar to a soil based on site-specific conditions, independent of soil test phosphorus. Preliminary batch studies were conducted in the laboratory with the objective of investigating any changes in sorption behavior and losses of P from soil in animal-agricultural system through biochar application. Three different rates (0%, 1% and 2% w/w) of hardwood biochar (made from pine, oak and maple trees), in 3 replications, were added to highly manure impacted soil samples collected from a dairy farm. Biochar was characterized for its basic chemical parameters. Basic characterization of hardwood biochar showed a medium to low level of water soluble P in it. The soil and biochar mixture was incubated in plastic containers for different time periods. The soils were kept at field capacity by sprinkling of water as appropriate. The soil samples were collected after 0, 7, and 21 days of incubation by batch destruction method. The mixtures have been kept for long term observation. The soil samples were analyzed for water soluble P along with other soil test P such as Mehlich 1 and Mehlich 3 P. Preliminary results included the characteristics of biochar and chemical/sorption behavior of soil and biochar mixture over a short period of time. A comparison of soil test P and water soluble P values did not indicate any particular trend of P sorption or release behavior of soil. The P sorption behavior by isotherm analyses of each sample will be presented. Long term data from 3, 5 and 12 months incubation will also be presented.

Keywords：*Biochar, P sorption, manure impacted soils, lab incubation, water soluble soil P, extractable soil P*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Preferential Rooting in Biochars

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Low available phosphorus (P) in most soils is the greatest constraint to soybean (Glycine max.) production in Africa combined with the expense of manufactured P fertilizers derived from finite reserves of rock phosphate. Limited access and affordability of P fertilizers in P deficient regions combined with low available P soils present critical problems for optimal production. P acquisition strategies of soybean roots encompass two fundamental traits; the ability to (i) explore and scavenge for P and (ii) mobilize P from poorly mobile soil P sinks. Varying concentrations (4)of biochar will be applied to four different soybean cultivars (organic "Envy", soybean cyst nematode resistant/Round Up Ready resistant, Round Ready or Liberty Link resistant, non-Round Up Ready/non-soybean cyst nematode resistant), each with specialized P acquiring efficiencies, root architectures, growth habits and responses to Pi fertilizers. Biochar is an old 'new' technology that has been studied in low P soils with compelling evidence of its ability to improve P availability after soil incorporation in five key effects: (i) root stimulation/growth, (ii) changes in soil biogeochemistry, (iii) altered microbial communities, (iv) increased presence of adsorbing surfaces, and (v) potential presence of signaling compounds and analogues. Beyond these indirect effects, little is known about the mechanisms controlling the interaction between roots and biochar. Biochars produced from oak (Quercus spp.) at 450C, cedar (Cedrus spp.) at 1000C, and rice husks at 600C (Oryza sativa) will be surface incorporated or banded at increasing application rates. Custom-made rhizotrons will elucidate key mechanisms in analyzing the exploitative potential of P foraging of soybean roots in high and low P environments, in acidic soil, under moisture stress and pathogenic pressure. In order to study how biochar influences in situ root morphology, a combination of approaches is required to first analyze directional root growth, root density, root volume, root plasticity, carbon (C) allocation, nodulation efficiency, nodulation phenology, root hair production, root elongation and overall root architecture during the lifespan of a soybean. The capability of biochars to dampen or sorb root diffusates and other low molecular weight compounds will be investigated using soybean cyst nematodes (Heterodera glycines) as a bio indicator in root infection efficiency. Rhizotrons can provide frequent "snapshots" of root growth over temporal and spatial scales that can later be modeled in 3-D. Understanding root morphologies and direct interactions between biochar and plant roots is essential to predict growth responses to biochar in the field.

Keywords：*biochar, root foraging, root architecture, root signalling*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Root Development of Non-Accumulating and Hyperaccumulating Plants in Metal Contaminated Soils Amended with Biochar

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Biochar, the solid product of the pyrolysis of biomass, may be used as an amendment to store carbon in soils and improve plant growth. Its ability to immobilize heavy metals has also raised the question of its use for the remediation of contaminated sites. The impact of biochar on the growth of plants in soils contaminated by heavy metals is however poorly known, particularly regarding the development of roots, which can directly control the uptake of metals by the plant. We focused here on the effect of biochar on the morphology of roots and on the local pH variations in the rhizosphere.

We examined the effect of biochar on the root growth of three plant species: two non-accumulating plant (ryegrass and maize) and one hyperaccumulator of Cd and Zn (alpine pennycress). Rhizoboxes were filled with one industrial soil contaminated by Zn, Pb and Cd, and a wood-derived biochar produced at about 450°C was added during the filling, either as a homogeneous mixture with the soil or as small biochar patches. Rhizoboxes were then placed in a growth chamber at an angle of 45°, and the development of roots was monitored each week by taking a high-resolutionphotography of the soil profile. At specific times, the spatial variation of pH along the roots and in biochar patches was recorded using planar pH optodes directly applied at the surface of the soil profile. After 3 to 12 weeks depending on the plant, roots and shoots were harvested, washed with deionised water and weighed. Morphologic parameters of roots (e.g. root length, root surface and average diameter) were measured using Winrhizo software. After drying, roots and shoots were digested with nitric acid and oxygen peroxide to measure their content of minerals and heavy metals.

Our results showed that biochar significantly affected the root growth of each plant depending on the amendment dose. In particular, a negative effect was observed on the production of root biomass for ryegrass and maize at high biochar doses, while for the hyperaccumulator, identical production of root biomass was observed but with a higher root surface due to the development of finer roots. The measurement of pH variations on the soil profile confirmed that both ryegrass and the hyperaccumulator alkalinized the rhizosphere while maize acidified it, whether biochar was present or not. Altogether, these results enable us to better interpret the influence of biochar on the uptake of metals or micronutrients by the plant by understanding its effect on root properties.

Keywords：*Biochar, Rhizosphere, Rhizobox, Plant metal uptake, Hyperaccumulator*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Environmental Benefits of Biochar to Improve Soil Quality and Carbon Sequestration in Soybean Production

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Carbon dioxide (CO2) emissions have been and will continue to increase over time, many countries are looking for ways to reduce or alter the amount of CO2 harming our environment. Biochar can be an important tool to combat this problem with implementation of carbon negative practices in agriculture. It is a charred carbon-enriched material intended to be used as a soil amendment to sequester carbon and enhance soil quality. An experiment was conducted at Dickinson Laboratory of Lincoln University, Missouri usinf five different feedstocks (Corn Stover, Giant Miscanthus, Pine, Willow and Switch Grass) to produce biochar with slow pyrolysis and was mixed with 10 Kg of sandy loam soil at the rate of 2% and 5% concentrations for production of soybean plant. Each biochar was treated with 3 times replication along with a control to give a total of 36 pots in RCBD method. Soybean (Glycine max L.) plants were grown in each pot for 60 days of duration and measurements such as plant height, leaf area, root weight, number of pods, nodule weight and bulk density were collected at the termination of the experiment. The result from experiment showed that addition of biochar is helpful to improve soil quality resulting improvement in soybean crop production. The most important application of biochar for carbon sequestration, and we found that the experiment became effective. Though 5% biochar helps in more carbon sequester, however, mixing of 2% of biochar concentration seemed better in terms of improving soil quality and yield of soybean plant.

Keywords：*Biochar, soil quality, carbon sequestration, sustainable agriculture*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

The Effect of Biochar By-Products from Biofuel Production Processes on Wheat Growth in Western Australia

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The pyrolytic conversion of biomass to biofuels is attracting interest as a renewable alternative to fossil fuel based energy processes. While research has mainly focussed on the potential of biofuels to address issues of future energy supply, the biochar (charcoal) by-products from the process may have potential to address global concerns of climate change and degradation of agricultural soils (Deenik, McClellan et al. 2010). The use of biochar as a soil amendment may offer a means of long-term carbon sequestration and a promising approach to improving soil quality and crop productivity (Laird 2008).

The heating of biomass in an oxygen limited atmosphere or pyrolysis causes release of volatile organic compounds (VOCs), such as alcohols, tars and acids, which are typically recondensed as liquids (bio-oil). However, VOCs may also recondense on the charcoal by-product. The few studies examining the effect of charcoal by-products on plant growth have reported mixed effects (Gell, van Groenigen and Cayuela 2011). In some cases, the presence of VOCs have had beneficial effects on plant growth, such as disease suppression (Mu, Uehara and Furuno 2003). However in the majority of cases, they had a detrimental effect on plant growth. The negative effects observed are widely attributed to the presence of sorbed volatile organic compounds (Bernardo, Lapa et al. 2010; Gell, van Groenigen and Cayuela 2011). The VOC content of biochar has been shown to be an important property in assessing the usefulness of the biochar as a soil amendment (Deenik, McClellan et al. 2010).

The ability of biochar to store carbon and improve soil fertility depends on its physical and chemical properties which are determined by pyrolysis conditions and choice of feedstock. Where pyrolysis conditions and feedstock are optimised for bio-oil production and cannot be altered, methods for removal of organic compounds may need to be explored. Solvent extraction of organic contaminants has been proposed as a technically viable option (Bernardo, Lapa et al. 2009).

We will present results of a study in which the biochar by-products from the pyrolytic conversion of Oil Mallee and Pinus Pinaster plant biomass to bio-oil will be evaluated as beneficial, toxic or benign for wheat growth in Western Australia. Rapid germination experiments and a short term glasshouse experiment (12 weeks) will be conducted to investigate the effect of the biochar amendments on plant growth under controlled conditions.

A portion of the Oil Mallee and Pinus Pinaster biochars was subjected to Dichloromethane and Methanol extraction to remove organic contaminants after preliminary germination tests showed significant germination inhibition of seeds treated with the biochars. Germination experiments were conducted to assess whether solvent extraction was effective at removing phytotoxicity of the biochars. Preliminary results indicate that solvent extraction of organic contaminants was effective at removing phytotoxicity of the P.Pinaster biochar, but had no effect on the Oil Mallee biochar. Since the biochars were produced under the same pyrolysis conditions, it is speculated that the effectiveness of solvent extraction may depend on feedstock. Organic characterisation of the

eluates is required to identify differences in the types and concentrations of organic compounds being removed. Further analysis to clarify results thus far in addition to the glasshouse experiment, are currently underway and due for completion by April 2014.

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Keywords：*Biochar, Bio-oil, Biofuel, Oil Mallee, Pine wood, Pyrolysis, Wheat*

P2-171

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Development of Rice Husk Biochar Briquette and its Effect on N Retention in Soil

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Low organic matters and low pH are common soil constraints in the humid tropics, which result in low yield and poor sustainability of agricultural production. Consequently, vegetable farmers have to use more fertilizer inputs to achieve desirable yield. Application of biochar as a soil amendment has been proposed as an innovative approach to conquer these soil constraints and to improve soil health and sustainability. Many research studies on the application of biochar have shown their effects on increasing crop yield and plant growth, which are attributed to their ability in enhancing nutrient and water retention ability, raising soil pH, improving soil physical properties and microbial activity. Biochar amendment has potential in expansion of vegetable production onto sites with less favorable soil fertility condition.

Rice husk is a common crop residue with abundant quantity in rice production system in Asia. It could be converted to rice husk biochar (RHB) by simple technique and could serve as a soil amendment to recycle nutrients, improve soil fertility, sequester carbon in soils and reduce greenhouse gas emissions. It occupies nearly 25% of potential global production of biochar from agricultural waste materials. Due to the dustiness and very fine texture of RHB, subsequently difficult to incorporate evenly for applications. When RHB is applied to sandy soil, the low bulk density may let biochar floats on soil surface and may lose in run-off or move into deeper soil profile after rain or irrigation. Processing rice husk biochar into briquette with fertilizer and other amendments can improve safe and easy handling, and enhance nutrient and water use efficiency. Concentrating application of RHB briquette on rhizosphere-soil system could further enhance such efficiency as well as to reduce the total application amounts. The objectives of this study aimed to formulate and produce RHB briquette with appropriate quality and durability; and to investigate the effect of RHB briquette application on nutrient retention in soil.

RHB was produced from the slow pyrolysis of raw rice husk in a high temperature furnace. Components of RHB Briquette were studied via manually-press machinery. Conditions for producing RHB briquette including percentage of starch and water mixture, pressed pressure and drying time were studied. The durability test of the air-dried RHB briquette was conducted by dropping method. 10 g of RHB equivalent to 40 t/ha of RHB application rate was processed into one large piece of RHB briquette or three smaller pieces of RHB briquette.

Nutrient retention capacity of best RHB briquette formula was investigated by soil column method. 500 g of soil was packed into glass tube to form a soil column with depth of 16 cm. RHB was mixed with 1/3 of soil in the central part (at 6~10 cm depth) of soil column. RHB briquette was placed on the central part of column and then covered with soil. Ammonium sulfate (N fertilizer) equivalent to the rate of 120 kg/ha was applied at 1st, 2nd, third and fifth weeks of incubation. After each fertilizer application, soil column was leached with 100 ml 0.001 M CaCl2 solution for 5 times, and leachate was collected and N in the leachate was analyzed. Cumulative nutrient retention amounts were calculated by summing up all amounts of inorganic N in daily leachate during incubation period.

Best formulation for producing RHB briquette was established and the criteria for durability test were identified. Results indicated that the application of RHB at rates of 10, 20 and 40 t/ha increased N retention in soils by 1.6, 3.6 and 6.7%, respectively in 60 days of incubation. In two separated trials, except the first 2 weeks, N retention rates decreased linearly with time of incubation. At 75 days after incubation, cumulative N retention rate of either RHB briquette or RHB-mixed soil application was significantly higher than soil without biochar application. Compared RHB amendment, RHB briquette could retain higher amounts of N; however, there was no significant difference between these two treatments. Results of incubation studies indicated that RHB briquette could increase or sustain N retention in soil as compared to RHB application alone while improve safety and easiness of RHB handling during application to soil.

Keywords：*Rice husk biochar, Rice husk biochar briquette, Nutrient retention*

P2-172

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Oil Palm Empty Fruit Bunch Biochar Soil Amendment in Amaranthus Viridis Cultivation to Improve Crop Performance and Soil Properties

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Malaysian soils are mostly classified as Ultisols and Oxisols, which are highly weathered acidic and infertile soils with low organic matter content and cation exchange capacity (CEC). Organic amendments such as compost and animal manure are needed to improve soil health for sustainable agriculture production on these soils. Application of biochar as a soil amendment is viewed as a promising alternative as it has been widely reported to improve soil quality and crop performance as well as sequestering carbon in soil due to its high carbon stability against microbial decay. A potential biochar feedstock is oil palm empty fruit bunch (EFB), a major waste from palm oil industry. The production of EFBB from EFB presents an appealing option of sustainable waste management for the oil palm industry. However, different biochars exhibit variations in characteristics, depending on feedstock and production process. Since EFBB is only recently produced, very little is known about its potential as a soil amendment for crop improvement and soil carbon sequestration. This study was conducted with the aim of investigating the effects of EFBB application on crop performance, nutrient uptake and soil properties with single and repeated application. A field study was conducted with 5 different EFBB application rates: 0 t/ha EFBB (BC0), one time application of 10 t/ha EFBB in 1 season (BC10), two applications of 10t/ha EFBB in 2 seasons (BC10+10), three applications of 10t/ha EFBB in 3 seasons (BC10+10+10) and one time 30t/ha EFBB in 1 season (BC30). The 5 biochar treatments were replicated 5 times in a RCBD layout with plot size of 1.5m x 2.0m. Three cropping cycles was established in November 2011, March 2012 and August 2012 respectively using bayam (Amaranthus viridis) as the test crop. EFBB was incorporated into the soil two weeks before transplanting. NPK 15:15:155 fertilizer was applied at the rate of 100kg N, 100kg K20 and 100kg P2O5 per hectare. Yield was recorded and plant tissue samples were collected for tissue analysis. Soil samples were taken from two different depths (0 - 20cm and 20 - 40cm) initially before planting and after each harvest for soil chemical analysis (pH, total C, total N, cation exchange capacity and exchangeable K, Ca and Mg. Soil carbon dioxide flux were also taken. Treatments with EFBB soil amendment showed significant increase in fresh yield compared to the treatment without biochar. However, there was no significant increase in yield with increasing EFBB rate. For soil properties after the first harvest, increasing EFBB rate showed significant increase in pH, and exchangeable K and Mg at 0-20 cm soil depth while exchangeable K was significant at the 20-40 cm soil depth. Similar trends were found for CEC and exchangeable K at 0-20 cm soil depth and total N and exchangeable K at 20-40 cm soil depth after the second harvest. At the third harvest, increasing EFBB application rate shows significant increase in CEC and exchangeable K for 0-20 cm soil depth and pH and exchangeable K in the 20-40 cm soil depth.

Keywords：*biochar, oil palm empty fruit bunch, soil amendment*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Maize-Straw-Derived Biochar Effectively Suppressed the Decomposition of Native Organic Carbon in an Intensively Cultivated Sandy Loam Soil of North China Plain: A Negative Priming Effect

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Conversion of plant residues to biochar is an attractive alternative to burning in field for mitigation of atmospheric carbon dioxide (CO_2) emission and enhancement of carbon (C) storage in soil. However, the effect of biochar application on the decomposition of soil organic C (SOC) as well as its mechanisms is not well understood in soil of the North China Plain. We investigated how biochar affected the decomposition of native SOC, using stable $\delta^{13}C$ isotope analyses by applying biochar produced from corn straw (a C_4 plant, $\delta^{13}C$ = -11.9‰) to a sandy loam soil under a long-term C3 crop rotation ($\delta^{13}C$ = -24.5‰). The incubation experiment included four treatments: no amendment (Control), biochar amendment (BC, 0.5% of soil mass), inorganic nitrogen (N) amendment (IN, 100 mg N kg^{-1}) and combined biochar and N amendments (BN). Compared with Control, N amendment significantly ($P < 0.05$) increased total soil CO_2 emission, even when combined with biochar amendment. In contrast, biochar alone amendment did not affect total soil CO_2 emission significantly. However biochar, even when combined with N amendment, significantly ($P < 0.05$) reduced CO_2 emission from native SOC by 64.9-68.8%, indicating that biochar inhibited the decomposition of native SOC and the stimulation effect of inorganic N on native SOC degradation, a negative priming effect. N addition immediately stimulated the growth of microorganisms and altered microbial community structure by increasing Gram-positive bacteria as measured by phospholipid fatty acid profiles compared to Control. Biochar amendment did not alter microbial biomass during the 720-h incubation period except at 168 and 720 h, but significantly ($P < 0.05$) lowered dissolved organic C (DOC) content in soil, primarily due to sorption of DOC by the biochar.

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Sorption Behavior of 2,4-D Herbicide and Sulfamethoxazole Antibiotic in Biochar-Amended Soils: A Spectroscopic Investigation

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Composting and land application are some of the common treatment processes cuurently being used to dispose a range of organic waste and other biomasses in New Zealand. However, given the tightening regulatory control and issues with the existing treatments including residues, run-off, odour and land availability, there is a desire within the waste management sector to identify alternative and long-term viable options for safe disposal of various organic wastes in a sustainable way. In this study waste derived from various agricultural commercial operations, including municipal sewage sludge were converted into biochar through pyrolysis. Given its high surface area, high carbon content, and porous nature, biochar has the potential to be used as remediation tool. Fundamental knowledge on biochars interaction with various contaminants and with the soil constituents is lacking. Though a number of published studies are currently available in the literature on sorption of various contaminants in biochar-amended soil, the underlying mechanisms responsible for the compounds sorption behaviour is still lacking.

The main objective of this study was to evaluate the sorption potential of a model pasture soil amended with 8 different biochars seprately, and explore the feasibility of the biochars as remediation material by conducting simple batch sorption studies. Biochars used in this study were produced from green waste (GW) at three different temperatures? 350oC, 450oC and 550oC using slow-pyrolysis. Corncob (CC) biochar was produced by flash carbonization technique at 650oC. Biochar from pine sawdust (PSD), paunch grass (PG: undigested grass from cow's stomach), broiler litter (BL), and sewage sludge (SS) were prepared by slow pyrolysis at 680oC. Pine bark (PB) and poultry litter (PL) biochars were produced at 450oC. A range of techniques (Scanning electron microscope, X-ray diffraction, Fourier transform infrared spectroscopy, 13C-solid-state nuclear magnetic resonance, energy dispersive X-ray, and X-ray photoelectron spectroscopy) were used to characterise each biochar during pre and post-sorption experiments. Laboratory batch sorption studies involving two ionisable compounds (a herbicide, 2-4D and a human pharmaceutical, sulfamethoxazole) were carried on a model soil amended with each biochar to determine the biochars sorptive affinity towards the compounds.

Results obtained from this study suggested that thePSD biochar amended soil exhibited remarkable sorption affinity for both compounds with effective distribution coefficient value (Kdeff) being several orders of magnitude higher than soil amended with any other biochar. There was a good correlation between the sorption parameters for the compounds for PSD biochar amended soil, and the amount of oxygen containing acidic functional groups as determined by potentiometric measurements. PSD biochar without visible distinct porous formation in the SEM images gave the highest values of sorption coefficients for sulfamethoxazole as compared to other biochars. This was attributed to high specific surface area and/ or to the presence of abundance of oxygen containing functional groups (aromatic and aliphatic fractions) in the char as supported by XPS and FT-IR data. PSD biochar

absorbed 150 times more SMO than soil alone. The sorption affinity for the biochar amended soil for 2,4D followed an order: PSD >> CC >PL>GW-550oC> PG>HCC>BL> control >SS. These results demonstrate that not all biochars when amended with soils enhanced its sorption capacity for 2,4D and sulfamethoxazole. Biochars made from different feedstocks and under different heat treatment conditions can possess different surface functional groups. XPS results provided new insights about the chemical composition of the biochars. The carbon functional groups for the biochars mostly consisted of C-C/C-H, C=O and C-OH.These variations in surface functionality could be responsible for the observed sorption behaviour for the compounds.Biochars produced from green wastes at variedpyrolysis temperatures had no effect on its sorptive ability in contrary to lignin derived biochars which showed high sorptive tendency. Soil-biochar interactions were governed the biomass source, heat treatment conditions and chemical and structural composition of the chars and the properties and contact time with soil. Based on the findings, biochar produced from biomass of ligno-cellulosic origin could potentially be an excellent sorbent to remediate soils contaminated with these or other similar compounds.

Key words: Functional groups, surface area, Fourier transform infrared spectroscopy, X-ray photo electron spectroscopy, molar ratio, sorption kinetics

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

The Effectiveness of Spent Coffee Grounds and those of Biochar on the Amelioration of Heavy Metals-Contaminated Soil

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Spent coffee grounds (SCG) and charred spent coffee grounds (SCG-char) have been widely used to amend heavy metals that contaminate soil; in this work, the effects of SCG and SCG-char on metal contaminated soil were evaluated using chemical and biological assessments; a phytotoxicity test using bok choy (Brassica campestris L.) was conducted for the biological assessments. While the bioavailable heavy metal content decreased in soils treated with SCG of SCG-char, the phytotoxicity only increased after SCG treatment. According to our statistical methodology, bioavailable Pb, Cu and As as well as the electrical conductivity representing an increase in organic content, affected the phytotoxicity of soil. The results indicated that SCG is comosed of small organic particulates, and this composition is a double-edged sword with regard to efficiency and toxicity, and the goal of remediation using SCG and agro-waste is enhanced relative to risk mitigation by adding biochar more effectively than adding raw materials. Also the chemical and biological assessments are also important for evaluating the efficiency of environment remediation technologies for in-situ remediation. Therefore, applying SCG during environment remediation requires careful biological assessments and evaluation of the efficiency of this remediation technology.

Keywords：*Heavy metals, soil, spent coffee grounds, biochar, phytotoxicity*

P2-176

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar as a Sorbent for Contaminant Management in Soil and Water: A Review

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Biochar is a stable carbon-rich by-product synthesized through pyrolysis/carbonization of plant- and animal-based biomass. An increasing interest in the beneficial application of biochar has opened up multidisciplinary areas for science and engineering. The potential biochar applications include carbon sequestration, soil fertility improvement, pollution remediation, and agricultural by-product/waste recycling. The key parameters controlling its properties include pyrolysis temperature, residence time, heat transfer rate, and feedstock type. The efficacy of biochar in contaminant management depends on its surface area, pore size distribution and ion-exchange capacity. Physical architecture and molecular composition of biochar could be critical for practical application to soil and water. Relatively high pyrolysis temperatures generally produce biochars that are effective in the sorption of organic contaminants by increasing surface area, microporosity, and hydrophobicity; whereas the biochars obtained at low temperatures are more suitable for removing inorganic/polar organic contaminants by oxygen-containing functional groups, electrostatic attraction, and precipitation. However, due to complexity of soil-water system in nature, the effectiveness of biochars on remediation of various organic/inorganic contaminants is still uncertain. In this review, a succinct overview of current biochar use as a sorbent for contaminant management in soil and water is summarized and discussed. This study was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Education, Science and Technology (2012R1A1B3001409) and by the Korea Ministry of Environment, as a Geo-Advanced Innovative Action Project (G112-00056-0004-0).

Keywords: *Black carbon; Charcoal; Activated carbon; Slow pyrolysis; Bioavailability; Amendment*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Comparative Sorption of Cd, Cu And Pb by Peat Moss and Peat Moss Derived Biochar

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Biochar has received research interest as a soil amendment not only for agricultural but also for environmental purposes. It was shown that biochar was capable to remove heavy metals from contaminated soil. Biochar is charred material produced from thermochemical processing of biomass and its properties can be influenced by pyrolysis temperature and time and composition of original materials. Pyrolysis develops aromatic structure and polymerization resulting in carbon enrichment and development of porosity, which is temperature-dependent. Different structure may result in different metal sorption capacity.

Peat moss is the partly carbonized remains mainly composed of organic matter. Heavy metals such as Pb can be adsorbed by peat moss through ion-exchange, surface adsorption, chemisorption, complexation and adsorption-complexation. Even though peat moss itself can adsorb heavy metals, pyrolysis of peat moss may increase metal sorption capacity by changing structure of peat moss. Therefore, the objective of the study is to compare metal sorption capacity of peat moss and peat moss derived biochar.

Peat moss derived biochar was produced under different pyrolysis conditions of temperature (400℃, 600℃, 800℃ and 1000℃) and time (30 min, 60 min, 90 min, 120min and 180 min) to produce the most efficient carbonized peat moss for metal removal. The sorption capacity and sorption dynamics of peat moss and peat moss derived biochar for Cd, Cu and Pb were analyzed using isotherm and kinetic models, respectively. Carbonized peat moss produced at different temperature showed different pore structure. As pyrolysis temperature and time increases up to 800℃ and 180 min, respectively, pore structure of biochar is well developed as evidenced by scanning electron microscopy. However, pore structure was destroyed at 1000℃ by melting.

Copper and Pb removal was the highest when peat moss was pyrolyzed at 800℃ for 180min. However, biochar produced at 800℃ for 90min is the most efficient in the removal of Cu and Pb when mass loss ratio is considered. Therefore, peat moss derived biochar pyrolyzed at 800℃ for 90min was used for analyzing sorption capacity and rate for Cd, Cu and Pb, which was compared with sorption capacity by peat moss. The experimental data of the adsorption process by both peat moss and peat moss derived biochar were found to follow Langmuir isotherm model for all the tested heavy metals. Maximum sorption capacity for Cd, Cu and Pb by peat moss derived biochar was 39.8 mg/g, 18.2 mg/g and 81.3 mg/g, respectively. Maximum sorption capacity calculated for Pb was significantly higher by peat moss derived biochar than peat moss. However, pyrolysis of peat moss did not increase sorption capacity for Cd and Cu. Increase in Pb sorption by biochar might be related to the high pH of biochar (9.27) compared to the pH of peat moss (3.77) because Pb easily precipitates at alkaline pH. The sorption of Cd, Cu and Pb on peat moss and peat moss derived biochar appears to follow pseudo-second-order reaction kinetics. The calculated equilibrium capacity from the second-order kinetics model was very close to the experimental value. Sorption of Cu and Pb by biochar was much quicker than their sorption by peat moss while sorption rate of Cd on both biochar and peat moss was similar.

Even though peat moss derived biochar was not very effective in the removal of Cd and Cu in water compared to peat moss, sorption capacity of peat moss for Pb has significantly increased by pyrolysis. Carbonization increases long-term stability of peat moss and as a result can enhance longevity and stability of immobilized metals. Increase of pH of biochar compared to the peat moss is favourable to plant growth. In addition, the use of biochar as a soil amendment may be beneficial due to improvement of soil physical properties.

Keywords：*Peat moss derived biochar, Heavy metals, Sorption, Isotherm, Kinetics*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Assessment of Potential Risk of Biochar from Different Biomass Sources with Seed Germination Test

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Application of biochar, by product of pyrolysis process of biomass, has attracted research interest for contaminants management such as heavy metals and organic compounds in water and soil environment. However, it has been known that boichar may contain contaminants with the nature of biomass and pyrolysis condition. Nonetheless, the majority of biochar researches showed that positive effects such as increasing nutrient retention, water holding capacity, plant growth yield, and immobility of contaminants. The objectives of this study was to evaluate the phytotoxic effects of biochars produced from various parent materials (Giant Miscanthus, municipal solid waste, and sewage sludge).

To assess safety and phytotixicity of these biochars, we conducted germination test with biochar eluate (solid/solution ratio is 1:80, w/w) on four crop seeds (Lactuca sativa, Brassica juncea, Brassica napus, Raphanus sativus). Twenty of each seeds were pressed into the plant culture laid filter paper, biochars eluate injected 5mL into each petri-dish. The petri-dish were placed in a growth chamber at 25℃ in the dark. After 72hr, the number of germinated seeds was counted, and the germination percentage was calculated by dividing control. Root lengths of the seedling were determined after 168 hr.

The germination of Lactuca sativa and Raphanus sativus in the eluate was not significantly different. However, the germination of Brassica juncea seeds and Brassica napus was lower at eluate of biochar produced from Giant Miscanthus at 400 ℃(84%), and municipal solid waste char (74%) and sewage sludge char (74%). The root growth of seedling in the eluate of all giant Miscanthus biochars showed good growth condition than municipal solid waste char and sewage sludge char. Therefore, the result of this work suggests that application of biochar to soil system should be with caution, because some types of biochars can exhibit phytotoxicity depending on the nature of parent materials and their processing conditions.

Keywords：*biochar, giant Miscanthus char, municipal solid waste char, sewage sludge char, germination test, phytotoxicity*

P2-179

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochars from a Giant Miscanthus for Removing Heavy Metals

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Biochar is becoming popular for recycling biomass into value-added products like activated carbon. Giant Miscanthus is being massively cultivated as an energy crop to produce biofuels and biochar in Korea. In this study, biochar (BC) and steam activated biochar (ABC) derived from the giant Miscanthus were applied to remove copper (Cu) as a model compound for heavy metals. The BC was produced by slow pyrolysis at 500 oC, and its physicochemical properties were characterized by SEM, elemental analysis and FT-IR. In addition, isotherms and kinetics studies were conducted to identify Cu sorption onto biochars. A toxicity testing using Daphnia magna was also carried out according to the OECD guideline 202 to evaluate the toxicity change in biochar treatments. Cu sorption rate was dependant on pH for both BC and ABC, which was abruptly increased above pH 6 likely due to precipitation of Cu. Though surface area of ABC (321.91 m2/g) was much higher than that of BC (180.96 m2/g), there was no significant difference in Cu sorption between them. In addition, both BC and ABC largely reduced the toxicity of Cu from aqueous solution. Considering that ABC itself is slightly toxic to D. magna while BC is inert, BC seems to be a promising as a sorbent for heavy metal removal. However, further studies are needed to evaluate a long-term stability and safety of biochar application.

Keywords：*Biochar, Daphnia magna, Heavy metal, Miscanthus sacchariflorus*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Role of Biochar and Nano Materials as Amendments for Immobilizing Metals in Shooting Range Soil

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High concentrations of toxic metals in military shooting range soils pose a significant environmental concern due to the potential release of metals such as Pb, Cu, and Sb as well as their metalloids. Although different amendments have been tested on metal contaminated soils, we report the potential application of biochar and nano materials to understand their effects on metal immobilization and/or release into shooting range soil. Biomass of an invasive plant (Ambrosia trifida L.) and its derived biochar produced at 300 and 700 °C, gibbsite, and silver nanoparticles were applied as soil amendments to shooting range soil in a 1-year laboratory incubation experiment. All amendments were applied on a weight basis either at 5 (biochar) or 0.1% (nano materials). The changes in metal bound phases of Pb, Cu, and Sb were investigated by destructive (chemical extractions) and non-destructive (molecular spectroscopy) methods. Ammonium acetate extractable and leachable metals were determined by 1 M ammonium acetate extraction and the toxicity characteristics leaching procedure (TCLP), respectively. At the end of the incubation period, pH increased by 1–2 units in the biochar treated soil but was not affected by the other amendments. All amendments reduced Pb and Cu availability compared to that in the control. Particularly, biochar had greater potential for increasing soil cation-exchange capacity than other amendments. Biochar produced at 300 °C was the most effective amendment showing maximum reductions of 94 and 70% in Pb and Cu bioavailability, respectively. Similarly, Pb and Cu leachability decreased significantly (77 and 79%, respectively) in soils treated with biochar, which may have been due to the greater abundance of functional groups in biochars. In contrast, Sb leached out in all treated soils except in the soil treated with biochar produced at 300 °C. Mechanisms for metal immobilization and soil biological activities will be further evaluated to understand the effects of biochar and nano materials on soil quality. This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Education, Science and Technology (Project number: 2012R1A1B3001409).

Keywords：*black carbon, charcoal, availability, nanoparticle, slow pyrolysis, synchrotron*

P2-181

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Amelioration of Acid Soil Using Biochar

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Biochar was used to improve the quality of acidic soil (initial pH of approximately 5) with respect to soil pH and exchangeable cations. Acidic soil was treated for pH improvement and exchangeable cation enhancement for 1 month with both soy bean stover- and oak-derived biochars in the range of 0 to 5 wt%. The treatment effectiveness was assessed in a maize growth experiment using the biochar-treated soil samples. After 1 month of curing, the treatment results indicated that the pH was increased more than 2 units in the 5 wt% amended soils for both biochars. The soil pH increase was more pronounced for the soybean stover derived biochar than the oak derived biochar. This may be attributed to the higher content of Ca in the soybean stover derived biochar compared to the oak derived biochar. The exchangeable cation values were also enhanced upon treatment in the 5 wt% amended soils for both biochars, after 1 month of curing. The highest exchangeable cation values of 8.11 and 4.93 cmol+/kg were attained upon addition of 5 wt% soybean stover- and oak-derived biochar, respectively. The growth of maize was superior in the biochar amended rather than the untreated soil samples. The presented results demonstrate that amelioration of acidic soil using biochars derived from soy bean stover and oak is beneficial for maize growth since soil pH was greatly improved and nutrients were replenished.

Keywords：*Biochar, Amelioration, Soil pH, Exchangeable cation, Maize growth*

P2-182

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Removal of Hexavalent Chromium in Aqueous Solutions Using Different Biochars

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Hexavalent chromium is considered more hazardous and toxic than trivalent Cr through all exposure routes due to its mutagenic and carcinogenic properties. Among many sorbents, activated carbon (AC) has shown promising results in removing Cr(VI) in water and wastewater. However, given the high production cost for AC, biochar can step in place of AC for cost efficiently. Hence, the objective of this research was to identify the potential of different biochars in removing Cr(VI) and to identify bichar properties related with Cr(VI) removal. Biochars (BCs) pyrolyzed from different feedstocks (plants and animal waste) were used to remove Cr(VI) in aqueous solutions. Batch adsorption experiments were carried out with 50 mg/L initial Cr(VI) concentration at pH 4. Results showed that the capacity of biochars in removing Cr(VI) were related to their physicochemical characteristics. The highest adsorption rate was observed in AC (23.75 mg/g), which was about 1.4 times higher than the best biochar for Cr(VI) removal (16.48 mg/g). However, when the adsorption data were normalized to the surface area, burcucumber (Sicyosangulatus L.) biochar produced at 300 0C showed the maximum adsorption (17.61 mg/m-2) while demonstrating the highest significant differences among others, which may be due to the availability of surface functional groups. BCs surface area showed the highest Pearson correlation coefficient to Cr adsorption to plant biomass-derived BCs. Nevertheless, the percentage of H of BCs was highly correlated with the Cr adsorption to animal waste-derived BC. Mechanisms for Cr(VI) removal by biochars will be further evaluated to understand the predominant factors. This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Education, Science and Technology (Project number: 2012R1A1B3001409).

Keywords：*chromium, activated carbon, charcoal, black carbon, slow pyrolysis*

P2-183

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Corn Residue Biochar on Hydraulic Properties of Sandy Loam Soil

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Applying biochar (BC) to soil is gaining global attention because of its ability to enhance soil quality and carbon sequestration. BC is a carbon-rich porous material produced by biomass pyrolysis. The relatively high specific surface area and porosity of BC alter the soil physical properties. This study was designed to assess the effects of BC application on hydraulic properties of sandy loam soil. Dried corn residue was pyrolyzed at 500 oC at a rate of 7 oC min-1 under a limited air supply. Soil was collected from experimental plot of Kangwon National University, Chuncheon, Korea and was air dried and 2 mm sieved. The BC was added to soil at 0, 2.5, 5.0, 7.5, and 10% (ww-1) and each treatment was conducted in triplicate. The saturated hydraulic conductivity (Ks), water holding capacity (WHC), and bulk density (BD) were determined for each sample, and the particle size distribution of the BC was assessed. Ks exhibited a significant exponential decrease with increasing BC application rate. BD was also significantly correlated with increasing application rate of BC. Additionally, WHC increased exponentially with a strong correlation with BC application rate. The results of the particle size distribution showed that adding a BC may affect soil physical properties by enhancing or changing soil micropore and hydraulic characteristics. This study was supported by the Korea Ministry of Environment as the Geo-Advanced Innovative Action Project (G112-00056-0004-0).

Keywords：*black carbon, charcoal, soil amendment, saturated hydraulic conductivity, soil aggregate*

P2-184

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Combined Effects of Carbon Nanotube and Biochar on Phytotoxicity of Heavy Metals in Shooting Range Soils

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Multi-walled carbon nanotube (MWCNT) and biochar (BC) may affect plant phenotype and soil microbiota. However, data reporting the effect of both MWCNT and BC on heavy metals (HM) in soils are scared. Hence, we examined the effect of MWCNT and BC on soil quality, phytotoxicity and HM immobilization in shooting range soil. Biochar was produced by slow pyrolysis of soybean stover at 300 ºC for 2 hrs at a rate of 7 ºC/min. Sandy loam soil comprised of total Pb as 17461, Cu as 1168 and Sb as 164 mg/kg was collected from a shooting range in Korea. Soil incubation and pot experiments with lettuce plants (Lactuca sativa L.) were conducted in triplicate with 0.5, 1 and 2.5 % (w/w) of both MWCNT and BC together and separately with control experiments lasting for 14 and 30 days, respectively. Dissolved organic carbon (DOC) and microbial analysis were performed, as well as single extractions of Pb, Cu and Sb by NH4OAC, DTPA, CaCl2 and NaNO3. Incubation results have revealed that the introduction of CNT alone slightly decreased DOC, TCLP-Pb, and TCLP-Cu by an average of 17.1, 6.7, and 19.0 %, respectively, when compared to the control. In addition, CNT decreased Pb and Cu concentration in single extractions with the increase of CNT application. Maximum extraction of heavy metals was observed from DTPA, whereas the minimum was reported with CaCl2, indicating a reduction of the bioavailable fraction. Based on pot experiment, CNT or BC or CNT+BC treatments increased plant height by 1-2 times more than that in the control. This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Education, Science and Technology (Project number: 2012R1A1B3001409).

Keywords：*Nano materials, Soil amendment, bioavailability, black carbon, charcoal*

P2-185

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effects of Biochar and Polyacrylamide on Decomposition of Organic Matter and 14C-Labeled Alfalfa Residue in Soil

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Biochar as soil amendment is gaining global attention due to its ability to enhance soil fertility and carbon sequestration. Polyacrylamide (PAM) is known to stabilize soil aggregate and to reduce soil erosion. These soil amendments may alter decomposition of native organic matter (OM) and crop residue in soil. An 80-day incubation experiment was carried out to investigate the effects of BC (10 Mg ha-1), anionic PAM (80 kg ha-1), and their combination (BC+PAM) on decomposition of OM and 14C-labelled alfalfa (Medicago sativa L.) residue in soil. Results showed that the BC and BC + PAM treatments decreased cumulative CO2 effluxes during 4-17 days of incubation by an average of 8.7% compared to that in soil with crop residue. BC and BC + PAM treatments significantly decreased the decomposition of crop residue by 5.3-8.3% compared to the control soil in the presence of crop residues. PAM increased cumulative CO2 effluxes during 55-80 days of incubation by an average of 6.7% compared to those in soil with crop residues. However, PAM did not affect the decomposition of crop residue after 80 days of incubation compared to soil in the presence of crop residues. BC had negative effects on added or native carbon (OC) due to its high sorption affinity for OC and/or labile crop residue substrates to its surface, providing physical protection for the dissolved C from soil microbial decomposition. Taken together, the BC and BC + PAM treatments applied with crop residues enhanced the native SOC or added C sequestration in soil over the long-term. This work is supported by the Korea Ministry of Environment as 'Geo-Advanced Innovative Action Project (G112-00056-0004-0).

Keywords：*crop residue, priming effect, soil organic matter, cahrcoal, black carbon*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Biochar on the Physico-Chemical Properties of Horticultural Growing Media and Plant Response

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Commercial horticultural growing media is generally composed of organic material such as coir dust and peatmoss, and inorganic material such as perlite and vermiculite. Korean horticulture industries are highly depending on the imported raw materials for manufacturing the growing media. Therefore, it is required to search out any prospective local based raw materials to substitute the imported materials. The current study was conducted to examine applicability of rice-hull derived biochar as horticultural growing media. For this, biochar was incorporated with a growing media and changes in physico-chemical properties were determined followed by growth study to show plant response on the incorporation of biochar.

Rice hull-derived biochar was incorporated to the growing substrate consisting of coir dust, perlite, and vermiculite at 0, 1, 2, and 5% (w/w) level. Then the mixture was analyzed for physical properties including dry bulk density, particle density, total pore space, water volume, air volume, and water retention. Also, chemical properties including pH, EC, NH4+, NO3-, P, K, Ca, Mg, organic matter content and ash content were analyzed. Plants (Cucumber (Cucumis sativus L.) and Kale (Brassica oleracea L. var. acephala)) were cultivated using the mixture for 25 days in association with supplement of nutrient solution. While the nutrient solution was supplied on top of the media every two days, the drainage was collected at every third irrigation and analyzed for the concentration of cations (NH4+, Ca2+, Mg2+, K+) and anions (NO3-, PO4-, Cl-, SO4-). Twenty-five days after cultivation, the shoot and root were harvested separately. Then the dry weight and nutrient (N, P, K) contents were determined.

Biochar application resulted in increase of water retention, nutrient adsorption and cation exchange capacity. In addition, it appeared that Ca2+, Mg2+, K+ and NO3- concentrations in drainage water decreased when biochar was incorporated. Decreased cations in drainage were attributed to the elevated CEC after biochar incorporation and nitrate decrease was also probably due to adsorption of nitrate onto the biochar particles. In the plant growth study, growth rate of kale increased as biochar incorporation rate increased while there was no significant difference in growth rate of cucumber except 5% biochar treatment. From this result it might be concluded that the rice hull-derived biochar could be introduced as a raw material for horticultural growing media.

Keywords: *Horticultural growing media, Rice hull-derived biochar, Nutrient, Cucumber, Kale*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Zncl2-Activation in Tabacco Waste Biochar on Adsorption Capacity of Phosphorus

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The use of biochar to remove phosphorus from wastewater has been still a relatively less explored. Little research has been conducted to explore the phosphorus removal potential of biochar. Thus, the effect of ZnCl2-activation on the adsorption of phosphorus onto the tabacco waste biochar was investigated. Also, the longevity of tabacco waste biochar for phosphorus removal was investigated in column experiment. The adsorption characteristics of phosphorus in tabacco waste biochar were determined by the Freundlich and Langmuir adsorption isotherm equations. The adsorption capacity of phosphorus in tabacco waste biochar with ZnCl2-activation was higher than tabacco waste biochar without ZnCl2-activation by the Freundlich and Langmuir isotherm equations. In column experiment, the longevity of tabacco waste biochar with ZnCl2-activation for phosphorus removal was longer than that without ZnCl2-activation. Tabacco waste biochar with ZnCl2-activation is a promising alternative adsorbent for treating phosphate from wastewater. Therefore, tabacco waste biochar with ZnCl2-activation can be used to treat the phosphate from wastewater.

Keywords：*Biochar, Freundlich adsorption isotherm, Langmuir adsorption isotherm , Phosphorus, Tabacco waste*

P2-188

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Biochar Amendment on the Chemical and Physical Properties of Reclaimed Tidal Land Soil and Maize (zea Mays L.) Response

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The quality of the soil from reclaimed tidal land known not to be productive for crop cultivation due to unfavourable physicochemical properties makes soil amendment necessary. The current study examined the applicability of biochar produced from rice hull to improve the physicochemical properties of reclaimed tidal land soil. For this, biochar was applied to the reclaimed tidal soil (5 kg) at 0, 1, 2, and 5% (w/w) level and then the incubation and maize cultivation studies were carried out at the same time. During maize cultivation for 6 weeks, 0.1% NaCl solution was supplied from the pot bottom to simulate the natural reclaimed tidal soil. The amendment effect was evaluated through determining water stable aggregate (WSA), exchangeable cations, growth of maize, and antioxidant enzyme activity including ascorbate peroxidase (APX) and glutathione reductase (GR). The same experiment was performed with bottom ash treatment of bottom ash at the same levels for comparison.

Both biochar and bottom ash showed increase in WSA percentage. The increase of WSA with biochar was related with elevated organic carbon contents in soil ($p<0.0005$) from applied biochar while no relationship with any examined soil properties was found with increased WSA rate in bottom ash applied soils. Increase in WSA percentage induced maize growth showing the highest increase of dry matter from 5% biochar treatment. In addition, biochar incorporation resulted in decrease of Na content in maize tissue and subsequent decline of APX and GR activity. This was probably attributed to the high concentration of K in biochar which might mitigate Na uptake by maize.

Keywords: *Rice hull-derived biochar, Reclaimed tidal land soil, Water stable aggregate, Sodium, Maize.*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Mono- and Multi-Nutrient Adsorption of Nitrate-N, Ammonium-N and Phosphate-P in Activated Sesame Biochar

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The objectives of this study were to investigate the adsorption capacities of NO3-N, NH4-N and PO4-P in activated sesame biochar loaded with ZnCl2 in mono- and multi-nutrient solution. The adsorption capacities of nutrients in activated sesame biochar were in the order of PO4-P >> NH4-N > NO3-N in mono-nutrient solution, and PO4-P >> NO3-N ≒ NH4-N in multi-nutrient solution using Freundlich adsorption isotherm. The maximum adsorption capacities of nutrients in mono-nutrient solution were higher than those in multi-nutrient solution using Langmuir adsorption isotherm. The maximum adsorption capacities (mg g-1) of nutrients in activated sesame biochar were in the order NH4-N (10.21) >> PO4-P (5.01) ≒ NO3-N (4.86) in mono-nutrient solution using Langmuir adsorption isotherm. On the other hand, the maximum adsorption capacities (mg g-1) of nutrients in activated sesame biochar were in the order NH4-N (2.75) >> NO3-N (1.86) ≒ PO4-P (1.44) in multi-nutrient solution using Langmuir adsorption isotherm. The maximum adsorption capacities of NH4-N in activated sesame biochar were higher than other nutrients in mono- and multi-nutrient solutions. The nutrients became more mobile in multi-nutrient than in mono-nutrient conditions. Results from the batch experiment show that competitive adsorption among nutrients increases the mobility of these nutrients.

Keywords：*Activated sesame biochar, Langmuir adsorption isotherm, Freundlich adsorption isotherm, mono-nutrient, multi-nutrient, Nitrate-N, Ammonium-N, Phosphate-P*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Sesame Stalk Biochar on Growth and Nutrient Contributions of Green Manure Crops of Gramineae and Leguminous Species in Rice-Green Manure Crop Rotation

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Application of biochar to soils is gaining considerable interest globally due to its potential to improve soil nutrient retention capacity, crop productivity and carbon sequestration in soil. In this study, for effects on single application of sesame stalk biochar (SSB) to paddy soil, growth and nutrient contributions of green manure crops of gramineae and leguminous species were investigated under different amount application of SSB. Sesame stalk biochar in this study was obtained from pyrolysis at 400℃ for 1hr. Gramineae crop used was Hordeum vulgare L. (green barley), and leguminous crop was Vicia villosa roth (hairy vetch). The amount application of SSB into paddy soil was designed with SSB250 (SSB of 250 kg 10a-1), SSB500 (SSB of 500 kg 10a-1) and SSB1000 (SSB of 1,000 kg 10a-1). By treating SSB in paddy soil, fresh weights of gramineae crops (green barley) and leguminous crops (hairy vetch) were increased as compared to paddy soil without SSB. The increase rates of biomass were higher in the order of 1,000 kg 10a-1 > 500 kg 10a-1 > 250 kg 10a-1 in all conditions as compared to paddy soil without SSB. By treating SSB, the increase rates of biomass and nutrient contributions in gramineae crops were generally higher than those in leguminous crops. Especially, nutrient contributions of gramineae crops were higher than that of leguminous crops. Therefore, gramineae crops in this study were more efficient green manure crops paddy soil with SSB than leguminous crops in rice-green manure crop rotation.

Keywords：*Biochar, Green manure crop, Growth, Nutrient contribution, Sesame stalk*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Bamboo Biochar on Mitigation of Greenhouse Gases in Lettuce Cultivation

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Greenhouse gases are increasingly due to industrial and agricultural activities. Especially, application of chemical fertilizer to increase growth and yield of plants is necessary for agriculture because greenhouse gases in paddy and upland soil are occurred. Biochar could be one of the most important technology reducing global warming. The objective of this study was to evaluate the mitigation of CH4 and N2O by application of biochar in lettuce cultivation. Biochar was obtained from pyrolysis 400℃ in 4 hour using bamboo. The field experiment was designed with C (control: non fertilizer and biochar), F (fertilizer: NPK), B500 (biochar 500 kg 10a-1), B1000 (biochar 1000 kg 10a-1), B2000 (biochar 2000 kg 10a-1) and B5000 (biochar 5000 kg 10a-1). Moisture and yield of bamboo biochar were 5.43 and 42.1%, respectively. Bamboo biochar was 9.71 for pH and 14.7 dS m-1 for EC. The concentrations of TN, TP and K2O in bamboo biochar were 1.28, 0.72 and 1.98%, respectively. The emission of CH4 in lettuce cultivation was reduced with increasing amount of bamboo biochar application. The emission of N2O in B5000 treatment was lower than those in other treatments. Therefore, our results indicate that application of bamboo biochar can reduce greenhouse gases emission in upland crop field.

Keywords：*Bamboo biochar, Biochar, Emission, Greenhouse gas, Upland*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Soybean Stover Biochar on Growth of Chinese Cabbage under Different Pyrolysis Temperatures

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Biochar can be obtained from pyrolysis of various biomass in anaerobic condition. Biochar studies are globally interested by a number of researchers due to reducing greenhouse gas, plant growth and effective soil amendment. The aim of this work was to evaluate biochar made by soybean stover under different pyrolysis temperatures for increasing growth of Chinese cabbage (CC). Production of biochar under different pyrolysis temperatures (400, 500, 600 and 700℃) in 4 hr condition was performed. Treatment conditions were C (control: non fertilizer and biochar), F (fertilizer: NPK), 400B (400℃ biochar), 500B (500℃ biochar), 600B (600℃ biochar) and 700B (700℃ biochar) and amount of biochar application was 1000 kg 10a-1, respectively. The agronomic (pH, EC, C, H and N) and major nutrient (TN, TP, K) properties of soybean stover biochar were investigated. Growth of CC was investigated at 90 days after application biochar. The yield of soybean stover biochar was higher 33.5% at 400℃. The pH and EC of soybean stover biochar were higher in the order of 700℃ > 600℃ > 500℃ > 400℃. C ratio of biochar derived soybean stover was increasingly higher at greater pyrolysis temperature. In contrast, H and N ratio of biochar derived soybean stover were decreasingly lower at greater pyrolysis temperature. The concentrations of TN in soybean stover biochar at 400, 500, 600 and 700℃ were 2.50, 1.36, 0.94 and 0.73%, respectively. On the other hand the concentration of TP in soybean stover biochar was 1.54% for 400℃, 1.58% for 500℃, 1.59% for 600℃ and 1.79% for 700℃. The concentration of K in soybean stover biochar at 400, 500, 600 and 700℃ were 2.93, 3.19, 3.53 and 3.78%, respectively and were higher than other pyrolysis temperatures. Height of CC in 400B treatment was higher than other treatments. In 400B treatment, biomass of CC was higher than other treatments. Therefore, biochar application for increasing growth of Chinese cabbage was useful in agricultural.

Keywords：*Agronomic properties, Biochar, Chinese cabbage, Nutrient properties, Soybean stover*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Adsorption Characteristics of Heavy Metals by Pepper Stalk Biochar

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Biochar is obtained by pyrolysis of biomass under anaerobic conditions. Biochar can fix CO2 and adsorb heavy metals. Recently, a number of studies about biochar made by agricultural by-products have been conducted. In many studies, biochar produced at high pH condition is known to absorb heavy metals in soil. Accumulation of heavy metals in soil effects the growth inhibition of crops and the collapse of the food chain. Especially, heavy metal contamination of soil around the abandoned mine is serious. This investigation was conducted to explore heavy metal removal potential of biochar in soil. The adsorption characteristics of heavy metals by pepper stalk biochar was investigated by SEM-EDS and heavy metal removal was studied using Freundlich and Langmuir equations. Freundlich and Langmuir adsorption isotherms were used to model the equilibrium adsorption data obtained for adsorption of heavy metals on biochar produced from pepper stalk. Pb, Cu, Cd and Zn equilibrium adsorption data were fitted well to the two models, but Pb gave a better fit to Langmuir model. Heavy metals were observed on the biochar surface after adsorption by scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS). In soil, the removal rates of heavy metals were higher in the order of Pb > Cd ≥ Cu > Zn, showing that the adsorption efficiency of Pb was higher than those of any other heavy metals. The two sharp peaks at 1600 cm and 1450 cm-1 corresponding to the vibration of C = O and -CH2- groups by FT-IR analysis. Thus, biochar produced from pepper stalk could be useful adsorbent for treating heavy metal contamination in soil around the abandoned mine.

Keywords：*Abandoned mine, Adsorption, Biochar, Heavy metals, Pepper stalk*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Wood Waste Biochar from Roadside Trees on Adsorption of NH_4-N and Cd

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Statistics showed that there are 5,481,678 roadside trees in Korea as of 2011. Trimming of roadside trees produces tremendous amount of wood waste annually. In 2009, the amount of the wood waste produced in Seoul by trimming was about 5,100 tons. The majority of wood waste has been disposed of either by incineration or landfill. Therefore, this study was performed to recycle the wood waste as adsorbent by making biochar through pyrolysis. The wood waste from zelkova (*Zelkova serrata*), platanus (*Platanus occidentalis*), cherry (*Prunus yedoensis*) ginkgo (*Ginkgo biloba*), and birch (*Betula platyphylla* var. japonica) trees produced in Seoul were used in this study. Wood waste was crashed , dried at 70℃, followed by pyrolysis at 300℃, 500℃, and 700℃, repectively. Physico-chemical properties of the biochar; pH, EC (electrical conductivity), CEC (cation exchange capacity), ash content, C content, BET (Brunauer-Emmett-Teller) surface area and FT-IR (Fourier transform infrared spectroscopy) were analyzed. Adsorption characteristics of NH_4-N and Cd by biochar in aqueous solution were tested for investigation of potential as adsorbents.

Properties of biochar were different by tree species and temperature of pyrolysis. With increasing temperature, pH, EC, BET surface area, and ash content of the biochar increased. While CEC, C content, C recovery rate, and functional group peak at FT-IR analysis decreased with increasing temperature. Result of adsorption experiment showed that biochar produced at 500℃ had the highest NH_4-N removal efficiency in the adsorption experiment. The NH_4-N removal efficiency of ginkgo biochar was the highest among all biochars. In Cd adsorption experiment, All of the biochars produced at 700℃ had the highest Cd removal efficiency and the maximum amount of adsorbed Cd by Languimir adsorption isotherm. All the biochars produced at 300℃ showed the lowest Cd removal efficiency and the maximum amount of adsorbed Cd. Cadmium removal efficiency of biochar from ginko tree was better than that of other tree species. As a result, wood waste biochar showed potential as adsorbent for NH_4-N and Cd. The biochar from ginkgo was more efficient than that from other tree species in adsorbing NH_4-N and Cd.

Keywords：*Biochar, Wood waste, Contaminant, Adsorption, Roadside tree*

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[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Effect of Biochars, Red Soiland Vermicomposton the Availability of Arsenic to Raphanus Sativus

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Agricultural soilscontaminated by arsenic (As)has become an importantissue as a result of industrial activities, excessive application ofcontaminated fertilizers and manures, and irrigation withmetal(loid)s-contaminated water. This study investigated the effect of organic amendments [vermicompost (5%w/w), and hairy vetch and poultry manure biochars (2%w/w) at two temperatures (450 and 700OC)]and red soil (RS-2% w/w) on the availability of As in radish (Raphanussativus) in a highly contaminated As (1341.54 mg As kg^{-1}) soil. Red soil was also combined with biochars to study the availability of As to radish because red soil reduced the extractable As when incubated with contaminated soil. The soil was incubated with amendments for a week and used for pot experiment. Although the radish plants showed some toxic symptoms, in general, there were less visual growth differences between the control and the treatments. The dry matter content of the amendment-treated plants was only slightly higher than the control. There was no significant difference in dry matter content among the biochars, vermicompost and red soil and also between biochars at different temperatures. After the completion of the experiment, the soils were analysed for extractable As, pH and DOC concentrations. While the extractable As increased in all the treatments, the pH decreased, and the DOC concentrations were not altered much. Although the extractable Asincreased in all the treatments, biochars,significantlyreduced the uptake of As compared to the control. Poultry manure biochar decreased As at a higher rate when compared to hairy vetch biochar, and the reduction percentage was significantly higher at higher temperature. Red soil and vermicompost also reduced the availability of As to radish but the percentage of reduction was similar to hairy vetch biochar at 450OC. Also, red soil in combination with biochars reduced the availability of As but the percentage of reduction was similar to biochars at 450OC. This study shows the effectiveness of biochar and red soil in the phytoremediation of As-contaminated soils. Results may vary, depending on types of biochar and temperature of pyrolysis during the formation of these biochars. However, a field experiment is required to confirm the results obtained from the glass house study to carefully understand the behavior of these amendments in the presence of Asat different application rates.

Keywords：*Arsenic, Radish, Biochars, Red soil, Vermicompost*

P2-196

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Biochar Effects on Crop Yields in a Calcareous Soil

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It remains unclear if biochar applications to calcareous soils improve crop yield. To resolve this question, a long-term field experiment to determine the effect of biochar on crop yields and soil properties was established in a calcareous soil in 2009, with five treatments: (1) Straw incorporation, (2) straw incorporation with inorganic fertilizer, (3) straw incorporation with inorganic fertilizer, and biochar at 30, 60, and 90t ha-1, respectively. The annual yields of winter wheat and summer maize were not increased significantly following biochar application, whereas the cumulative yields over the first 4 growing seasons were significantly increased. Soil pH, measured in situ, was increased by a maximum of 0.35 units after 2 years following biochar application. After 3 years, soil bulk density significantly decreased while soil water holding capacity increased with 90 t biochar ha-1, alkaline hydrolysable N decreased following biochar application while exchangeable K increased, and 0.5 M NaHCO3 extractable (Olsen) P did not change compared to the treatment without biochar. The results suggested that biochar could be used in calcareous soils without yield loss or significant impacts on N availability.

Keywords：*biochar, calcareous soil, crop yield, soil pH, long-term effect*

P2-197

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

The Effect of Biochar on Water Vapor Movement in Soil During Winter Period Revealed with Stable Isotope Technology

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Water movement in freezing soils is an important link of water cycle in nature, and it's also important for agriculture, water resources and environmental systems. Biochar additions to soils can have consequences on soil physical and chemical properties. Pores and particles in different sizes of biochar will impact energy balance, vapor transport, and water movement of soil in field condition. Micro-plot experiment was set up to test the effect of biochar on soil moisture in wintering period, and the effect of biochar on soil water osmotic potential as well. The amount of sublimation and upward moving water was calculated using stable isotope techniques and Isotopic Mass Balance (IMB) method.

Biochar additions have obvious effect on surface soil water content of wintering period in field condition, and these effects are different in soils with different textures.6% biochar addition increase 24%,14%,10% of water retention capacity before winter and 13%,22%,7% of water retention capacity after winter of sand, loam and clay.

The phenomenon of water increase in soil after frozen occurs significantly in surface soil during wintering period, mainly in the 20-30 cm layer. Biochar additions can depress the water increase, and the decrease range is sand > clay > loam. For sand, the water increase in soils with 3% and 6% biochar addition is 6% and 0%, both less than 19% in no biochar added soil; for loam, the water increase in soils with 0, 3%, 6% biochar addition is 19%, 14%, 17%, respectively; for clay, the corresponding water increase is 44%, 14%, 24%.

Soil water δ 18O values of different treatments during wintering period varies significantly, which means soil water also varies. According to the results of IMB, the order of the account of upward moving water (kg/m2) is clay (6.9)> sand (4.3)> loam (3.3) with no biochar addition; with 3% biochar addition, clay (6.9)> loam (4.5)> sand (1.8); with 6% biochar addition, clay (5.8)> loam (5.2)> sand (-0.6). The water increase in soil after frozen depends mainly on the upward moving water, and biochar additions decrease the water increase in soil after frozen.

Biochar additions also affect the osmotic potential. Biochar addition increase the osmotic potential of below 20-30cm layer of all three kinds of soil with different texture, and 6% biochar addition increase the osmotic potential more obvious.

Keywords：*Biochar, winter season, vapor movement, isotope mass balance*

P2-198

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

The Difference and Characteristics of Salt Leaching in the Saline Soil Added with Different Rates Of Biochar

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Background and aims Biochar is produced from the pyrolysis of organic materials, with the characteristics of high carbon concentrations, porous structure, huge specific surface area and various functional groups. When buried into soil it can act as a long term soil carbon store. Evidence suggests that biochar can improve plant growth, increase crop yields, reduce nutrient leaching and stimulate microbial activity. Moreover, as a soil conditioner, biochar can significantly improve soil fertility. But few data have been obtained on the impacts of biochar on salt leaching of saline soil. Therefore, the aim of this study was to investigate the effect of biochar on leaching of salts and ions from the saline soil.

Methods In this experiment, different rates of mushroom medium biochar (0%, 2%, 5%, 10%, w/w) were added into 0-20 cm surface soil in a sulfate saline soil column collected from Hetao Inner Mongolia. Following washing with deionized water, the eluent was collected and measured for electrical conductivity (EC) and main ions. At the end of the leaching, the contents of main ions in the leached saline soil profile added with different rates of biochar were also measured.

Results The results showed that the eluent from biochar-amended columns appeared much earlier, by 5~36 days ahead. The duration of EC reduction to lower than 5mS/cm was shortened by 41~100 days. Moreover, the more the biochar added, the earlier the eluent was collected and the sooner the EC was reduced to lower than 5mS/cm. It was thus obvious that the biochar could shorten salt leaching time and increase salt leaching efficiency as well. However, biochar addition had not significant effect on the leaching order and rate of the salt ions. Besides, the contents of salt ions in the tested soil was quite high, after the leaching, all of them have significantly decreased. Such as contents of Na+, Cl- and SO42- have respectively decreased by 65%, 86% and 95% in surface soil. The exception were that contents of CO32- and HCO3- have increased in all the soil, and the content of K+ has also increased by 16-115% in surface soil of null and low biochar-added treatments.

Conclusion Addingbiochar into saline soil can accelerate salts leaching significantly and shorten leaching time greatly. What's more, the more the biochar added, the higher the salt leaching efficiency, but had not significant effect on the leaching order and rate of the salt ions. However, considering the benefit of biochar to improve soil physical, chemical and biological properties, it is great potential for biochar to accelerate salt leaching and improve soil fertility in saline soil.

Keywords：*saline soil, soil columns, biochar, salt-leaching*

P2-199

[IDS5] Biochar Soil Amendment for Environmental and Agronomic Benefits

Short -Term Effects of Seed Dressing with Azorhizobium Caulinodans on Establishment, Development and Yield of Early Maturing Maize (Zea Mays L.) in Zimbabwe

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The majority of soils in communal areas of Zimbabwe are sandy and inherently infertile and sustainable cultivation is not feasible without addition of plant nutrients. Most farmers find it difficult to raise the capital required for investments in mineral fertilizer and find it cheaper to use low nutrition animal manure. An experiment was conducted to determine the effects of nitrokara biofertiliser on early growth, development and maize yield while also comparing nitrokara biofertiliser on availability of nitrogen and phosphorous in soil. The experiment was conducted at Africa University Farm. The experiment had six treatments (nitrokara +300kg/ha Compound D, nitrokara+ 300kg/ha Compound D(7N;14P;7K) + 75kg/ha Ammonium Nitrate(AN), nitrokara +300kg/ha Compound D +150kg AN, nitrokara +300kg/ha Compound D +225kg/ha AN, nitrokara +300kg/ha Compound D + 300 kg/ha AN and 0 nitrokara+300kg/ha Compound D +0 AN). Early maturing SC 403 maize (Zea mays) was inoculated with nitrokara and a compound mineral fertilizer at 300 kg/ha at planting while ammonium nitrate was applied at 45 days after planting. There were no significant differences ($P>0.05$) on emergence % from 5days up to 10 days after planting using maize seed inoculated with nitrokara. Emergence percentage varied with the number of days. At 5 days the emergence % was 62% to a high of 97 % at 10 days after emergence among treatments. There were no significant differences ($P>0.05$) on plant biomass on treatments 1 to 6 at 4 weeks after planting as well as at 8 weeks after planting. There were no significant differences among the treatments on the availability of nitrogen after 6 weeks ($P>0.05$). However at 8 and 10 weeks after planting there were significant differences among treatments on nitrogen availability ($P<0.05$). There were no significant differences among the treatments at week 6 after planting on soil pH ($p>0.05$). However there were significant differences among treatments pH at weeks 9 and 12 ($p<0.05$). There were significant differences among treatments on phosphorous availability at 6, 8 and 10 weeks after planting ($p<0.05$). There were no significant differences among treatments on stem diameter at 3 and 6 weeks after planting ($p>0.05$).However at 9 and 12 weeks after planting there were significant differences among treatments on stem diameter ($p<0.05$).There were no significant differences among treatments on plant height from week 3 up to week 6 on plant height ($P>0.05$).However there were significant differences among treatments at week 9 and 12 ($p<0.05$). There were significant differences among treatments on days to early, 50% and 100% anthesis ($P<0.05$). There were significant differences during early, 50% and 100% days to silking among the treatments ($P<0.05$).Also there were significant differences during early, 50% and 100% days to silking among the treatments ($P<0.05$).The study revealed that inoculation of nitrokara biofertiliser at planting with subsequent addition of ammonium nitrate has a positive effect on maize crop development and yield.

P2-200

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Evaluation the Effects of Plant Growth Promoting Rhizobacteria (pgpr) on SOD, MDA and Proline Content in Two Wheat Cultivar Under Normal and Drought Stress Condition

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In order to study the effects of Plant Growth Promoting Rhizobactria (PGPR) on superoxide dismutase antioxidant enzyme (SOD), malondialdehyde biochemical biomarker (MDA) and Proline content of two bread wheat under normal and drought stress condition, the experiment wase done in field agricultural research Islamic Azad University (IAU) of Karaj branch in 2010-2011. The studies were carried out in factorial experiment based on a randomized complete block design (CRDB) with four replactions and in two separate experiments under drought stress and normal conditions. The factors were PGPR at five levels, including: seed inoculation with Azotobacter chroococcum, with Azospirillum lipoferum, with Pseudomonas fluorescens, with Mixing bacteria (A. chroococcum +A. lipoferum +P. fluorescens) and control (Non-application bacteria), and two wheat cultivars, including: Tjan and DN11 and irrigation treatments at two levels, including: well watered (Normal) and drought stress (stop irrigation at after anthesis stage). The main and itntraction effects of different PGPR's, wheat cultivars and irrigation on all experimental traits were significant. The highest of SOD and lowest of MDA content were related to DN11 cultivar. Generally, inoculation of wheat seeds with bacteria, either alone or mixed, increased crop tolerance to drought stress. The result of experiment showed that drought stress increased all of experimental traits (SODs, MDA biomarker and proline). The DN11 cultivar, with mixed bacteria (A. chroococcum +A. lipoferum +P. fluorescens) increased SODs in both stress and normal condition, Inverse, MDA and proline content was decreased. According to the lowest MDA and highest SOD belonged to mixed bacteria, it can be concluded here that the bacteria can help wheat cultivars in both normal and drought conditions. Perhaps, reduction in the proline content in mixed bactetria was due to higher production of SODs and ability of this Enzyme to scavenge toxic oxygens and will cause wheat cultivars easily tolerated to drought stress. MDA reduction in mixed bacteria represents a reduction of lipid peroxidation and consequently will be remain safe biological membranes. Finally, results showed that mixed bacteria can increased wheat tolerance to drought stress and also DN11 was more tolerated to drought stress than Tajan cultivar.

Keywords：*Wheat cultivar, PGPR, Drought stress, SOD, MDA and proline.*

P2-201

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Promotion of Upland Rice Growth by Actinomycetes under Growth Room Condition

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A study was conducted to evaluate the effectiveness of actinomycetes on the growth of upland rice. Five actinomycete isolates were tested under growth room condition at the National Institute of Molecular Biology and Biotechnology (BIOTECH at UP Los Banos) to study their effects on rice root and shoot growth. Rhizosphere competence was also determined at 14 and at 30 days after sowing by comparing the cell population in the rhizosphere soil (R) with that in the non-rhizosphere soil (S) expressed as R: S ratio. In this study, actinomycetes increased root dry weight of upland rice by 24 to 71% at 14 days after sowing (DAS). Highest root dry weight (0.36g/magenta jar) was obtained with YB6y inoculation. On the other hand, inoculation did not significantly improve shoot and root fresh weight, and shoot dry weight at 14 DAS.

All five isolates were rhizosphere competent. Rhizosphere competence was assessed by comparing the cell population in the rhizosphere soil (R) with that in the non-rhizosphere soil (S) expressed as R:S ratio. The actinomycete isolates colonized the roots of upland rice with population densities ranging from 5.9 x 105 to 1.2 x 107 CFU g-1 rhizosphere soil with R:S ratios of 0.8 to 1.1 at 14 days after sowing (DAS).

The ability of actinomycetes to colonize the rhizosphere demonstrates their potential as plant growth-promoting inoculant. However, field assessment of the promising actinomycetes is needed where some factors affecting upland rice production such as weeds, decreased or excessive supply of nutrients, and moisture stress are present.

Keywords: actinomycetes, rhizosphere competence, R:S ratio

Keywords：Keywords: actinomycetes, rhizosphere competence, R:S ratio

P2-202

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Hyphal Production and Organic Matter Decomposition in Response to Summer Drought and Warming in Three Temperate Ecosystems

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The temperature in Europe is predicted to increase between 2.3 °C and 5.3 °C and contemporary decreases of summer precipitation over this century may affect mycorrhizal hyphal production as well as soil organic matter decomposition and carbon stabilization. We investigated how summer drought and warming impacts upon mycorrhizal hyphal production and decomposition of organic material in three shrublands and one temperate forest ecosystem. The study was conducted in three shrublands located in Porto Conte, Italy; Clocaenog and Peaknaze, UK and a mature forest at Achenkirch in Austria. In the Shrublands the treatment infrastructure, established in 1998, were comprised of night-time warming (+1 °C), and repeated summer drought applied by automatic retractable roofs, and controls (n=3) (Beier et al 2004). In the forest site, a replicated (n=3) warming treatment (+4 °C) was applied using underground heating cables and compared against controls. Fungal ingrowth bags filled with acid washed sand and two litter types (labile and recalcitrant) were buried at a depth of 5 cm. Each litter bag was incubated for 190 days at the Italian site, 170 days at the Austrian site, and 57 days at both UK sites. Fungal biomass was determined by the abundance of the chitin breakdown product ergosterol in the ingrowth bags. Saprophytic fungal biomass was measured by ingrowth bags installed in trenched cores. Mycorrhizal biomass was calculated by deducting saprophytic fungal biomass from total fungal biomass in the same plots. Decomposition rate as well as carbon stabilization factor (the inhibiting effect of environmental condition on decomposition of labile fraction) were calculated based on weight loss of labile and recalcitrant litter (Keuskamp et al 2013). There were no significant differences in ectomycorrhizal fungal biomass in the warming plots in Italian and Austrian sites but a trend towards a higher biomass in both sites were observed. Even though the stabilization factor reduced the decomposition rate was also reduced in drought and warming treatments at Sardinia's site. Decomposition was generally slower at the Austrian forest than the shrublands. As expected we observed higher decomposition rate in warming treatment with reduced stabilization factor in the forest site. The lower stabilization factor indicates to reducing carbon stabilization as recalcitrant carbon by the warming treatment. We assume that the microbial population community structure, biomass or activity in the Austrian forest site resulted in reduced carbon stabilization compared to the shrubland communities. At the UK sites, we observed no significant relationship between decomposition rates and carbon stabilization but this maybe a product of the shorter incubation period. Our preliminary results suggest that in the long term soil organic matter carbon loss may increase with increasing soil temperature due to decreased stabilization of litter.

Keywords: *Mycorrhizal fungal production, decomposition rate, summer drought, carbon stabilization*

P2-203

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Isolation and Identification Rhizosphere and Phyllosphere Microfungi of Keben (barringtonia Asiatica Kurz.) in Pancur Costal Forest Alas Purwo National Park East Java

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Research about isolation and identification microfungi on rhizosphere and phyllosphere of Keben (Barringtonia asiatica Kurz.) in Pancur coastal areas, Alas Puwo National Park, East Java has been done. The method used is an exploratory. The sample was plant in PDA medium and calculation of fungal colonies were calculated used Total Plate Count method. The growth colonies was moved for purified in a petri dish with a pointed method and identified morphologically by Moist Chamber. To observe the microscopic structure, this study refers to the mushroom identification book, namely Introduction to Food Borne Fungi by Robert A. Samson. Fungal colonies have different numbers after the incubation time. There are five fungal isolates were found in the rhizosphere, consist of Aspergillus, Monillia, Penicillium and Rhizopus. On the phyllosphere, five isolates were found composed of, Acremonium, Monillia, Mucor and Penicillium.

Keywords：*Microfungi, Rhizosphere, Phyllosphere, Barringtonia asiatica, Isolation and Identification*

P2-204

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Effect of Artemisia Seed-Gum in Combination with Cyanobacteria on the Arid Soil

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【Introduction】

Currently, one-third of the terrestrial land area of the world is desert, and approximately 60,000 km2 of land becomes desertified every year. In China also, about 27% area already became desertified and sandstorm causing problem. The results of previous study indicate that cyanobacteria isolated from saline soil have the potential to survive under saline conditions in the Alashan soils of Inner Mongolia, China with increase of soil C and N, decrease in soil pH, and reduction of soil temperature and evaporation, better for reclamation of degraded soil ecosystems. However it needs a long time to increase cyanobacteria in such dry area with little rainfall. In this study, we used Artemisia seed-gum and cyanobacterial strains collected from Alashan (AL-S and Nostoc flagelliforme) inoculating to the soils can be used to promote the plant growth in saline soil.

【Materials and methods】

In this study we used Artemisia seeds and polysaccharides taken from Artemisia seed grown in Alashan. It is known that Artemisia seed secrets polysaccharides, so called seed-gum to fix sandy soil and absorb rainfall water. Powdered Artemisia seed-gum (0.1g) and cyanobacteria (AL-S and Nostoc flagelliforme, 0.1g) were inoculated to the sandy soil surface and cultivated for 60 days under 25℃,16L/8D conditions, then soil pH,EC and total organic carbon(TOC) were measured. Germination and growth of Artemisia was examined (n=5).

【Results and discussion】

In our study, the inoculated of cyanobacteria decreased the soil pH of surface and subsurface soils to levels that are possible to plant growth. But the soil EC of surface and subsurface soils were no change, and also higher by inoculated with the soil crust than control. TOC showed also no particular change from control. The effect of Artemisia seed ?gum feed cyanobacteria to growth Artemisia more than control. Thus combined Sowing Artemisia seed-gum with cyanobacteria was beneficial to grow Artemisia by increased soil moisture and hardness. In such way, Artemisia seed-gum combined with cyanobacteria inoculating to the soils makes better plant growth condition in early stage in dry area for reclamation of degraded soil.

Keywords：*Cyanobacteria,Artemisia seed-gum,desertification,bioreclamation*

P2-205

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Soil Microbes Decrease Allelopathic Effects of Invasive Plants over Time by Degrading Allelochemicals

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1. Many studies that test the roles of allelopathic interactions in biological invasions especially in terms of the novel weapons hypothesis do not take into account the effects of soil microbes, which may evolve to or inherently degrade allelochemicals of introduced plants. Here we hypothesized that allelochemicals-degrading microbes may accumulate in soils over time, decreasing the importance of allelopathic interactions in biological invasions.

2. To test this hypothesis, we first studied the effects of soil microbes on allelopathic interactions of nine invasive plants using the methods of soil sterilization and controlling the amount of soil microbes. Then we further studied how invasion history or severity influences the effects of soil microbes on allelopathy and degradation of allelochemicals using a subtropical invader (Ageratina adenophora).

3. Soil microbes significantly decreased allelopathic effects of eight of the nine invasive plant species studied. Allelopathic effects decreased significantly with increasing soil microbes in all five studied invasive plants. Ageratina adenophora showed lower allelopathic effects in soils invaded heavily or moderately by the invader than in soils invaded newly. Consistently, 9-Oxo-10,11-dehydroageraphorone and 9β-hydroxyageraphorone (two main allelochemicals of the invader) were degraded more rapidly in soils invaded heavily or moderately than in soils invaded newly. The invader exhibited the highest allelopathic effects in soils deep below ground, in which the two allelochemicals were degraded the most slowly and microbe content was the lowest.

4. Synthesis. Our results indicate that soil microbes may decrease allelopathic effects of invasive plants by degrading allelochemicals, challenging the importance of allelopathic interactions in invasion success of introduced plants. It is necessary to take into account the effects of soil microbes when testing the roles of allelopathic interactions in biological invasions.

Keywords：*adaptation, Ageratina adenophora, allelochemicals, degradation, invasive plants, soil microbes*

P2-206

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Iron-Reducing and Sulphate-Reducing Bacterial Populations' Dynamics and Activities in Rice Paddy Soil under Subsurface Drainage

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Iron and sulphides toxicities are of the mains edaphic constraints that hamper rice production in West African savanna and forest lowlands. Many inland valley swamps and lowlands (rainfed lowlands, irrigated lowlands, mangrove swamps) have soil and water conditions that promote iron and sulphides toxicities in rice. Although chemical reduction processes of various types of pedogenic iron and sulphides oxides could not be underestimated, the bulk of these processes can be ascribed to the specific activity of Iron-Reducing Bacteria (IRB) and Sulphate-reducing Bacteria (SRB). The reducing conditions of waterlogged lowland soils boost iron and sulphides toxicities through the reduction of almost all iron into ferrous form (Fe2+) and sulphate reduction into sulfides. Thus, ferrous iron and sulfides productions in rice fields at high level cause rice injury.

Aiming to contribute at the improvement of rice yield in Africa, this study was developed to evaluate the impact of subsurface drainage on IRB and SRB dynamics and activities during rice cultivation.

Twelve concrete microplots field with a sandy-loam soil and a rice variety sensitive to iron and sulphides toxicities (FKR19) were used for the experiment. Soil in microplots was drained each 7 days (P1), 14 days (P2), and 21 days (P3), respectively. Control microplots (T) without drainage were prepared similarly. Same fertilization was applied for each microplot. IRB and SRB populations' evolution and the content of ferrous iron and sulphides in the paddy soil and rice rhizosphere were monitored throughout the cultural cycle using MPN and colorimetric methods, respectively. Data obtained were analyzed in relation to the type of drainage, the rice growth stage, and rice yield using the Student t test and XLSTAT 7.5.2 statistical software.

From the results obtained, the subsurface drainage reduced significantly IRB populations ($p=0,024$). However, the drainage did not affect significantly ferrous iron concentration in the rice rhizosphere ($p=0,708$). The concentration of ferrous iron ($p <0.0001$) in soil and the number of IRB ($p <0.0001$) were significantly higher during the rice tillering and maturity stages. Though the subsurface drainage did not reduced significantly SRB populations ($p= 0.187$), it however affected significantly sulphides concentration in the rice rhizosphere ($p= 0.032$). The concentration of sulphides ($p <0.0001$) in soil and the number of SRB ($p<0.0001$) were significantly higher during the rice tillering and maturity stages. Although no significant difference was observed for rice yield among drainage treatments due probably to the NPK fertilization, the control and P2 subsurface drainage showed the highest yield and the lowest concentration in sulphides and ferrous iron.

Keywords：*Iron-Reducing Bacteria, Sulphate-Reducing Bacteria, Fe II, Sulphides, Toxicity, Microplots, Subsurfa*

P2-207

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Microbial Community Diversity of Forest Soils in Northeastern and North Central USA

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In 2012 a novel collaborative study was initiated between scientists at 7 locations within the Northern Research Station of the USDA Forest Service, and additional cooperators in the Rocky Mountain Research Station, Michigan Tech University, and the Agricultural Research Service. The Northern Research Station Belowground Decomposition Study will use decomposition rates of wood standards placed in the forest floor and mineral soil in a variety of sites to assess soil productivity. The specific objectives are – (1) evaluate the effects of soil properties on wood decomposition rates; (2) estimate impacts of land management practices on wood decomposition; (3) examine the relationship between microbial diversity, wood decomposition, and several soil properties; and (4) provide parameterization information for models that incorporate carbon cycling.

Installations have been created in Queens, NY, Baltimore, MD, Somerset, MD, and at Long Term Soil Productivity (LTSP) sites in Missouri, Minnesota, Michigan and West Virginia. In addition to establishing belowground decomposition studies at these sites, which include urban forests and parks, forested wetlands, and long-term soil experiments, soil samples were collected and analyzed for belowground microbial community diversity using phospholipid fatty acid analysis (PLFA). Preliminary results suggest that the soil microbial community is dominated by bacteria (mainly gram negative) on these sites, and there are slight differences in the presence of arbuscular mycorrhizae among the sites. We hypothesize that belowground microbial diversity should be correlated with belowground decomposition rates, which in turn can be related to soil temperature and moisture variables, among others. Such information can be helpful in refining our understanding of carbon cycling in forests, and fill in gaps in existing carbon cycling models.

Keywords：*forest soils, microbial diversity, fungi, actinomycetes*

P2-208

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Bioaccumulation and Biosorption of Heavy Metals from Aqueous Solutions by Isolated Bacteria from Contaminated Soils

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Microbial biomass has high capacity for the remediation of heavy metals in the solutions of the containing of these metals. Both living (bioaccumulation) and non-living (biosorption) microbial biomass can act as effective metal scavengers. Bioaccumulation is based on the incorporation of metals inside the living biomass, while biosorption is a metabolism-independent process and metallic ions remain at the cellular surface. Most microbial cells exhibit colloidal characteristics in the adsorption of metals or hydrolyzed metals similar to those of soil mineral oxides. A large number of microorganisms such as bacteria, fungi, yeasts, and algae have been reported to bind a variety of metals to different extents in solutions. Bacteria are preferred as bioremediators more than other microorganisms because of (a) their high surface to volume ratios, (b) a high content of potentially active chemosorption sites such as on teichoic acid in their cell walls and (c) their abundance in all environments such as water and soil. They also can be easily propagated under laboratory conditions. The metal ions in solution are adsorbed on the bacterial surface through interactions with chemical functional groups such as carboxylate, amine, amide, imidazole, phosphate, thioether, hydroxyl and other functional groups found in the cell wall biopolymers. The sites for metal binding are different according to bacterium species and metals. Bioccumulation and biosorpton studies have focused mostly on the selection of metal-resistant microorganisms from polluted environments. It could be hypothesized that microorganisms of metal-polluted soils have developed tolerances to the metals and probably increased metal bioremedition capacities. Long-term application of wastewater and sewage sludge may result in the accumulation of heavy metals in soils and exert a selection pressure on soil microorganisms. The pollution of the environment with metals has led to the appearance of metal-resistant microorganisms in the soil and water of industrial regions. Therefore, it is important to explore microbes from such environments for use in metal biosorption.

The objectives of the present study are the isolation and identification of metal resistant bacteria from contaminated soils, the evaluation of their Cd and Ni bioaccumulation and biosorption potentials in the aqueous solutions of the containing of different concentrations Cd and Ni. Initially, the bacteria that had resistant to Cd and Ni, isolated from the soil of treated with sewage sludge (more than one decade) and identified by Morphologica characteristics and biochemical tests. Also Cd and Ni minimum inhibitory concentration (MIC) determined for the bacteria. Then Cd and Ni bioaccumulation and biosorption potential analyzed for these bacteria.

The results indicated that Actinomycete sp., Streptomyces sp. and Bacillus sp. had the most resistance against the presence of Cd and Ni in the environment. Bioaccumulation and biosortion experiments revealed that Actinomycete has maximum bioaccumulation, but had not observed a significant different in the biosorption of three bacteria. Bioaccumulation and biosorption by three bacteria increased to augmentationt of heavy metals, but bioaccumulation percent highly decreased and biosorption percent had not significant different. Indeed, with increasing the metals concentrations in the solution, bioaccumulation efficiency decreased by decreasing the bacteria resistance to high values of the metals; but biosorption efficiency didn't have a significant decreasing. In the both bioremediation systems (bioaccumulation and biosorption) that reviewed here, all the studied bacteria had more capacity for the Cd remediation in comparison to Ni. Amount of Cd and Ni bioaccumulation was more than biosorption in the fewer concentration, but in the high concentrations, amount of biosorption was more.

Keywords：*Bioaccumulation, Biosorption, heavy metals, bacteria*

P2-209

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Differential Response of Single-, Co- and Multi-Strain Inoculation of PGPR for Improving Growth, Physiology And Nutrient Balance of Maize Under Salinity Stress

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Salinity is one of the major limitations for sustainable agriculture round the globe. Gradual climate changes are also affecting the environmental scenario of the world leading to fluctuation in annual rainfall pattern. In Pakistan, situation is worst due to decrease in annual rainfall resulting in more aridity and soil salinity. Plant growth promoting rhizobacteria (PGPR) enhance the plant growth under salinity stress by improving plant physiology and nutrient balance. In present study, three different PGPR strains i.e. Pseudomonas syringae (S5), Enterobacter aerogenes (S14) and Pseudomonas fluorescens (S20) were employed alone (single-) as well as in their dual (co-) and multi-strain combinations for improving growth, physiology and nutrient balance of maize under various salinity levels (0.94, 4, 8 and 12 dS m-1). Results showed that maize growth decreased non-significantly at 4 dS m-1 salinity level but it decreased significantly at 8 and 12 dS m-1 salinity levels as compared to 0.94 dS m-1 salinity level. However, inoculation with PGPR containing ACC deaminase significantly improved all the growth and physiological parameters as well as nutrient status of maize under salinity stress. The response of single-, co- and multi-strain inoculation was variable at different salinity levels for improving growth, physiology and nutrient balance of maize. Comparatively effect of multi-strain inoculation was more prominent for improving growth and physiological attributes of maize as compared to single- and co-inoculation at all salinity levels. Multi-strain inoculation significantly improved shoot length, root length, dry biomass, photosynthetic rate (A), transpiration rate (E), stomatal conductance of CO2 (gs), sub-stomatal conductance of CO2 (Ci), chlorophyll contents (SPAD value), water use efficiency (A/E) and relative water contents of maize as compared to respective un-inoculated control at all salinity levels. Moreover, multi-strain inoculation also significantly improved the nutrient balance of maize plant by enhancing the uptake of nitrogen, phosphorus and potassium under salinity stress. Relatively better performance of multi-strain inoculation for improving maize growth and physiology could be due to synergy of different PGPR strains which might have resulted in cumulative effect of various mechanisms adopted by PGPR.

Keywords：*multi-strain inoculation, PGPR, salinity*

P2-210

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Microbial Dynamics in Salt Affected Soils

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Soil salinity is a worldwide problem which not only influences the physical and chemical properties of soil but may also seriously affect the microbiological properties of soil. A study was undertaken to assess the behavior of various soil microbial attributes in relation to salinity in a series of incubation experiments during 2009-12. We observed that almost all microbial attributes including microbial biomass-C (MBC), microbial biomass-N (MBN), basal soil respiration, nitrification and N mineralization were negatively correlated with increasing salinity (r = -0.89, -0.74,-0.79, -0.64 and -0.57 respectively). It was noticed that the depressive effects of sodium absorption ratio (SAR) and exchangeable sodium percentage (ESP) on soil microbial indices were much stronger than that of carbonates and bicarbonates. Both NaCl and MgCl2 induced salinity significantly reduced the rate of CO2 evolution and N mineralization during all incubation periods. The NaCl induced salinity depressed cumulative CO2 production by about 80% and N mineralization by 50% during 40 days of incubation. Whereas MgCl2 induced salinity decreased cumulative CO2 production by 95% and N mineralization by 81% during 30 days of incubation. These results suggested that the impact of MgCl2 salinity on microbial indices was stronger than that of NaCl. Moreover, the amendment of saline-sodic soil with pressmud, gypsum and farmyard manure (FYM) significantly improved the rate of CO2 evolution, N mineralization, microbial biomass-C and microbial biomass-N. The effects were more pronounced with combined application of pressmud and farmyard manure or gypsum. It was also evident that the effect of pressmud + FYM was further improved with microbial inoculums isolated from a high salt affected soil. Both wheat and maize seeds failed to germinate under the prevailing saline-sodic conditions despite repeated re-seeding and thus no data was generated in this respect. These results suggested that all microbial indices decreased significantly with increasing salinity levels indicating that soil microorganisms were sensitive to different types of salinity. Thus, salinity is a stress factor and can reduce microbial diversity and control microbial abundance, composition and functions. Although, amendments of saline-sodic soil with organic sources (such as FYM, pressmud) substantially improved microbial attributes they did not enable the germination and survival of wheat and maize sown in the soil. Nevertheless the evidence suggests that organic matter may play significant role in the amelioration of saline-sodic or sodic soils.

Keywords：*Microbial biomass, soil respiration, N mineralization, soil salinity*

P2-211

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Functional Resilience and Soil Biota Dynamics in Rain-Fed Agroecosystems

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The measurement of a soil biological property reflects the capacity of soil to function at a particular time, whereas knowledge of a soil's resilience assists in the development of systems and practices that promote a stable biological functional capability. Both human-induced and environmental stimuli and stress events can alter the composition and activity of microorganisms and fauna. Although there is a large literature on the effects of these factors on populations of soil microbes and fauna, their ability to recover after a disturbance in terms of system level function is not well understood. In this presentation, we aim to discuss latest developments in concepts and methodology for evaluating functional resilience of ecosystem functions in response to changing global environmental factors and associated change in crop management.

Modern DNA and RNA based methods have improved our ability to measure changes in the total and active populations, including rare microorganisms. We can now evaluate both microflora and fauna on an even footing and more comprehensively investigate the biological functional resilience. With the help of nucleic acid stable isotope probing we can track the flow of carbon and nutrients from substrates of varying quality through the microbial primary decomposers to the soil fauna and assess their response to stresses and stimuli. These new techniques assist with evaluating of the stability of specific biological processes, e.g. nitrification, and also the resilience of functions at the ecosystem level e.g. the N cycle.

Functional redundancy in microbial communities can contribute to their resilience, whereas species diversity and the presence of compensatory mechanisms regulate the stability of soil fauna. For example, in agricultural soils, the depletion of carbon rich microsites affects the distribution, diversity and metabolic status of microbial communities and the overall biological resilience. Differences between microflora and soil faunal groups, in size parameters (μm to cm), standing biomass, mode of living, energy requirements and turnover times, influence their relative contribution to carbon and nutrient cycling and soil functions and affect their response to environmental pressures and stimuli. Therefore, habitat structure which influences the accessibility of substrate and biotic and abiotic protection can play a critical role in biota resilience.

In the rainfed cropping regions of the world, soil biota are exposed to multiple wet-dry cycles varying in duration and intensity which can have substantial effects on biota populations and functional capability. The legacy effect of drought on soil microbiota and the food web can be a direct effect on their ability to recovery or acts indirectly through loss of available carbon and nutrients and habitat integrity. Such long-lasting stress events can also influence the resistance and resilience of biota by altering the quantity and quality of carbon inputs into soil. Fungal dominated soil food-webs, generally associated with reduced till and pasture based agricultural systems, have been suggested to be more stable than the bacterial dominated food-webs generally found in intensive annual cropping and cultivated systems. However, the contribution of plant-soil feedback on the mechanisms of resistance and resilience of various members of food web and their impact on ecosystem level function is not well understood.

We investigated the impact of 3-5 years of crop rotation, tillage and stubble retention on microbial activity, diversity and resilience in field experiments on Alfisol and Vertosol soils in South Australia and New South Wales, Australia. Crop rotation, tillage and stubble retention practices significantly influenced microbial and faunal composition and function. Exposure of soils to repeated wet-dry cycles resulted in a decline in the rate of nitrification and amoA copy number compared to those not subjected to stress, with the highest decline occurred in the soils under a legume-wheat rotation. The response of biological functions to moisture and temperature stress differed between cropping systems with lower resilience in soils from a fallow-crop rotation than under continuous cropping. The decline in the biological resilience of soils under fallow-crop rotation could be due to the boom-bust cycles of C availability. No-till systems with stubble retention showed greater stability of microbial catabolic potential than systems with stubble removed or incorporated and this effect varied with soil type. In conclusion, a better understanding of the resilience of a system is useful to evaluate the effect of changing environment on ecosystem function.

Keywords：*Resilience, biological function, diversity, microflora, fauna, climate*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Arbuscular Mycorrhizal Fungal Diversity Associated with Tea Plant (*camelia Sinensis*) Roots under Inorganic and Organic Fertilization in Acidic Soil in the East Black Sea Region of Turkey

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Arbuscular mycorrhizal fungi (AMF) are important components of natural and agricultural ecosystems, as they form symbiotic associations with the roots of most terrestrial plants. Mycorrhizal associations involve transfer of mineral nutrients from the fungus to the host plant in exchange for carbon. It is well known fact that absorption of phosphorus to the host plant is enhanced by AMF symbiosis. Some other benefits of AMF to host plants, including tolerance of water deficiency, mitigation of heavy metal toxicity, and protection from pathogens, as well as improvement in soil physical properties due to stabilization of soil aggregates by hyphal elongation. AMF can therefore have significant positive effects on agricultural systems, and improve crop growth and productivity. *C. sinensis* is well known to live in acidic soils where low P availability due to low native P content and high P fixation capacity is one of the major problems in tea agriculture. In addition, plants growing on acidic soil are often exposed to relatively severe mineral stress, including Al and Mn toxicity and P and K deficiency. The AMF–root symbiosis may help to alleviate these problems.

The East Black Sea region is a main tea production area in Turkey. However, the tea gardens are extremely old and their soils are suffering from low soil fertility due to increasing soil acidification in relation to intensive chemical fertilization during last few decades. Some tea gardens have been converted to organic farming, since soil pH was decreased due to excessive chemical fertilization. The fertilization may affect the soil microbial community structure, and change their functions in agroecosystems. In the present study, terminal restriction fragment length polymorphism (T-RFLP) analysis was performed to understand the relationships between symbiontic AM fungal community structures associated with *C. sinensis* and soil management (i.e. organic and chemical fertilization practices) and a series of soil chemical characteristics such as soil pH, EC, organic matter content, total N and plant available P.

The rhizospheric soil samples were collected from tea gardens under long-term chemical fertilization, transition between chemical fertilization and organic farming (e.g. no fertilization during 2 year) and 5-year organic fertilization in Rize, Trabzon and Artvin, the East Black Sea region of Turkey. The fine roots were collected from the rhizospheric soil samples. Whole DNA was extracted from ground fine roots. AM fungal 28S large subunit ribosomal DNA was amplified using nested-PCR with the primer sets of LR1/FLR2 and fluorescent FLR3/FLR4. Second PCR products were digested using restriction enzyme *Taq*I. AM fungal communities were characterized by T-RF profiles. The indigenous AMF related to each T-RF were estimated based on DNA sequences of AM fungal spores extracted from the soil samples and those associated with the root of *C. sinensis*.

Overall, our results indicated that soil EC and organic matter content affect the AM fungal community. No clear difference in AM fungal T-RF profiles was found among the three different fertilization managements. Fertilization practices had a slight effect on soil chemical characteristics such as soil pH, EC and organic carbon contents. The T-RF profiles obtained from soil samples with low pH were relatively similar. In comparison among different tea production areas under intensive chemical fertilization, we consider that the soil characteristics i.e. pH and EC could affect AM fungal communities better than such regional conditions such as altitude and distance did.

Keywords：*Arbuscular mychorrizal fungi, Acidic soil, T-RFLP*

P2-213

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Changes of Soil Microbial Community Structure During Soil Mineralization under Two Kinds of Shrubland in Mountainous Area of Southern Ningxia, Northwest China

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Study on the characteristics of soil microbial community structure in soil mineralization process is very crucial for a deep understanding of the mechanism of nutrient transport and transformation and improving soil quality. Two typical artificial shrub lands Caragana korshinskii and Prunus davidiana in a mountainous area of southern Ningxia were taken as test objects. In this study, soil mineralization process

in a year was examined by the methods of in situ closed-top PVC tube incubation. The basic soil physicochemical properties and microbial phospholipid fatty acid (PLFA) were measured to explore the different soil microbial community structure in the two typical artificial shrub land in the soil mineralization process. The results displayed that microorganism PLFAs in the caragana korshinskii land were higher than those in the prunus davidiana land. The soil microbial PLFA contents of two soils were highest in summer, followed by spring and autumn, and winter ($P < 0.05$). The soil had significant difference on the ratio of soil bacteria to fungi and the ratio of soil gram positive bacteria (GP) to gram negative bacteria (GN) ($P < 0.05$). The ratio of soil bacteria to fungi of caragana korshinskii in summer and antumn was higher than that in spring and winter, but the ratio of soil bacteria to fungi of prunus davidiana was lowest in winter. The ratio of GP/GN of two soils was both highest in spring. In addition, principal components analysis (PCA) revealed that microbial community structure was influenced significantly by shrub types and deposition time in our study. Meanwhile, changes of microbial community structure mainly were caused by the changes of bacteria with 16:0, 16:1n9c, 16:1n9t, 17:0, 18:0, cy19:0 and fungi with 18:2n9,12c. The soil microbial biomass correlated or significantly correlated with soil organic C, nitrate nitrogen and soil moisture, but negatively correlated with the soil pH. This showed that the physical and chemical properties of soil were closely associated with the soil microbial biomass.

Keywords：*Shrubland; soil mineralization; PVC tube closed-topin situincubation method; soil microbial communit*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Identification of Carbon Flow Derived from Callus Mediated BYT4-Type Bacteriophages in Microbial Loop in Rice Soil

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As the most abundant biological entities, viruses are increasingly recognized as a major driving force of global biogeochemical nutrient cycles. The results of many studies indicate that viruses have significant effects on primary production and microbial food webs in marine environments. However, little study has paid attention to the microbial loop driven by viruses in soil.

Tailed phages are predominant in aquatic environments, including the floodwaters of paddy fields. T4-type phages are an important component in the Myoviridae family, the order of Caudovirales in tailed phages and gene 23 (g23), which encodes the major capsid protein of T4-type phages, has been widely used to analyse T4-type phage communities and diversity in soil environments.

To elucidate whether viruses are involved in the microbial loop in rice field soil, we analysed the major capsid gene (g23) of T4-type bacteriophages in a rice field soil incubated with 13C-labelled or unlabelled rice callus cells under aerobic and anaerobic conditions. Rice callus cells were used as a model material of root cap cells, which allow us to focus on the microbial loop in the rice rhizosphere. DNA was extracted from the soil periodically and subjected to polymerase chain reaction (PCR) and denaturing gradient gel electrophoresis (DGGE) after density gradient centrifugation. Comparison of DGGE band patterns of isopycnically fractionated samples from unlabelled and 13C-callus treatments showed many bands exclusively retrieved from the heavy buoyant density fractions for 13C-callus treatment under the aerobic soil conditions. The g23 fragments retrieved from the heavy fractions were judged to be 13C-labelled and sequencing showed that their belonged to Paddy Group V, VIII or IX. Some g23 fragments were detected throughout the incubation period and some others were obtained only at the early or late incubation period. Because phages are strictly parasitic and do not proliferate outside their hosts, the 13C-labelling of phage DNA in the 13C-callus treatment indicates the flow of carbon from callus cells to phages via bacterial hosts (callus cells / bacteria / phages) under the aerobic soil conditions. T4-type phages are virulent, resulting in the release of host cell materials into the DOC pool after the infection of host bacteria. These results showed that the T4-type phages drove the microbial loop in the decomposition process of the callus under the aerobic soil conditions. On the contrary, no 13C-labelled g23 fragments were detected in the anaerobic soil incubation, which suggested that the infection trait of T4-type phages to soil bacteria was very different between aerobic and anaerobic soil conditions. This study provides strong hints for the existing of a microbial loop driven by T4-type bacteriophages in the rice rhizosphere.

Keywords：*Bacteriophage, Carbon flow, g23, microbial loop, Root cap cells*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

The Effects of Freeze-And-Thaw Cycles on Ammonium and Nitrate Availability in Highland Soils in Turkey

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Global warming may result in colder soil and thawing cycles and will increase the frequency of soil freezing-and-thawing-treated cycles (FTCs) during winter in the cool-temperate and high-latitude regions. The purpose of this study was to determine the effects of repeated freeze–thaw cycles on the avaliability of ammonium and nitrate in lab experiments on Pellustert, Argiustoll, Haplustept, Fluvaquent, and Calciorthid soils, the major soil groups in Turkey and five different nitrogen doses (0, 100, 200, 300 and 400 mg kg-1) applicated. The results demonstrated that, depending on the soil type, the freeze–thaw cycle could generally first increase the avaliability of NH4-N and NO3-N and then after decrease the avaliability of NH4-N and NO3-N a certain temperature range. The avaliability of NH4-N and NO3-N were strongly correlated with the number of FTCs. The highest NH4-N and NO3-N avaliability were found in Pellustert (59.62, and 65.58 mg kg-1), and Fluvaquent (49.90, and 54.34 mg kg-1) when refrozen at –10°C for 15 d, then thawed at +2.5°C for 18 h, and 6 times FTC in 200 mg kg-1 nitrogen doses; Argiustoll (52.34, 57.78 mg kg-1) when refrozen at –10°C for 15 d, then thawed at +7.5°C for 18 h, and 6 times FTC in 200 mg kg-1 nitrogen doses; Haplustept (62.42, and 66.99 mg kg-1) when refrozen at –10°C for 15 d, then thawed at +2.5°C for 18 h, and 6 times FTC in 400 mg kg-1 nitrogen doses; Calciorthid (61.93, 63.27 mg kg-1) when refrozen at –10°C for 15 d, then thawed at +7.5°C for 18 h, and 3 times FTC in 200 mg kg-1 nitrogen doses.. This study results showed that NH4-N and NO3-N avaliability depended as increasing the frequency of freeze–thaw processes that leads to decreased plant-available soil nitrogen, thus requires more nitrogen fertilizer in soil solution to supply adequate nitrogen during the plant-growth period.

Keywords：*Freeze-thaw cycle, Ammonium, Nitrate*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Significance of Arbuscular Mycorrhizal Fungi Inoculation on Tuber Yield of Dioscorea Alata under Moisture Stress Condition

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Root and tuber crops are among the most important staple foods in Tropical Africa, they play a vital role in food security. Majority of world population depends on tuberous crop for food and income. Water yam (Dioscorea alata L.) is the most widespread of the six economic important species of Dioscorea throughout the world but second to white yam in Africa. Effects of extreme climate events such as drought on yield of yam have become a global challenge. Yam genotypes may differ in their responses to limited quantities of soil water.

This study was conducted as a pot trial at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The responses of 12 genotypes of water yam (Dioscorea alata) under water deficit were evaluated under mycorrhizae inoculation. The trial was laid out as a factorial combination of 12 genotypes (G), two mycorrhizae (My) levels (with and without inoculum treatments) and three water levels (WL) in a randomized complete block design with three replications. Data were collected on growth and yield traits. AMF colonization differed significantly ($P \leq 0.01$) with respect to the effect of the three factors; genotypes, mycorrhizae and water stress. Mycorrhizal inoculation showed high significant ($P \leq 0.001$) influence on D. alata genotypes. Within mycorrhizal inoculation treatment, fresh tuber weight of D. alata genotypes ranged from 25.01 g (TDa02/00151) to 63.9 (TDa00/00064) while for non-mycorrhizae effect, fresh tuber weight ranged between 13.6 g (TDa02/00012) and 47.4g (TDa297) with the mean weight of 37.8g. Mycorrhizae inoculation effect also varied significantly with the level of stress imposed for fresh and dry root and tuber weight, and number of AMF spores. Mycorrhizae inoculation led to an enhancement of the performances of D. alata genotypes. Thus the use of the technology may enhance water yam production under inclement weather thereby impacting on security. There is the need to further explore the use of mycorrhizae in yam production programme especially in a drought environment.

Keywords：*D. alata, Mycorrhizal inoculation, drought, food security, tuber yield*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Effect of Halophilic Bacteria-Producing Exopolysaccharide on Some Growth Parameters of Wheat in Saline Soils

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Drought and salinity are the most important stresses which reduce crop production in arid and semiarid areas. Halophilic bacteria are just such extremophiles and the properties of their extracellular polysaccharides seem to offer numerous applications in various fields of industry. Different studies shown that the bacterial polysaccharides protects plant root-associated bacteria against both excess and desiccating soil water conditions.

In this study, effect of halophilic bacteria-producing exopolysaccharide was investigated on decreasing Saline Stresses on Some Growth Parameters of Wheat such as dry weight of roots and shoots. In First step the best isolated was selected from saline soil sample (Eshtehard). Determination of 16S rRNA gene sequences of isolates was shown that TP7 and TP5 isolates are most closely related to Bacillus subtlis subsp. Inaquosorum (T) (98.49 % sequence similarity) and Marinobacter lipolyticus SM19 (T) (97.69 % sequence similarity) respectively. Then a study was carried out in factorial form with completely randomize design on wheat. The factors included: bacteria in four levels (without inoculation of bacteria (B1), isolated bacteria TP7 (B2), isolated bacteria TP5 (B3), both isolates bacteria (B4), saline soils (in four levels of 2, 4, 8, 16 dS m-1).

The results showed that inoculated treatments had higher dry root and shoot weights rather than non inoculated treatment. This increasing has been remarkable in inoculated treatments with two bacteria(B4) in both 8 and 16 dS m-1. Inoculation with bacteria can increase plant resistance to salt and drought stresses by decreasing Na+ uptake by plant, improvement of soil structure and water holding capacity. Generally results showed that EPS can be used as a tool for reducing adverse effects of salt and drought stresses.

Keywords：*Bacteria producing-exopolysaccharide, Saline Soils, Wheat*

P2-218

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Glomalin in Alpine Soil Along an Tibetan Altitudinal Gradient is Highly Correlated with Hyphae Growth but Not Community Composition of Arbuscular Mycorrhizal Fungi

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To date the diversity of arbusucular mycorrhizal (AM) fungi and their ecological roles in alpine ecosystems on Tibetan Plateau remain largely unexplored. Two dominate plant species of Kobresia pygmaea and Carex haematostomaNees were sampled along an elevational transect from the west slope to the east slope along Mila mountain on Tibetan Plateau. The relative abundance (RA) of the two sedges in the local plant community fell within the range of 12-46% and 7%-29% respectively. Fungi communities colonizing roots of K. pygmaea and C. haematostomaNees were analyzed by PCR, cloning, and sequencing. A structural equation model (SEM) was built to analysis the biotic factors affecting glomalin content in rhizosphere soil. Roots of the two sedges of K. pygmaea and C. haematostomaNees were well colonized, and the colonization rates were within the range of 14%-40% and 15-44% respectively. Glomalin content in soil was 3.7-6.7 mg/g dry soil. Although glomalin content of K. pygmaea and C. haematostomaNees was significantly different among elevations, it did not show a clear elevation pattern. Further analysis showed that factors affecting glomalin content in SEM analyses explained 75% of the variation. The effect of AMF community composition on glomalin stock was weak. The direct effect of RA of K. pygmaea and C. haematostomaNees on glomalin content was not significant. However, the RA of K. pygmaea and C. haematostomaNees had a strong indirect effect on glomalin content and the effect was related to the growth of the extraradical mycelium (ERM). Plant richness in sampling quadrats also affected the glomalin stock and the effect was exhibited via direct and indirect paths. In conclusion, glomalin stock in alpine soils on Tibetan plateau is mainly influenced by growth of external hyphae, which is largely affected by the relative abundance of the dominated plant species (sedge plants in the present study) and plant richness, but not by the AM fungi communities in roots.

Keywords：*arbuscular mycorrhizal fungi, diversity, glomalin, sedges, grassland, alpine*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Assessing Enzyme Activities Changes of Superoxide Dismutase and Catalase in Canola under Salinity Stress

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Various environmental stresses (including biotic and abiotic stresses) are always the main reducing factors of crop production, and the main obstacles of different products to reach the potential yield. This study was carried out with the aim of evaluating the changes of superoxide dismutase (SOD), catalase (CAT) enzyme activities under salinity stress in canola. Greenhouse experiment was conducted with two varieties (Sarigol (S) and Licord (L)), four fertilizer levels (twice potassium (OP), twice zinc (OZ), twice zinc plus potassium (OZP), and optimum nutrients condition (O)) with three replications in a factorial completely randomized design for morphophysiological parameters of canola. The results showed that activity of superoxide dismutase enzyme in the pre flowering stage, and in Sarigol (S) variety was higher and has significant difference with other treatments, and it was at least 97/33% ($P < 0.05$). SOP treatment (Sarigol variety in the treatment of optimum nutrient) concerning superoxide dismutase activity was greater than SOZP, LOP, LO, LOZ, SO, SOZ, and LOZP, respectively, 33/41%, 47/06%, 48/51%, 51/95%, 54/84%, 59/12%, and 64/29%. Interaction effect of time*treatment*variety on catalase enzyme activity in OP treatment in Sarigol (S) variety at the pre flowering stage showed significant difference with other treatments ($P < 0.05$), in such a way that this variety and treatment indicated at least 25.65% difference with the others. In general, optimum nutrients treatments through promoting antioxidant system of plants and enhancing enzyme activity lead to increase of salinity stress tolerance.

Keywords：*Soil salinity, Enzyme Activity, Potassium, Zinc, Stress*

P2-220

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Recovery of Soil Microbial Biomass and Enzyme Activities Across the Chronosequence of Forest Fires in Northern Boreal Forests in Finland

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In northern boreal ecosystems fire is one of the most important disturbance factors and it is expected that the frequency and severity of these fires will increase due to global climate change. Fungi and bacteria are important drivers of soil organic matter decomposition, as they produce extracellular enzymes required to degrade litter inputs of the plants, animals and microbes. There is increasing interest in the role of boreal forests in the global carbon cycle and in feedbacks between climate change, forest fires and the carbon cycle. A more complex understanding of the way in which fire affects soil microbes and fungal communities is necessary to predict ecosystem carbon dynamics under future global change. If fire affects decomposition processes, through changes in enzymatic activity and changes in fungal and microbial community, this could be significant at the ecosystem scale and would result in changes in carbon and nutrient cycling.

We measured changes in litter enzymatic activities, soil microbial and fungal biomasses and soil carbon dynamics following fire disturbance in Scots pine (Pinus sylvestris L.) stands in the northern boreal forests, of eastern Lapland, Värriö Strict Nature Reserve, Finland (67°46' N, 29°35' E). The sites are situated north of the Arctic Circle, near to the northern timberline at an average of 300 m altitude. We have established 8 sample areas (with two replicate plots in each) in a chronosequence of 4 age classes (2 to 152 years since the last fire). The chronosequence consisted of four types of areas: (i) fire 2 years ago, (ii) fire 42 years ago, (iii) fire around 60 years ago, (iv) fire 152 years ago. We measured the potential activities of lignocellulolytic enzymes; laccase (LAC), β -glucuronidase (GLR), β -xylosidase (HYL) and cellobiohydrolase (CEL), β -glucosidase (GLS) as well as the enzymes degrading chitin (N-acetylglucosamide (NAG)) and P-, N- containing organic compounds (acid phosphatase (PHO)). Also the soil carbon content and soil CO_2 effluxes were measured. The soil respiration in this study was defined as the sum of autotrophic respiration from plant metabolic activity and heterotrophic respiration from the decomposition of organic material by microbes Soil fungal biomass was determined using ergosterol analysis and soil microbial C biomass (C_{mic}) was determined using the chloroform fumigation direct extraction method.

Our results indicate that fire has long lasting multi-decadal effects on the soil respiration, soil microbial and fungal biomass and the activities of extracellular enzymes. The values for all these measured parameters were lowest straight after the fire and seem to recover to pre-fire levels within 40 to 60 years following fire disturbance. Across all enzyme types we measured fire reduced the enzymatic activity. Carbon dissolving enzymes (XYL, GLR, CEL, GLS, LAC), nitrogen dissolving (NAG) and phosphorus dissolving enzyme (PHO) showed similar responses to the time since fire. In our northern boreal study area even 42 years after fire disturbance the values for microbial biomass (C_{mic}), fungal biomass, soil CO_2 efflux were significantly lower compared to the areas where the fire was 60 and 152 years ago.

Keywords：*Boreal forests, forest fire, enzyme activity, microbial biomass, soil respiration, ergosterol content*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Heathland Response to Nitrogen Deposition: Effects of Form and Frequency

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Nitrogen deposition is considered a leading determining driver in the species composition changes. Inputs of N to ecosystems have been more than doubled as a result of anthropogenic activities and a further increase of up to 70% is predicted for oxidised N deposition by 2050 from 1990s levels, while reduced N is predicted to rise by up to 133% over the same period. Reduced and oxidised atmospheric N deposition is responsible for various biogeochemical processes, contributing to nutritional balance of terrestrial ecosystems and acid deposition. Atmospheric N deposition mainly comprises of reduced N, resulting largely from agricultural sources, and oxidised form mostly from stationary combustion sources and traffic activities.

As a better simulation of natural deposition processes, small & frequent N additions may result in greater plant growth and proportional increases with greater retention of N within the system. The main aim of this study was to investigate the response of heathland plant community to continued N addition in different forms (reduced & oxidised) with varying application frequency. Heathlands turf cores, soil and sand samples were collected from the burnt area of Thursley Common, a National Nature Reserve in Surrey, UK, and taken Silwood Park Campus, Imperial College London to set up mesocosms. N was added to experimental mesocosms in reduced and oxidised from on weekly, two weekly, monthly, two and four monthly basis.

After 2 years of N additions in different forms and with varying application frequency, the results supported our hypothesis that plants show greater responses to small and frequent N applications. This was confirmed by significantly increased plant growth, Calluna species cover, estimated biomass, elevated foliar N concentrations in N treated mesocosms, suggesting that the experimental site originally used for Calluna turf collection is still primarily limited by N. Soil analyses also revealed the differences in below-ground responses to different N forms and application frequency. Both the N forms affected soil pH in the opposite directions suggesting that N form should be considered for assessing the plant community responses to N.

Keywords：*heathland, N deposition, Calluna*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Nitrogen Deposition: A Modifier of Plant Response to Ozone?

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Nitrogen deposition may modify the effects of increasing tropospheric ozone on plant communities. Our evidence suggests that negative responses to ozone are exacerbated under conditions of high N availability. This highlights the importance of considering interactions between pollutants in the evaluation of critical levels (or loads) for semi-natural ecosystems.

During the last century, concentrations of ozone in the troposphere have risen considerably as a result of anthropogenic activities. Ozone is an important phytotoxic air pollutant, with current ambient concentrations high enough to cause visible O3 injury and detrimental effects on plant growth in many parts of the world. Some evidence exists to suggest that environmental factors such as soil fertility and nitrogen deposition may influence plant sensitivity to ozone. An experiment was, therefore, established to examine the effects of these two global change issues, in combination.

Two plant species Trifolium repens and Festuca ovina were exposed to O3 under differing levels of N addition to address the question of how soil resource availability (nitrogen status) affects plant response to O3 in a grass-legume mixture. Mixed species pots were exposed to ozone in a series of 16 open top chambers at Silwood Park (Ascot) for a period of 16 weeks. Ozone exposure was carried out from 9am-6pm daily, with target concentrations of 0 ppb, 30 ppb, 60 ppb and 90 ppb (resulting in seasonal AOT40 values from 0 – 25,492 ppb.h). In addition, weekly applications of Hoagland's solution with nitrogen levels equivalent to 0 or 50 kg N ha-1 were given to pairs of pots over the course of the experiment. Plant performance was monitored during the exposure period, after which aboveground plant material was harvested, separated into living, senescent or dead material and then oven dried and weighed. Below ground biomass was also measured, following root washing.

Results show a negative effect of O3 and N on above-ground biomass of T. repens and positive effects of both pollutants on the biomass of F. ovina. Aboveground biomass reductions of 80.6% (HO3+N) and 70% (HO3-N) for T. repens indicate greater effects of ozone in high N treatments. Below-ground biomass also showed a significant decrease in ozone treatments (44.6%, HighO3+N and 35.8% HighO3-N) compared with filtered air. Overall, results suggest that N deposition may exacerbate the effects of O3 on legumes, driving changes in plant productivity and community composition. There were signs of negative effect of O3 on the microbial activity with the increasing AOT-40 concentrations.

Keywords: *N deposition, microbial activity, ozone*

P2-223

[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Biochar Addition to Soil Alters its Resilience to Drought

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Changes in precipitation patterns are projected to be one of the biggest consequences for the tropical areas as global climate change intensifies over this century. Predicted shifts in precipitation include: an increase in the frequency of extremely wet or dry months and regional increases or decreases in dry season length and intensity. This could have a negative effect on soil resilience. Ecological resilience is the ability of an ecosystem to return to its original state following a perturbation, thereby maintaining its essential characteristic taxonomic composition, structures, ecosystem functions, and rates of key processes.

On the other hand biochar addition to soil can result in crop yield increases, in particular in tropical areas, but changes in the resilience of soil microbial communities in agroecosystems after biochar addition have not been addressed do date.

In our work we study the resilience of the microbial communities in a tropical soil following biochar addition.

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

The Impact of Pleurotus Ostreatus on Transformation Processes of Organic Matter and Metal Ions From Enriched Organic And Mineral Soils of Spent Oil

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Purpose The aim of this work was to determine the effect of Pleurotus ostrreatus on the transformation processes of organic matter (OM) and determination of the kinetics of these changes. This paper also defines the ability of Pleurotus ostrreatus to transform organic matter compounds with heavy metals, including samples enriched with spent oil.

Material and methods The experiment was conducted as a 56 – day pot experiment done in six combinations (with four replications). The six combinations of different substrates were: 1) peat; 2) sandy soil; 3) peat + sandy soil; 4) peat + spent oil; 5) sandy soil + spent oil; 6) peat + sandy soil + spent oil. Samples were collected at equal intervals (1st measurement period after 7 days from the start of the experiment; 2nd measurement period after 14 days from the start of the experiment; 3rd measurement period after 21 days from the start of the experiment; 4th measurement period after 49 days from the start of the experiment; 5th measurement period after 56 days from the start of the experiment) from each combination, for physicochemical and chemical analysis, including heavy metals concentration. The mineral soil used for the experiments was sandy (taken from surface horizons), classified as a Spodosoil (Soil Taxonomy 1999). Its main characteristics were: sand 74%, silt 25%, clay 1%, pH 5.0, 1.55% of TOC. The used organic soil was a peat taken from surface horizons of Histosols (Soil Taxonomy 1999). Its main characteristics were: pH 5.4, 52.7% of TOC.

The content of heavy metals in spent oil was determined with the ASTM 5185 method and the following: Cr, Cu, Pb, Cd, Ni, Zn. IR spectra of spent oil was made by the AM-S 1440-01 method. The kinetics of organic matter changes were calculation.

Results and discussion This study showed the effect of Pleurotus ostreatus on transformation processes of organic matter and heavy metal ions in organic soil (peat), mineral soil (sandy soil) and their mixtures enriched with spent oil. The transformation processes of organic compounds occurred as a result of the impact of the remediation from the applied Pleurotus ostreatus K22 mycelium. Significant differences were seen depending on the substrate used which can confirm the ability of oyster mushrooms to easily degrade components by their enzymatic system. The partial rapid reaction rate in all the analyzed OM properties vary according to the stage of transformation. In all the objects the fastest processes took place during the first stage of the experiment. This means that during the initial phase of organic matter transformation the reaction took place faster, since the more easily degradable substances broke down first (protein), then cellulose, and finally, lignin and bitumen. Therefore OM decomposes more slowly in pots with peat, which has significant quantities of lignin and bitumen.

Conclusions Macroscopic observations and chemical analysis showed significant differences in the abilities of the substrates used in this study to grow fully developed oyster mushrooms (producing fruiting bodies). Pleurotus ostrreatus significantly affects the kinetics of the organic matter transformations, as is evidenced by the constant speed of the process.

The oyster mushroom significantly affects the transformation of organic matter since it has the ability to transform heavy metals from the different substrates through organic-mineral transformation, and to 'clean up' heavy metals by becoming part of the trophic chain.

Keywords：*Heavy metals; Kinetics of OM transformation; Pleurotus ostreatus; Spent oil*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Modifying Rhizospheric System for Soil Carbon Sequestration

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There is a general consensus that increasing CO2 concentration is primarily responsible for global warming and the subsequent climatic haphazard. Moreover, there is a growing body of evidence clearly indicate that increasing CO2 level have serious implications on the homeostasis of various ecosystems. Among the various strategies recommend by IPCC to reduce CO2 level, the soil carbon sequestration comes in the forefront and provide practical solutions for the sequestration of CO2 in terrestrial sink. However, there is a paucity of information regarding the feedback of terrestrial ecosystems to increasing CO2 and climate change. There are also uncertainties regarding the effect of warming climate on soil nutrient dynamics and soil microbial responses. As we previously postulated, the warming climate together with increasing CO2 concentration may affect the soil organic carbon dynamics, plant metabolic processes, rate of root exudation, nutrient dynamics and associated rhizospheric microbial community. Therefore, it is the need of the hour to develop suitable methods to study the response of soil system to changing climatic conditions and developing strategies to enhance the carbon pool of soil and ensuring the diversity of the key microbial functional groups. Most importantly, reducing the carbon turnover from surface and subsurface soil and increasing the residence time of soil carbon is a better option to reduce the negative outcomes. So manipulating rhizospheric system with appropriate physical, chemical and biological means are an important strategy to maintain the soil carbon pool and improving plant-microbe interactions. The present paper summarizes latest trend as well as the importance of rhizospheric manipulations for soil carbon sequestration and its future perspectives.

Keywords：*Elevated CO2, Soil carbon dynamics, Rhizospheric microbial community, Soil carbon sequestration*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Ecology of Halophilic Microbes Associated with Dominant Halophytes and Salt Tolerant Plants from Coastal Saline Ecosystem

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Soil samples from the rhizosphere of the dominant halophytes and salt tolerant plant species prevailing in the coastal salt affected areas of Gujarat, India were collected. Soil bacteria and mycorhiza were isolated. The rhizosphere soils were also analyzed for physical and biochemical properties. It was found that the pH of all soil samples varies from 8.3 to 9.6 with EC values ranging from 0.55 dS/m to 82 dS/m. The soil samples from rhizosphere of salt tolerant plants/halophytes of the salt affected areas of Coastal Gujarat were collected and analysed. It was found that the pH of all soil samples varies from 7.37 to 8.48 while EC values, ranged from 0.19 dS/m to 37 dS/m. Total 100 bacteria were isolated on Nutrient Agar media from the 15 samples. The highest CFU per gram soil (3.10 X 108) was found in the rhizospheric soil sample of Salvadora olidies (Kavi) followed by 2.05 X 108 in Cressa cretica (Dehgam). Most of the isolated bacteria were Gram-negative and of rod shaped. There was a wide variation in their colony characteristics. There were total 23 isolates that could produce pigmentation. Out of which, 4 isolates of light yellow, 10 isolates of yellow, 3 isolates of light orange and 6 isolates of orange pigment observed. 12 out of 100 isolates were able to produce amylase enzyme. Indole production was not found in any of the isolates. 23 isolates were positive for Methyl Red test, while 39 isolates were positive for Voges-Proskauer test. Only 3 isolates were negative for Nitrate reductase test. Fifteen isolates were positive for urea hydrolysis test. From the Triple Sugar Iron (TSI) agar test, it was found that 19 isolates were able to utilize all the sugars from the triple sugar iron agar medium. The salt tolerance of bacterial isolates was determined and it was found that all the isolates of various samples were able to tolerate salt concentration upto 5%, while 75 isolates out of 100 were able to tolerate salt concentration upto 7.5% NaCl. 50 isolates and 13 isolates out of 100 isolates were able to tolerate salt concentration upto 10% and 15%, respectively. Out of 13 isolates that were able to tolerate salt concentration upto 15% NaCl, 3 were from the rhizospheric soil of Capparis decidua (Kavi), 2 each from both, rhizospheric soil of plants of Capparis decidua (Dehgam) and Salvadora oleoides (Neja) and 1 each from the rhizospheric soil of Cressa cretica (Dehgam), Cressa cretica (Neja), Aleuropus lagopoides (Neja), Suaeda maritima (Neja), Cressa cretica (Chidra), and barren land. VAM spores were also isolated and it was observed that the rhizospheric soil collected from Salvadora olidies (Neja) having maximum number (132 on 106µm sieve) of VAM spores. Majority of the VAM isolated, having Globular shaped spores, and germination shield was absent in most of the spores. PSB and endophytes were isolated and characterized having different levels of salt tolerance. So, from the rhizosphere of various halophytes and other salt tolerant plant species, various halotolerant bacteria, which were able to tolerate salt concentrations upto 10%, have been isolated. The halophilic bacteria isolated and characterized for plant growth promotion were explored for their potential to remove salt and remediate the saline soils. Further, the database of the isolates from coastal saline ecosystem was prepared and strains deposited to NCBI recognized repository.

Keywords: *halophiles, bacteria, halophytes, rhizosphere, mycorrhiza*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Potential Use of Microbial Inoculums in Ameliorating Soil Salinity Impact on the Productivity of Faba Bean (vicia Faba)

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Eight isolates were collected from different sites at Kafr El-Sheikh Governorate. These isolates were cultivated on YMA medium supplemented with different NaCl concentrations (0, 2, 4 and 8 dS/m), using Leonard's jars to evaluate the most salt-tolerant and efficient isolates. The most salt-tolerant rhizobia R2 and R6 were selected in addition to A-mycorrhizae for inoculation of faba bean grown in pots. The soil had artificially salinized with different salinity levels. The results were different in significant, highly significant and not significant. Increased salinity was deleterious for dry weights of plants, number and dry weight of nodules, legumes and seeds. Total chlorophyll, N, P, K, Mn, Zn, Cu and Fe concentrations had also decreased with increasing salinity levels. However, Na concentrations and proline increased in plant and seeds. On the other hand, inoculation with the selected bacterial isolates and/or A-mycorrhizae enhanced the abovementiond parameters except Na%. Salinity had negative effect on the microorganisms of soil and inoculation had the positive effect. In conclusion, salt-tolerant rhizobial isolates isolated from salt-affected soils are more efficient than isolates from normal soils. Application of salt-tolerant rhizobia and/or A-mycorrhizae is beneficial, effective and enhancing plant growth parameters and productivity, under salinity stress conditions.

Keywords：*Salinity, inoculation, salt-tolerant isolates, A-mycorrhizae, Rhizobium leguminosarum biovar viceae,*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Effects of Elevated Ozone on Soil Microbial Community Composition and Metabolic Diversity Depending on the Ozone-Tolerance of Wheat Cultivars

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Tropospheric ozone concentration has risen from about 10 ppb to current 40 ppb in Northern Hemisphere due to the anthropogenic emissions. Although responses of aboveground subsystem to elevated ozone have been studied widely, relatively few attentions have been paid on the effect of elevated ozone on belowground subsystems, especially on soil microbial community and functional diversity. Using the free-air ozone enrichment platform (FAOE), the effects of elevated ozone on soil microbial community structure and functional diversity were investigated in ozone-tolerant and -sensitive wheat cultivars. The principal components analysis of PLFAs indicated soil microbial community structure under elevated ozone differed from those under ambient ozone at wheat ripening stage. Microbial metabolic diversity between ozone-tolerant and ozone-sensitive wheat cultivars reflected their preference for different carbon sources. Soil microbial communities inhabitting the rhizosphere of ozone-tolerant cultivars preferred consuming easily degradable carbon sources (carbohydrate, such as monosaccharide), while more complex carbon sources (aromatic acid) were preferred by those of ozone-sensitive cultivars. These changes may in turn influence the plant growth through alteration in nutrient availability and resource distribution. The cultivar-specific variation in microbial community function could also be a potentially important drive-factor for the tolerance of plant cultivars to the future elevated ozone or climate change.

Keywords：*Free-air ozone enrichment; Microbial functional diversity; Wheat cultivars; Ozone-tolerance*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Molecular Analysis On Fungal Community Structures And Diversity In Different Fertilization Management Practices In Volcanic Ash Citrus Orchard Soil

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Soil microorganisms play an important role in the regulation of dynamic ecosystem, and they occupied the vast majority of species on Earth. This study carried out to evaluate the effect of long-term(17 yrs) different fertilization management on fungal group changes, species richness estimators, diversity indices, and community structures in volcanic ash citrus orchard soil. Experiment plots composed no-fertilization(Control), Compost, half of recommend application plus Compost(1/2NPK+Compost), recommend application(NPK), recommend application plus Compost(NPK+Compost), 3 times recommendapplication(3NPK). Soil samples were taken earlier in March, 2011. Pyrosequencing analysis performed using 454 genome sequencer with PCR amplicon after DNA extraction from wet soil. Rarefaction curves at the 97% sequence similarity showed that distribution range of a clone and the OTUs were high in NPK plot, which were range from 3NPK(617) to NPK(968). Species richness estimators of Ace, Chao1, and Shannon diversity indices showed that were higher in 1/2NPK+Compost (5,273), NPK(2,933 and 5.8) than 3NPK. In phylum level, The most abundant fungal group were Ascomycota, Chlorophyta, Basidiomycota and those occupied at Control(79.4%)-NPK+Compost(89.4%) among the soil-borne fungal community in citrus orchard soil. In genus level, The dominant fungal group were Ascomycota, Sordariomycetes, Chlorophyta and Chlorococcales, which were distributed range from 46.1%(Control) to 56.5% (NPK+Compost).

Keywords：*Fungal community structures, fertilization, volcanic ash soil, citrus*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Comparison Of Spatial Interpolation Methods For Estimation Of Air Temperature

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Because Korea has complex geomorphological form, weather fluctuation is varied by region. Agricultural fields are greatly affected by meteorological changes. Especially, air temperature of agricultural ecosystems is influenced by topographic features of the surroundings making accurate interpolation of regional meteorological data baed on point data. This study was conducted to compare accuracy of spatial interpolation methods for estimating more precise air temperature in Korean Peninsula with the rugged terrains in South Korea. Four Spatial interpolation methods (Inverse Distance Weighting(IDW), Spline, Kriging and Cokriging) were tested to estimate monthly air temperature of unobserved stations. 456 automatic weather stations (AWS) data from January to December in 2012 were used to generate gridded air temperature surface. And 131 AWSs data were used for validation of estimated air temperature. The results of cross validation showed that exponential theoretical model produced a lower root mean square error(RMSE) than Gaussian theoretical models such as kriging and cokriging. In conclusion, the spline method showed the lowest root mean square errors(RMSE) of spatial interpolation methods in both of maximum and minimum air temperature estimation and the highest accuracy to estimate air temperature of unobserved points.

Keywords：*air temperature, meteorological changes, Spatial interpolation methods*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Isolation and Characterization of Arbuscular Mycorrhizal Fungi Spore Associated Bacteria from Saemangeum Reclaimed Soil

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Arbuscular mycorrhizal fungi (AMF) are wide spread in nature and are known to colonize more than 80% of land plants. AMF help plants to withstand various biotic and abiotic stresses and help plants to uptake nutrients more efficiently even in adverse environmental conditions. Many soil bacteria were found to be associated with AMF spores either as mycorrhizal helper bacteria or as pathogenic. However, their mechanism of interaction is still not clear. Our present study aimed to isolate bacteria which are embedded on the spore walls of AMF and identify their mechanism of interaction. Saemangeum is one of the world's largest reclamation site created by constructing theworld's largest sea dike, where 30% of its land area was allotted for agricultural purposes. Rhizosphere soil samples were collected from Saemangeum reclamation site where plant growth is inhibited due to unequal distribution of the soil gradient. Spores were isolated and differentiated based on their morphological characteristics. Three types of spore were identified as follows:Type 1- small, circular, dull yellow;Type 2 - big, circular, white; and Type 3 - small, irregular, red brown. Different types of disinfectant solutions and different duration of disinfection were applied to effectively isolate the spore embedded bacteria. Spores were first vortexed for 5 sec to remove the debris attached to spore surface and then immersed into different disinfectant and antibiotic solution combinations for 0 (control), 10, 20, and 30 minutes. After every treatment, the washings were collected. All washings were subjected to PCR with universal bacterial primers 27f and 1492r. The effective combination of disinfectant and antibiotic solution was found to be 2% chloramines-T and 100 ppm streptomycin. From Type 1 spores, there were 19, 5, and 3 bacteria isolated at control, 10, and 20 min of treatment, respectively. From Type 2 spores, 57, 16, and 5 bacteria were isolated at control, 10, and 20 min of treatment, respectively. From Type 3 spores, 28, 4, and 2 bacteria were isolated at control, 10, and 20 min of treatment, respectively. At 30 min of treatment no bacterial growth was observed from all three types of spores. Moreover, PCR result of the spore washings was only positive in control washings. Other treatment washings did not show any band. This also confirms that the disinfectant solution was effective in removing the bacteria which are loosely attached on the spore walls. Even after spores were treated with disinfectant solution for 10 to 20 min, some bacteria were able to live on the spore walls. One reason for this could be that the bacteria can obtain nutrition from the chitin-rich spore walls for their survivability. Thus, chitinase-producing plant-growth-promoting bacteria can thrive in soil even in adverse environmental conditions when inoculated with AMF like Saemangeum reclamation site.

Keywords：*AMF, fungal-bacteria interaction, helper microorganism, spore associated bacteria*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Assessment of Heavy Metals Incorporated into Soil Microbial Biomass with a Direction Chloroform Extraction Method

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For assessing bioavailability of heavy metals, total metal content is often partitioned into labile, directly available, and inert fractions. On the other hand, soil microorganisms not only uptake macronutrients (C, N, and P), but also micronutrients and heavy metals. However, the role of soil microorganisms in turnover and storage of heavy metals has not been investigated enough, mainly due to difficulties in direct extraction of that fraction. In assessment of microbial C and N, the chloroform fumigation and extraction method is widely used, based on the fact that cell lysis caused by fumigation increases extractable organic C relative to a nonfumigated control. We have used a similar approach but with a slight modification to quantify heavy metal contents in soil microbial biomass. Direct chloroform extraction rather than fumigation was tried, because various gas permeability of the soil can give inconsistent fumigation efficiency. In addition, 0.5 M MgCl2 was used as the extractant to minimize spectral interferences. For a heavy metal contaminated rice paddy in southern Korea, the amounts of microbial (or chloroform-extractable) fraction are estimated to be around 3% and 9% of the total for Cd, and Ni, respectively. However, the microbial fractions of Cu, Pb, Zn, and As were very small (< 1%). There was no significant relationship among the different fractions of heavy metals. In general, in comparison with water-soluble (0.1-2%) and labile (2-40%) pools, the microbial fraction was considered to be an important factor determining bioavailability of heavy metals, depending on soil characteristics and contamination pattern.

Keywords: *Heavy metal partitioning, Microbial fraction, Bioavailability, Chloroform extraction*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Psychrophilic Characteristics and Plant Growth Promotion Effect of Pseudomonas Vancouverensis OB155 in Tomato (solanum Lycopersicum)

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More than 50 per cent of Earth's land surface is seasonally frozen and this phenomenon limits distribution and agricultural productivity of several crop plants. Chilling temperatures can be taken as low but non-freezing temperatures that are common in temperate parts of the world. Exposure to chilling causes numerous anomalies in plant metabolism such as membrane damage, stomatal closure, reactive oxygen species (ROS) generation, destabilization of protein complexes and nucleic acids. Bacterially mediated tolerance to such abiotic stress in plants has been studied upon and is gaining importance owing to their environmental friendly approach. The objective of the present study was to isolate cold-adapted bacteria which survive low temperature conditions and induce tolerance to chilling in plants thereby promoting plant growth under unfavorable temperature conditions. Soil samples were collected from frozen field soils at Chungcheongbuk-do Agricultural Research and Extension Services, Ochang, during January 2012 and used for isolation of bacteria using pre-cooled psychrotolerant salicylic acid bacteria isolation (PSI) media devised to selectively isolate cold-adapted bacteria. Sixty-six isolates that were able to grow at 5 °C were obtained, on enrichment followed by isolation. Fatty acid methyl ester (FAME) analysis was carried out for 63 isolates by growing them in tryptic soy agar plates (TSA) at 25 °C. Extraction and analysis of whole cell fatty acids were carried out and results compared with ITSA1 (Instant Environmental TSA library). Universal primers 27F and 1492R were used to amplify 16S rDNA sequence from 40 isolates. Sequence assembly was carried out using BioEdit v7.0.9.0 and their nearest neighbors identified using the EzTaxon-e server (http://eztaxon-e.ezbiocloud.net). Relative growth rate co-efficient (RGRC) analysis was carried out by comparing the growing periods of the strains at 5 and 25 °C respectively. These isolates were then studied for plant promoting traits such as production of auxin, phosphate solubilization and ACC deaminase production at 5 °C. Based on their plant growth promoting traits expressed at low temperatures, four stains were selected and inoculated in tomato. The plants were grown in controlled plant growth chambers at 12/12 h of light-dark conditions at 25 °C and at the end of two weeks, half of the bacterized and non bacterized plants were moved and maintained at 18/15°C under 12/12 h light-dark. Results from 16S rDNA showed that 22 strains belonged to genus Pseudomonas, 7 strains to genus Flavobacterium (Fig. 1), and 6 strains belonged to Arthrobacter. Strains from genus Massilia, Flavimonas and Pedobacter were 3 strains and 1 in the remaining genus respectively. On comparing the major fatty acids of the isolates obtained by FAME analysis for characteristic fatty acids of psychrotrophs, 30 of the 40 isolates which were phylogentically characterized showed presence of characteristic fatty acids indicating adaptation in cell membranes of the bacteria to cold. On comparing the membrane fatty acids, growth temperature range and relative growth rate coefficient (RGRC) values, it was observed that all isolates were more adapted to grow under psychrotolerant conditions. Moreover, their phylogenetic characterization also suggests that they represented genera that were earlier reported to be psychrotolerant or psychrophilic in nature. In plant experiments, at the end of one week of cold treatment the harvested plants showed significantly improved growth in shoot and shoot lengths when treated with Pseudomonas vancouverensis OB155. Dry matter content and proline in leaves showed an increase compared to uninoculated control, however the increase was not found to be statistically significant. Cold-adapted plant growth promoting bacteria therefore can effectively increase tolerance of crop plants against chilling stress and improve plant growth under environmentally challenging temperature conditions.

Keywords：*low-temperature stress, cold-adapted PBPB, psychrophilic adaptation, plant chilling tolerance*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Structural and Functional Changes in Soil Microbial Community in Response to Heavy Metal Contamination as Assessed by Culture-Dependent and Biochemical Analysis Techniques

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Changes occur in microbial community structure and function as affected by presence and contamination of heavy metals in soil. In this study, changes in cultivable microbial population, enzymatic activities and community level physiologic profile (CLPP using BiologECO) were assessed in soils from the vicinity of the Janghang town smelter in Chungnam Province, South Korea. Three study sites were selected mainly on the basis of degree of metal contamination and phytoremediation trials. Site 1 is located 260 m from the smelter and represented a region of high metal contamination. Site 2 is located 240 m from the smelter and showed high metal levels as site 1 from an earlier initial assessment. With various remediation efforts underway along different sections of the refinery, site 2 has been designated as part of an initial phytoremediation trial to assess the metal accumulating capacity of aster Aster koraiensis and 12 species of fern. Site 3 consists of rice paddy soil located 3500 m from the smelter and represented an area of low metal contamination. Analyses of soil properties as well as concentrations of different metals were measured using standard laboratory protocols. Culturable populations of bacteria, fungi and actinomycetes were determined by counting colony forming units (CFU). Carbon source utilization patterns of soil microbial communities were determined on 96-well BiologEco plates and the average well color development (AWCD) were calculated. Soil enzyme activities including dehydrogenase, phospatase / phosphomonoesterase, urease, protease and Beta-glucosidase were also measured. Lower populations of cultivable heterorophic bacteria, actinobacteria and fungi were oberved in highly contaminated soils, but the differences with other sites showing higher populations of cultivable microbiota were not statistically significant. Metabolic degradation of carbon derived from AWCD values showed highest potential in highly contaminated soils after short term phytoremediation, however, no statistically significant differences were seen. Diversity indices and evenness computed from the AWCD values showed highest diversity in site 2 but there were no statistical difference between the three sites. Microbial populations from site 1 showed higher preference for carbohydrate substrates as c-source, those in site 2 showed highest utilization of amine/amide and miscellaneous c-sources, whereas, populations in less contaminated, site3 showed stronger preference for amino acid c-sources. Utilization of phenylethylamine, D-malic acid and L-phenylalanine was significantly highest in site 2. Pearson's correlation analysis between soil physico-chemical properties, microbial population and functions showed that except for fungi population and metabolism of carbohydrates and miscellaneous carbon sources, there is generally, a negative correlation between metal concentration and soil microbial population and functions. Among the metals and metalloids, Zn values had consistent positive correlation to all soil enzymatic activities, with significant values for DHA, acid phosphatase and protease at $P<0.05$. Higher As and Cd levels were significantly linked to lower protease and urease activities, while Cu levels negatively correlated to β-glucosidase ($P<0.01$) and urease ($P<0.05$) activities. All enzymes tested showed reduction in activity in highly contaminated soil. Significantly lower acid phosphatase, β-glucosidase, protease and urease activities were recorded from site 1 compared to site 3. However, site 2 showed the highest readings for dehydrogenase and urease activities, comparable to those of site 3.

Keywords: *average well color development, community level physiological profile, metal contamination*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Effect of ACC Deaminase Producing PGPR Strains Inoculation on the Growth and Nutrient Accumulation of Maize and Sorghum-Sudangrass Hybrid in Saemangeum Reclaimed Soil

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Saemangeum Development Project is a national project to build a global city as a frontrunner of green growth. It will create 283 km2 of reclaimed land and a lake as large as 118 km2 by constructing the world's longest 33.9 km sea dike. It is an estuary tidal flat on the coast of the West Sea in South Korea. Thirty percent of the land in Saemangeum has been set aside for agricultural, use of which barely 17% are under low levels of salinity and thereby, sustainable for cultivation. The remaining 83% of the land had salt levels ranging from 0.3-1.0% and deemed not suitable for crop growth. The physical and chemical properties including organic matter (0.1-0.5%), major and minor nutrients levels were very low. 1-aminocyclopropane-1-carboxylate (ACC) deaminase-producing bacteria can stimulate the cleavage of ACC, the immediate precursor of ethylene, to ammonia and α-ketobutyrate thereby reducing the inhibitory effects of high levels of ethylene in plants. Plant growth is inhibited by high levels of salinity. B. iodinum RS16 which was isolated from coastal saline soil is can fix N2 and has ACCD activity. M. oryzae CBMB20 which was isolated from rice stem, as well, has the ability to produce ACC deaminase. The study evaluated the effects of inoculation and co-inoculation of B. iodinum RS16 and M. oryzae CBMB20 on the growth and macro-nutrient uptake of maize (Zea mays L.) and sorghum-sudangrass hybrid (Sorghum bicolor L.) in Saemangeum reclaimed soil. The impact of microbial treatment on these two crops was assessed based on plant height, dry biomass accumulation and macro-nutrient uptake. M. oryzae CBMB20 treatment increased plant height in maize by 41.2% at 30 days after sowing (DAS), shoot dry weight and total dry weight compared to non-inoculated treatment. Macro-nutrient accumulation (N and P) in maize roots was significantly increased with co-inoculation treatment, K and Ca content was significantly increased at B. iodinum RS16 treatment compared to non-inoculated treatment. Macro-nutrient accumulation (P, K, Ca and Mg) in shoot was higher with M. oryzae CBMB20 treatment compared to non-inoculated treatment. In case of sorghum-sudangrass hybrid, co-inoculation treatment showed 33.7% increase in plant height compared to non-inoculated treatment at 30 DAS. M. oryzae CBMB20 treatment increased root dry weight and total dry weight, macro-nutrient accumulation in roots and N, Ca and Mg accumulation in shoot compared to non-inoculated treatment. P and K accumulation in shoot was significantly increased at co-inoculation treatment compared to non-inoculated treatment. The results of this study proved that single and coinoculation of PGPB strains (B. iodinum RS16 and M. oryzae CBMB20) significantly improved plant growth of maize and sorghum-sudangrass hybrid in Saemangeum reclaimed soil. Moreover, macro-nutrient accumulation of maize and sorghum-sudangrass hybrid was significantly increased with single and co-inoculation of B. iodinum RS16 and M. oryzae CBMB20. The consistent improvement of maize and sorghum-sudangrass hybrid growth by B. iodinum RS16 and M. oryzae CBMB20 suggest the potential of these strains for large scale field application.

Keywords：*Brevibacterium iodinum RS16, Maize, Methylobacterium oryzae CBMB20, Saemnangeum Reclaimed Soil, Sorg*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Arbuscular Mycorrhizal Fungi Inoculation Modulates Plant Responses to Soil Salinity with Respect to Biomass, Nutrient Uptake, and Proline Accumulation: A Meta-Analysis

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Soil salinization has been identified as one of the most significant abiotic stress limiting crop yield and sustainable agriculture in most of the arid and semiarid regions of the world. According to FAO report, until now >7% of the earth's land and 33% of the world's arable land are affected by soil salinity. In such condition, plants are not able to control Na+ uptake over K+ uptake, and an increase of Na+ in plant tissues at disproportionate level is anticipated, causing cell damage and nutritional disorder. In this respect, ecologists and physiologists found that mycorrhizal application as a solution to alleviate salt stress. Precise quantifiable changes in plant growth and nutrient uptake under salt stress are crucial factors for evaluating arbuscular mycorrhizal fungi (AMF) as a significant predictor of mycorrhizal ecology. In order to analysis the hypothesis that AMF inoculation has a higher capacity to alleviate salt stress in plants, weighted meta-analyses were applied across independent studies. More specifically, considering the size and quality of the collected data, our meta-analysis aimed to answer the following questions: (1) Is AMF inoculation under salt stress interrelated with changes in biomass and nutrient uptake? (2) Are there significant differences in plant responses in context to identities of AMF, plant species, and plant functional groups? (3) Is there any relationship between Na uptake and proline accumulation in AMF inoculated plants under salt stress condition? (4) Is there a relationship between differential uptake of K and Na in AMF inoculated plants? Meta-analyses were conducted with MetaWin v2.1 software. The effect sizes were calculated as the natural log of the response ratio (LRR), which is the mean of the treatment (with arbuscular mycorrhizal inoculation) divided by the mean of the control (without inoculation) as a metric for the AMF inoculation responses under salt stress. Testing for the significance of predictors was based on a randomization resampling procedure with 4999 iterations. Confidence intervals (95% CIs) were constructed according to the bootstrapping (BS) method integrated in MetaWin. The inoculation effects were considered as significant if the 95% BS CIs did not overlap. Statistical differences were considered as significant when $P<0.05$. The present meta-analysis was based on 534 independent observations from 43 published studies that explored the effects of AMF inoculation on the growth and nutrient uptake of salt-stressed plants. The present meta-analysis revealed that the AMF inoculated plants under saline conditions significantly increased total, shoot and root biomass by 53.5% (n=93; LRR = 0.429 ± 0.432395); 52.5% (n=91; LRR = 0.4225 ± 0.4261) and 30.1% (n=93; LRR = 0.2629 ± 0.261), respectively. Also, phosphorous (P), nitrogen (N), and potassium (K) uptake significantly increased by 81.1% (n=39; LRR = 0.5937 ± 0.59955), 29.4% (n=16; LRR = 0.2583 ± 0.2549), and 59.6% (n=61; LRR = 0.468 ± 0.4778), respectively. However, sodium (Na) uptake (n=79; LRR = -0.1806 ± -0.1771) in plants decreased significantly, and proline accumulation (n=80; LRR = -0.0181 ± -0.0249) was found to be non-significant. An enhanced root nutrient uptake by AMF is attributed to extra-radical hyphae that extend beyond root depletion zones, changes in root traits such as formation of lateral roots, elongation of root, root surface area, higher root volume and extensive root hairs and less coarse roots. Across studies, identities of AMF (Glomus fasciculatum) and host plants (Acacia nilotica, herbs, woody and perennial) were found to be more important in predicting significant plant responses to salt stress. Thus, it can be concluded that under salt stress, mycorrhizal plants have extensive root traits and mycorrhizal morphological traits which help host plants uptake more P and K, resulting in enhanced plant biomass. In the present study, AMF inoculation showed a significant increase of K uptake but a significant decrease in Na uptake compared to the non-AMF plants. This suggests that inoculation with AMF increases K+/Na+ ratios which are beneficial in maintaining ionic homeostasis in the cytoplasm or Na+ efflux from plants. Lower Na+ in the mycorrhizal plants compared to non-AMF plants may also be explained by the dilution effect due to growth enhancement. Furthermore, mycorrhizal inoculation-mediated selectivity of K+ over Na+ ion is essential in understanding plants' tolerance to salt stress.

Keywords：*Arbuscular mycorrhizal fungi, Meta-analysis, Salinity stress, Plant growth, Proline accumulation*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Effect of ACC Deaminase Producing Methylobacterium spp. on Seedling Development and Ethylene Emission under Greenhouse Condition

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Under transplanting crop systems, seedling vigor is very important for plant growth and productivity upon planting. Inoculated plant with 1- aminocyclopropane-1-carboxylate (ACC) deaminase producing Methylobacterium can increase plant growth and development by reduction of ethylene stress in plant. This study examined for the ability of seven available Methylobacterium isolates in our laboratory to improve the seedling growth and reduce ethylene emission of tomato and red pepper plants under greenhouse condition. Seven Methylobacteria (CBMB12, CBMB15, CBMB20, CBMB17, CBMB31, CBMB35 and CBMB110) were characterized for IAA and ACC deaminase production. Seeds were immersed in culture suspension at O.D 600 nm= 1.0 (108 C.F.U ml-1). Seeds were then planted in seedling trays (50 holes tray-1 and one seed per hole). At twenty one days, seedling was transplanted in 300 ml plastic pot with 10 ml by applied bacterial culture (O.D 600 nm=1.0, 108 C.F.U ml-1) on leaf and soil (10 ml) weekly after transplanting. Biomass production (dry weight, root length and plant height) was recorded at 45 and 55 day after sowing (DAS). Under pot culture condition, all Methylobacterium isolated showed the positive impact on biomass production, root length and plant height of tomato and red pepper. Inoculation with isolated CBMB20 and CBMB27 enhanced the increase in biomass accumulation by 2.29 g plant-1 and 3.15 g plant-1 ($p \leq 0.05$) respectively for tomato and red pepper plants over uninoculated control plant at 55 DAS. At 45 DAS isolated CBMB20 showed maximum increase in plant height of tomato (40.2 cm plant-1, $p \leq 0.05$) while inoculation with CBMB27 enhance plant height (64.8 cm plant-1) at 55 DAS. In red pepper, inoculation with CBMB27 and CBMB110 recorded significantly higher in plant height (37.7 cm plant-1 and 36.2 cm plant-1 respectively) at 55 DAS compared to uninoculated plants. CBMB31 and CBMB20 also enhanced the root length of tomato and red pepper by 22 cm plant-1 and 18.6 cm plant-1 respectively at 55 DAS. In addition to biomass production, ethylene emission in leave and whole plant of tomato and red pepper was measured. Isolate CBMB20 was found to have the lowest ethylene concentration (22.9 pmol of ethylene h-1 g dry weigth-1) in tomato plant, while inoculation with isolate CBMB110 and CBMB31 also showed the lowest ethylene level in red pepper (7.3 and 7.7 pmol of ethylene h-1 g dry weigth-1 respectively). Pretreatment with Methylobacterium spp. showed the higher reduction in ethylene level from 70.2 % to 51% and 88.9% to 56.3% respectively in tomato and red pepper plants compared to unioculated plant. The CBMB20 and CBMB110 inoculated plants recorded in ethylene levels in whole plant of tomato and red pepper by 7.29 and 3.53 pmol of ethylene h-1 g dry weigth-1. Our result clearly elucidated that healthy seedling of tomato and red pepper was greatly increased by Methylobacterium inoculated plants by reduction in ethylene level in plant, subsequent improvement of root length. The present study clearly demonstrated that Methylobacterium isolated posed the plant growth promoting traits that allow them to enhance the seedling growth and development after transplanting. This study showed isolate of Methylobacterium can also decrease the ethylene levels in leave and whole plants, subsequent root elongation. These finding indicate that Methylobacterium spp. can be the promising candidate for plant growth promotion in transplanting horticulture system by reducing the ethylene levels in plant.

Keywords：*ACC deaminase, Ethylene emission, Methylobacterium spp., Seedling development*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

A New Report on Plant Growth Promotion and Antagonistic Potential of Pigmented Facultative Methylotrophic Bacteria (delftia Sp And Bacillus Spp.) against Root Pathogens in Tomato

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The plant growth promotion and biocontrol potential of three pink pigmented facultative methylotrophic isolates Viz., PPO-1, PPT-1 and PPB-1 isolated from the phylloplane of tomato were studied in tomato under pot culture condition. Isolate PPO-1 exhibited 96.62% 16S rDNA gene sequence similarity to type strain of Delftia tsuruhatensis T7T and formed a monophyletic clade from the cluster containing Delftia tsuruhatensis T7, Delftia lacustris DSM 21246 T, Delftia acidovorans ACM 489T Delftia litopenaei wsw-7 T in ML and MP trees. However, in NJ tree, isolate PPO-1 formed a separate clade from the cluster containing genera such as Delftia, Hydrogenophaga, Curvibacter and Variovorax. The isolate PPB-1 exhibited close 16S rDNA gene sequence similarity to Bacillus cereus ATCC 14579T and in phylogenetic tree it clustered with Bacillus cereus group which comprises of Bacillus mycoides ATCC 6462T, Bacillus anthracis ATCC 14578T, Bacillus thuringiensis ATCC 10792T Bacillus cereus ATCC 14579T. Isolate PPT-1 showed 99% 16S rDNA gene sequence similarities to Bacillus subtilis NCIB 3610T, and clustered with Bacillus subtilis in all the phylogenetic trees constructed in the present study. The 16S rRNA gene sequence data and ML, MP and NJ trees revealed that isolates PPT-1 and PPB-1 belong to Bacillus subtilis and Bacillus cereus, respectively. The two facultative methylotrophic Bacillus isolates (PPT-1 and PPB-1) obtained from this study did not hydrolyze the blood (non hemolytic). Hence, it was concluded that isolate PPB-1 as non pathogenic to animal and human. 16S rRNA gene sequence analysis revealed that the isolates PPO-1, PPT-1 and PPB-1 showed 96.62, 99.91and 99.38% similarities to type strains of Delftia tsuruhatensis, Bacillus subtilis and Bacillus cereus, respectively. The in vitro antagonistic potential of the three isolates PPO-1, PPT-1 and PPB-1 showed maximum inhibition of mycelial growth of Fusarium oxysporum f. sp. lycopersici (2.15, 2.05 and 1.95 cm), Sclerotium rolfsii (2.14, 2.04 and 1.94 cm), Pythium ultimum (2.12, 2.02 and 1.92 cm), and Rhizoctonia solani (2.18, 2.08 and 1.98 cm) and also produced the volatile antibiotics. Under controlled plant growth chamber condition, methylotrophic bacterial isolates PPO-1, PPT-1 and PPB-1 significantly reduced the disease incidence of tomato. Further, these three isolates were evaluated under pot culture condition for reduction of wilt and rot disease incidence and induction of systemic resistance in tomato. Plants treated with methylotrophic isolates Delftia PPO-1, B. subtilis PPT-1 and B. cereus PPB-1 and challenge inoculated with F. oxysporum f. sp. lycopersici, S. rolfsii, P. ultimum and R. solani, showed increased presence of pathogenesis related proteins and defense enzyme on day 1 after inoculation. On day 4, maximum phenylalanine ammonia lyase, peroxidase, polyphenol oxidase, catalase, β-1, 3-glucanase and chitinase activities were recorded. Methylotrophic bacterial isolates produced the siderophore and salyclic acid and those compounds may competitively be excluded the growth of the tested pathogens. Production of siderophores by methylotrophic bacteria probably increased the uptake of the essential cations like Fe2+ and Zn2+ which in turn might have stimulated the biosynthesis of other antimicrobial compounds by these bacteria. In the pot culture experiment, imbibitions of tomato seeds with methylotrophic isolates Delftia sp. PPO-1, Bacillus subtilis PPT-1 and Bacillus cereus PPB-1 significantly increased the germination percentage and the seedling vigor compared to control. This is the first report on the methylotrophy in Delftia, B. subtilis, and B. cereus and their direct antagonism and induction of systemic resistance in tomato against fungal pathogens in response to methylotrophic bacteria suggests the possibility of using these pink-pigmented facultative methylotrophic bacteria as a bio-control agent.

Keywords : *Antagonistic effect, Defence enzymes, Methylotrophic bacteria, Plant growth promotion, PR proteins*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Effect of Varying Levels of Salinity on EPS Production And Biofilm Formation by Halotolerant Bacteria

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Harmful effects of salinity on plant growth is one of the major agricultural problems limiting crop productivity in most of the arid and semi-arid regions of the world. Bacteria which are able to produce exopolysaccharides (EPS) and colonize the root zone of plants growing in salt-affected soils might help to alleviate salt-stress through biofilm formation on root surfaces or rhizosphere soil particles. Binding of EPS to cations can help to decrease Na+ ion concentration in roots and in addition to alleviating Na+ stress, these polysaccharides are also helpful in protecting the plants from toxicity of other metal ions such as Cu2+. Formation of biofilms is the most important approach used by bacteria for their successful survival in stressful external environments. Formation of aggregates is another strategy employed by bacteria for survival stress conditions. The objective of this study was to compare biofilm formation potentials and EPS production by halotolerant bacterial strains (Brevibacterium oiodinum RS16, Micrococcus yunnanesis RS222, Bacillus aryabhattai RS341, Bacillus lichenifomis RS656) under different salinity levels. Production of EPS among the strains were studied and quantified in terms of dry mass and total carbohydrates. In addition, aggregation, biofilm formation and PHB accumulation were studied under different levels of salinity. Most of the studied strains showed an increasing trend in EPS-dry mass with respect to increasing salt levels. B. aryabhattai RS341 produced highest EPS-dry mass of 5.4±0.4 gL-1, than other studied stains at 2 M NaCl concentration. However, highest EPS-glucose levels was observed in M. yunnanesis RS222 with available glucose at 35.5±1.9, 60.5±2.8, 69.6±3.0, 45.9±9.2 mgL-1 concentration under 0, 0.5, 1, 2 M NaCl concentrations respectively. Maximum EPS-glucose levels were observed in strains B. iodinum R16 and M. yunnanesis RS222 at a salt concentration of 1 M NaCl. On studying biofilm formation, maximum bacterial biofilms were formed by the strains at 0.5 M NaCl concentration except for B. aryabhattai RS341 strain. Results from studying aggregate formation showed that strains B. aryabhattai RS341 and B. lichenifomis RS656 exhibited an increasing trend in aggregation with related to increasing salinity levels. Aggregation of B. aryabhattai RS341 increased gradually from 5.8±0.6 to 19.7±2.0 % when salt concentrations increased from 0 to 2M NaCl and an increase in aggregation percentage from 6.8±1.9 to 21.6±0.9 % was observed in case of B. lichenifomis RS656. Other strains however, did not show such trends when salinity was increased. Results from aggregation of B. aryabhattai RS341 and B. lichenifomis RS656 demonstrate increased aggregation with increasing salinity levels, coherent with their nature of EPS production. Moreover, EPS also play a significant role in the stability and adhesive properties of biofims on various biotic or abiotic stresses. Therefore, both the processes of biofilm formation and EPS production can be considered closely related. All bacterial strains showed production of PHB but we could not ascertain any trend in production that could be related to varying salinity levels. From our results it is understood that both strain B. iodinum RS16 and M. yunnanesis RS222 form biofilms more efficiently on plant roots and strain B. aryabhattai RS341 and B. lichenifomis RS656 showed a higher aggregation strategy under salinity stress. This research might provide useful insights on the strategies used by halotolerant bacteria to alleviate salt stress in plant.

Keywords：*Halotolerant bacteria, Exopolysaccharide, Biofilm, Poly-β-hydroxybutyrate, Salt stress*

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[IDS6] Soil Microbial Ecology under Stress and Global Climate Change

Exopolysaccaride Production, Intracellular Carbon Accumulation and Stress Tolerance of Methylobacterium Strains under High Carbon Conditions

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Excessive use of chemical fertilizers can raise problem not only on imbalance in plant nutrients absorption but also environmental pollution by leaching nutrients with water. For that reason, microbial inoculation has resurfaced as alternative. In this study, CBMB20, CBMB27, CBMB35 and CBMB110 of Methylobacterium strains were studied to confirm the change of growth pattern, floc yield, EPS production and PHB accumulation, and the increase in tolerance of osmotic and acid stress condition. This study was performed in HCN-AMS media containing carbon concentration with C/N ratio of 30:1. All strains of Methylobacterium grew faster in HCN-AMS medium than AMS medium without any modifications. The most value of OD was in CBMB27 of 1.32 after 84 h incubation, and CBMB110 also showed high OD value of 1.15. In general, population of Methylobacterium strains were increased in HCN-AMS medium. The biggest difference of growth populations between the two media was shown in CBMB110 with a 4.2% increase at 7.40 log cfu/ml in HCN-AMS medium. Increases of 80.0, 52.1, 93.0 and 65.2% floc yield were observed in CBMB20, CBMB27, CBMB35 and CBMB110 strains respectively, using HCN-AMS medium. The highest growth pattern was in CBMB35 and CBMB27 of 8.5 and 7.25 mg/ml dry weight in HCN-AMS medium at the end of incubation period. All Methylobacterium strains were positive for EPS production as evidenced in the fluorescence with calcofluor staining method. EPS production was more increased in HCN-AMS medium at 4.2 to 75.0% than AMS medium, and the highest of EPS production was recorded in CBMB27 (0.41 mg/ml) in HCN-AMS medium. All Methylobacterium strains showed brightly refractile cytoplasm inclusions under phase contrast microscopy and dark inclusions with the Sudan black stain under bright field microscope. PHB accumulation of CBMB27, CBMB35 and CBMB110 was increased 3.8%, 36.7% and 12.0% respectively in HCN-AMS medium, compared with AMS medium. Above all, the amount of PHB accumulation was more in CBMB27 of 1.20 mg/ml. In osmotic stress condition, Methylobacterium strains grew better in HCN-AMS than in AMS medium. Similar to the osmotic stress, growth caused by acid stress at pH 5.0 was also higher in HCN-AMS medium compared to the AMS medium. EPS production and PHB accumulation enhances Methylobacterium strains survivability under stress conditions and lead to increased carbon concentration. The results of this study showed that strains of plant growth promoting Methylobacterium incubated in HCN-AMS medium had increased in carbon concentration which also increased their survival rate. Furthermore, the strains studied may have the potential of helping plants survive under osmotic and acid stress by EPS production and PHB accumulation.

Keywords：*Metylobacterium strains, carbon concentration, HCN-AMS medium, EPS production, PHB accumulration,, tolerance of osmotic and acid stress*

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[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Soil Morphology as an Indicator for Assessment of Drainage System Efficiency in Sugarcane Cultivated Lands, South Khuzestan, Iran

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Land drainage is an operation which increases land production and ensures sustainable land use. Soil scientists attempt to arrive a scientific procedure for assessing the efficiency of drainage system, among the correlation between soil morphological characteristics, mainly soil color and redoximorphic features and water table behavior. The aims of this study were investigating the efficiency of drainage system through soil morphological and micromorphological characteristics and judge about the existence of episaturation or endosaturation, in Khuzestan sugarcane cultivated lands after years of artificial drainage. 5 pedons were dug and characterized based on their morphological and micromorphological features. The characteristics of redoximorphic features showed no considerable differences in drainage class between artificial drained field and virgin land. The only contrast was shallower ground water table in virgin lands. 4 pedons were classified as somewhat poorly drained and one as well drained. These drainage classes show that despite the existence of artificial drainage system, the problems haven't been eliminated yet. All pedons showed horizons with low chroma colours in deeper horizons and different types of redoximorphic feature. Micromorphological observations proved that the lands were involved in Endosaturation due to high ground water level.

Keywords：*Episaturation, Endosaturation, Drainage, Redoximorphic, Soil micromorphology.*

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[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Inventory of Pedoturbation in Some Heavy Clay Soils of Bangladesh

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In Bangladesh, sedimentation has recently been recognized as an immense disaster. This kind of disaster is getting momentum due to the recent climatic and anthropogenic activities. As a result, soil materials may accumulate over a short period of time which impacts on the soil forming or pedospheric processes. Brammer (1996) reported that the soil forming processes identified in Bangladesh were ripening, homogenization, reduction, formation of acid sulphate conditions, ferrolysis, decalcification, formation of gleyans, clay eluviations and illuviations, formation of mottles, alkalization, salinization, calcification, formation of peat, etc but no record of pedoturbation in Bangladesh soils. In Bangladesh, Typic Endoaquerts soils was reported by Idris and Uddin (2013) in six soil series of Bangladesh which were Garuri, Ghior, Santhia, Arial, Batra and Benapol where pedoturbation seems to be appear in the above soils. Considering the above concepts, Batra soils (Typic Endoaquerts) was selected for the morphological study which revealed that these are seasonally very deeply flooded, poorly drained, heavy clays (>70%) developed on basin sites of the Ganges River floodplain. They are grey to olive grey, occasionally olive brown, non-calcareous heavy clays with strong, very coarse prismatic structure breaking into strong medium and fine blocky and wedge shaped structure and with prominent ped cutans. Ped interiors are finely mottled yellowish brown and strong brown. Subsoil showed a well developed prismatic and blocky structure breaking into fine and very fine lenticular, with prominent coatings and common slickenside's. The heavy clay exhibits significant swell and shrink characteristics under wet and dry conditions to develop unique structure and features of pedoturbation in the soil profile. Wedge-shaped aggregates are the structural units that generally result from the intersection of slickenside's. In conclusion, it may be said that some unique features of argilli-turbation have been recognized in some heavy clay soils of Bangladesh.

Keywords：*Pedoturbation, Pedospheric Processses, Heavy clay soils*

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[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Hillslope Soils of Khao Yai Area, Nakhorn Ratchasima Province, Northeast Thailand

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This study aimed at characterizing hillslope soils of Khao Yai area, Nakhorn Ratchasima Province, Northeast Thailand, the fragile land where the forest had been advanced by agricultural activities, cassava and sugarcane are for instances. Four pedons which similarity underlying geological structure (Soi Woi Intrusives, Upper Triassic Age) was detailed investigated. They consisted of the solum (A-B) which thicknesses ranged from approximately 1 m to 3 meters or more, the parent material (C) and weathered bedrock (Cr) horizons. For gravels- and coarse fragments-containing soils (Pedon 1, 2, and 3), their shapes together with patterns of particle size distribution indicated the local transported materials deposited on the in situ weathering part. Pedon 1 and 2 presented the clay-accumulated horizon 'Bt', indicating the stable situation for soil forming processes, however the different properties among topsoil and the underlying parts implied the severe erosion on hillslopes. No-signs of clay-accumulation parts were noticed in Pedon 3 and 4. In addition, several times of deposition were clearly determined from particle size distribution and some chemical properties. Morphology, they had strong brown topsoil, yellowish red and reddish yellow subsoil. The parent material- and weathered rock-parts were red, reddish yellow and white colors. They had medium to fine textures, silt loam, clay loam, silty clay loam and clay, in most. Pedon 1 contained the highest clay particles, while Pedon 4-the lowest. Pedon 1 had the coarse-sized size dominated whereas the others-the medium-sized silt pronounced. Chemical properties, they were acid soils which pH of 4.31 to 6.09. They had very low available phosphorus (lower than 5 mg kg-1). The summation of bases (Ca2++Mg2++K++Na+) ranged from 0.96 t0 12.03 cmol(+) kg-1 which Ca2+ the highest and K+ the lowest. Pedon 1 had the highest CEC (18.45-40.87 cmol(+) kg-1) resulting from the highest clay contents (194.7-532.6 g kg-1). The distributions with depth of extractable micronutrients implied the differentiations within the pedon. In most cases, the Mn contents were higher than Fe.

Keywords：*hillslope, soil, chemical properties, Nakorn Ratchasima Province, Thailand*

P2-244

[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Structural Analysis of Soil Cover on the Watershed of Ribeirao Feijao-SP, Brazil

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The watershed of Ribeirão Feijão is located in the central-east of the state of São Paulo, southeastern Brazil, covering in its area, the municipalities of São Carlos, Analândia e Itirapina. The watershed has fundamental importance as urban water supply source for these cities. Thus, conservation and preservation of water resources available there, it is essential for prolonged use of the same, and consequently its entire watershed requires constant monitoring with regard to the quality of its waters.

According Guerra and Mendonça (2004) watersheds are open systems in terms of energy imputss, originating from rainfall, and outputs related to water and sediments, derived from fluvial erosion and slopes. The concern with the proper management of surface water must, also, take into account the occurrence of erosive processes, as these can cause siltation of rivers and reservoirs, and in agricultural areas, are susceptible to contamination because of the use of pesticides.

Based on the Morfopedology (TRICART & KILLIAN; CASTRO & SALOMÃO, 2000) and through a study of geomorphological subdivision developed as work of completion of course by the student, homogeneous units of landscape forms, soil and geology were established to the watershed of Ribeirão Feijão. These knowledge make it possible to visualize the representative landscape sectors for detailed bidimensional characterization of soil cover in toposequences.

The methodology that allows such understanding corresponds to the Structural Analysis of Pedologic Coverage (Bouletet al, 1982; Boulet, 1988; Ruellan et al, 1989) which is based on a morphological approach of soil structures, aiming to identify them and establish their role in operation of this system. It includes, from morphology field studies until more detailed studies of optical microscopy, scanning electron microscopy, electron microprobe, etc. According to Queiroz Neto (2002) is the concern of researchers in understanding the distribution of soils in the landscape, its causes and factors, interpreting the processes responsible for its distribution.

Through Structural Analysis of Pedologic Coverage, and using micromorphology scale, which allows reconstitution of vertical and lateral organizations of water and matter movement (BOULET, 1992 apud SOLOMON, 2002), this level of morphological structures approach, aims to identify them and, thereby, establish their role in the functioning of the soil.

This research aims to systematize information of landscape structure, as obtained through the relationships that are established between the physical features of the landscape (geology-soil-relief), and then consider the more detailed level of observation of soil-landscape relationships that necessarily passes through a vertical, morphological and structural observation.

Starting from these assumptions, the overall goals are that through interaction pedo-geomorphological studies, will be conducted to identify the arrangement of soil particles, the geometry of their horizons and consequent recognition of lateral movement of subsurface water from an approach morphological predominantly in a toposequence, which will allow the provision of representative information of components of nature.

From the perspective of landscape analysis as an open system, subject to the exchange of energy and matter, and the landscape as physical expression of these exchanges, losses and transformations, the study of soil cover in micro-scale can be reveal as an important tool for understanding the dynamics of landscapes and its destabilization.

It is intended, therefore, contribute to the understanding of the dynamics of the physical environment, which affects the quality and possibilities for agricultural uses, as well as degradation of water resources in the territory. It is hoped, through the study topossequence, understand the strand as a continuous coverage in the study by micromorphology, know the main factors that act on the dynamics of the causes of linear erosion in the watershed of Ribeirão Feijão, with notes which contribute to relational potential impacts on the environment and human activities embedded in it, allowing notes of planning guidelines for use and occupation suited to the dynamic environment.

Keywords：*relationship soil relief - toposequence- morphology*

P2-245

[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Micromorphological Diagnostics of Pedogenetic Processes in Loamy Cambisols in Middle Taiga Zone of Western Siberia

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Western Siberia is an extensive area with slightly undulating topography that stretches from Arctic to steppe zone. The most extensive is the taiga zone, which is characterized by high proportion of peatlands. In the middle taiga zone the upland positions are occupied by Podzols, if the parent material is sandy, and by poorly differentiated Cambisols in the case of loamy sediments. The latter group of soils is insufficiently studied. Their morphology does not correspond to the central concept of taiga pedogenesis, i.e. the formation of texturally-differentiated soils. Thus, we aimed at the diagnostics of the pedogenetic processes responsible for the formation of these unusual soils in Western Siberia. We studied the mineralogy and micromorphology of the Cambisols that form on gentle hills and ancient Ob River terraces. The parent material of the studied soils is believed to be of ancient marine and alluvial origin. The climate of the study area is cool, with mean annual temperature -4 --2°C; in January the mean temperature is -20°C, and in June it is 18°C. The annual precipitation is 580 mm, with the most intensive rainfalls from July to September. The study are has insular permafrost, but the particular study sites has no evidence of permafrost down to 2 m. The profile of the soils is poorly differentiated into pedogenetic horizons. The soil profiles have light brownish colours. Some soils have evidences of water stagnation in the upper part of the profile. In two of the studied profiles also there are greyish spots in the BC and C horiozons that can indicate groundwater gleying. The soils have small iron nodules throughout the profile. The soil structure in the BC and C horizons is platy, and in the B horizon it is strong granular (so-called “caviar structure”). There is no humus-accumulative A horizon, or it is very shallow (2-5 cm). The texture slightly varies with depth, reflecting mostly the irregularity in sedimentation. In most soils the topsoil contains less clay than underlying horizons. The soils are strongly acid in the upper horizons (pH in water extract 4.0-4.8); with depth the pH increases to 5.6-6.1. The clay mineralogy of the parent material is characterized by the presence of smectite, illite, and kaolinite, which has been recorded as common components for the majority of sediments in Western Siberia. In the upper soil horizons the intensity of the signals of smectite and illite minerals decreases. In the B horizons there are evidences of the presence of Al-interlayered vermiculite. The micromorphological study of the soils showed the presence of numerous iron-manganese nodules of various sizes. Soil aggregation is strong, and the form of aggregates is rounded; some of them have surprisingly regular form. In some of the aggregates there are iron nodules in the centre. Though iron nodules are very common in these soils, the study of the soil water regime did not show the presence a significantly long period of water stagnation, characterized by reducing conditions. Most probably, the iron nodules reflect paleoenvironments or even the conditions of sedimentation. In the lower horizons (BC and BCG) there are clay and silty-clay coatings that indicate the existence of illuviation of fine particles in these soils. Most of them are found in cracks and big voids. However, the expression of the coatings clearly shows that the illuviation cannot result in a significant differentiation of soil texture. We hypothesized that slightly lower content of clay and the loss of smectite and illite in the topsoil are the results of clay dissolution in the upper extremely acid horizons. The specific granular (“caviar”) structure may be ascribed to the frost action that breaks the plates into polygonal fragments and polish these fragments. We believe that similar microstructures in paleosols may be interpreted as analogs for the Western Siberian soils under study, and thus the existing environments of middle taiga of Western Siberia may be extrapolated to the paleoenvironments for the paleosols with similar morphology.

Keywords：*micromorphology, clay mineralogy, strongly acid soils, Al-interlayered vermiculite*

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[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Digital Soil Mapping and Classification for Sustainable Crop Cultivation in Northeast, Akwa Ibom State, Nigeria Using Digital Elevation Model and Geographic Information System

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For farmers and other land users to have better understanding of the kind of soils found in the landscape where they operate, there is need for proper soil mapping and classification. This will facilitates the judicious allocation of land to best uses. Hence, digital soil mapping and classification in northeast Akwa Ibom State, Nigeria using digital elevation model and geographic information system, was carried out. The aim was to assess the effectiveness and reliability of the tools in digital soil mapping and classification. Contour map of the study area was generated from digital elevation model (DEM) and superimposed on the topographic map at scale of 1: 50,000 to produce the base map. The base map was classified, which resulted into predicted soil classes. With the help of hand held Global Positioning System (GPS) and random soil augering at representative locations, the predicted soil classes and soil boundaries were established in the field. Three soil mapping units were delineated. Profile pits were sunk at various representative locations within the three mapping units. A total of 16 profile pits were dug in the study area and 70 soil samples were generated for laboratory analysis. The results of soil characterization of the soil units showed that soil unit 1 was characterized with mottles in the A-horizon. Soil unit 2 was characterized with mottles in the B-horizon, while soil unit 3 was characterized with no mottles within 200 cm of soil depth. Mean soil reaction measured in KCl was strongly acidic (pH 5.1) in the topsoil and very strongly acidic (pH 4.7) in the subsoil of soil unit 1. In soil unit 2, mean soil reaction was very strongly acidic (pH 4.5-4.9) in both top and subsoil. In soil unit 3, mean soil reaction was very strongly acidic (pH 5.0) in the topsoil and extremely acidic (pH 4.3) in the subsoil. Organic carbon was high (1.6-1.9 %) in topsoil of soil units 1 and 2, and moderate (1.4 %) in soil unit 3. Mean available P was moderate (8.17-19.50 mg/kg) in both top and subsoil of all the three soil units. Exchangeable K (0.05-0.12 cmolkg) and total N (0.04-0.13 %) were low in all the three soil units. CEC was moderate (12.53-14.39 cmol/kg) in the topsoil and low (11.14-11.75 cmol/kg) in the subsoil in all the three soil units. Available Fe was excessive (280.0-344.4 mg/kg) in all the three soil units. According to USDA Soil Taxonomy, soil unit 1 was classified as Typic Epiaquept, which approximately correlated to Gleyic Cambisol (FAO / UNESCO Soil Map of the World Legend). Soil unit 2 was classified as Aeric Epiaquept (USDA Soil Taxonomy), which correlated to Gleyic Cambisol (FAO /UNESCO). Soil unit 3 was classified as Typic Hapludult (USDA Soil Taxonomy), which correlated to Haplic Acrisol (FAO / UNESCO).

Keywords：*Digital Soil mapping, GIS, Akwa Ibom State soils, classification*

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[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Morphological Properties of Soil Compaction in a Steppe Zone

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Development of the global scientific and technical cooperation in soil science leading to increased demand for universal scientific terminology and data format. One of the main directions in the Global soil cooperation, which was recently adopted by the FAO is «harmonizing methods, measurements and indicators for sustainable management and soil conservation» (Montanarella and Vargas, 2012).

Soil compaction of the steppe zone soils is an actual problem, both agricultural and soil science. Compaction and degradation of the soil structure of the steppe zone soils is caused, as a rule, by processes of compacting (vertic process), alkalinization and mechanical densification, as well as their combinations.

In this work we discussed the structural problem of condition of soils, which is among the main factors determining the fertility of the soil is one of the most important functions of the soil. For highly productive natural soils is typical loose composition and lumpy multi-ordered structure.

Compaction processes of soil structure can be as natural genesis (salinization, compacting), and mechanical densification. Agricultural practices violate the natural structural balance of the soil and leads to the processes of degradation of soil structure. Three-dimensional visualization and quantitative morphological assessment of soil aggregates and then is a topical method of diagnostics, evaluation and monitoring of the physical condition of agricultural soils.

Important methodological problem is poly-component soil mass, because soil contains a lot of various neoplasms and inclusions, which has a great diagnostic value. Such as accumulation and migration of clay components, organic matter, heavy metals, salt, vegetable residues and other, and also pedo- and lithorelicts and anthropogenic inclusion. One significant problem is the all-time dynamics of the soil structure (wetting-drying), which may affect the representativeness of the samples and the reliability of the obtained results. Unlike the pore space many of these structural elements are poorly allocated in the x-ray shadow projections. For contrasting soil tumors and inclusions may need special scene modes and image processing (Ivanov et al., 2013) or a number of additional studies using other methods (micro-morphological analysis, mineralogy etc.).

We successfully applied micro-tomographic method for analysis of the structure of pore space in order to evaluate the degree of degradation of the soil structure and evaluate soil compaction. In our opinion, this method works well because it showed good results comparable with expert judgement, and therefore, it is applicable for this type of task and research and can serve as a method for visualization of results, and also, after more detailed elaboration of mechanisms for the interpretation of digital data, serve the automated method of analysis and evaluation of structural state of soils. To specify and compliment the results we produce micro-morphological and mineralogical analysis.

Keywords：*Micro-morphology, Micro-tomography, Soil compaction, Steppe soils*

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[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

An Index of Soil Structure Derived from Water Retention Data and Particle Size Distribution

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Soil water retention characteristics (SWRC) are used to infer pore size distributions that reflect the combined effects of texture and soil structure. A way to isolate and quantify the effect of soil structure from soil texture is to measure the departure of SWRC-derived pore size distributions from a reference distribution that can be attributed to the random packing of soil particles. This can be done with the Kullback Leibler Divergence (KLD) defined as a measure of the distance between two probability distributions. Our objective was to investigate relationships between KLD values and corresponding texture, soil structure description done in the field, soil depth and horizon type. KLD was estimated by assuming that pore- and particle- size distributions were log-normally distributed. More than 500 samples selected from the European Hydropedological Data Inventory (EU-HYDI) were used to calculate KLD across a range of soil conditions. Results show that KLD values are not influenced by texture. Larger values of KLD were found in small aggregates in the A and B horizons and in large aggregates in mainly the C horizon. In general, KLD values decrease with depth and were smaller in the C horizons. The KLD measure is a promising tool to assess the influence of environmental factors on soil structure.

Keywords：*soil structure, relative entropy, EU-HYDI*

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[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Transformations of the Primary Soil Cover in Different Types of Land Use

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The survey was conducted in three basins without outlets located in young glacial landscape in north-western Poland. Particular closed basins differed in type of land use. The aim of the study was to recognize and examine soil typology changes which have been occurred in these specific land forms as an effect of natural (soil erosion) and anthropogenic processes (anthropogenic denudation). Influence of these processes on soils is very wide. A degree of changes varies depending on land use. Additional factors which have an influence on appearance of transformations in soil cover are: time, climate, flora and water conditions. As a result of influence of these factors, soils, which primary were observed on the surface, have been filled with sediments. An impact of soil-forming factors caused that amorphous allochthonous material was transformed into soil. These new soil units have a significant impact on buried soils, which occurred below. According to type of land use, total area of untransformed soils is different. Valid modifications have been taking place not only in mineral soils, which are located on slopes, but especially in soils of the bottom of sedimentary basins. In a fact, most of natural soil properties and morphology are replaced by new characteristics.

Keywords：*basins without outlets, primary soil cover, soil redistribution, anthropogenic denudation, soil eros*

P2-250

[C1.1-1] The Role of Environment on Soil formation: Morphological Indicators

Modification of Soil Map in Accordance with Rapid Regional Changes in Land Use

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Recently, reduction of cropland has been accelerated rapidly. This reduction was caused by the changes of external factors; urbanization, readjustment of arable land, road building, building innovation cities etc. However, there are internal factors of the reduction. For example, the price gap of products from paddy fields or uplands caused changes of paddy fields to uplands or greenhouse facilities by fill-up arable lands or to non-cultivation lands. The objectives of this study were 1) to investigate changes of land-uses, soil characteristics, and soil maps from areas with many land-use changes, such as Gangwon-do Wonju, Gyeonggi-do Icheon and Gwangju and 2) to analyze soil environments of incorporated areas like innovation cities. Korea's arable lands (2011) decreased by 17.3 ha compared to 2009. Paddy fields decreased by 24.2 ha, while uplands increased up to 7.0 ha. The main reasons of the paddy field reduction were switching fields and paddies (20.7 ha) > public facilities (3.2) ≥ building construction (3.2) > abandoned land (1.3) > others (0.9). The reasons of the upland increase were switching fields and paddies (20.7 ha) > cultivation (4.5) > restoration (0.3). The reason of switching fields and paddies was conversion from rice farming to higher income farm or greenhouse products. Arable lands (paddies, uplands, orchard) from cities and counties of severe landuse changes reduced by 6,980 ha in Wonju, 6,980 in Icheon and 3,692 in Gwangju compared 2011 data to upland soil survey project(1995～1999). This result showed the arable lands reduced by 45%～25% compared to 1999 data.

Soil information in Wonju changed portion of paddies in valley to uplands or orchards and changed to poorly drained lands in case of drainage classes because of road construction etc. In particular, severe changes of land uses in paddy fields caused by greenhouses, uplands, orchards, non-cultivation and fill-ups. The land suitability results of incorporated areas to Wonju innovation city were mainly poor level, 3~4 suitability classes for paddies; 70.8% of 3 suitability class and 29.2% of 4 suitability class. Uplands were also 88.7% of 4 class of soil suitability, which fortunately lands of good levels were not included in construction of innovation cities. Arable lands are irreversible if they are used for building or road constructions, therefore establishment of legal and institutional strategies should be a priority to conserve good arable lands.

Keywords：*Soil survey, Landuse, Paddy field, Soil suitability classes, Wonju, Icheon, Kwangju*

P2-251

[C1.2-1] Pedodiversity and Ecological Services - Bridging Soil Geography and Land Use

Indegenous Knowledge of Soil Classification and Srategies of Land Use

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The analysis of indegenous knowledge of soil classification and strategies of land use were carried out in the province of Soum in Burkina Faso by a study of soil profil along toposequences, selected according to geology and geomorphology.Soils ranking and soil identification were done in the field by fulani farmers using an approach based on semistuctured interviewing on upper reference horizons. Soil samples were taken from the top 20 cm.Samples were analyzed physically and chemically by BUNASOLS soil laboratory. we found that main denomination criteria were soil morphology and topography. Soils are unevenly cultivated because of sociocultural reasons. Fulani farmers perception of soil physical and chemical properties was confirmed to match well with laboratory results, proving fulani farmers knowledge of soil and the revance of their classification criteria. So, it is urgent to take into account indegenous knowledge in research programs and projects to have a best undertanding and make more and more correlation with scientific classification system. It is a simple and pratical classification than can contribute efficiently to a sustainable land management.

Keywords：<*indegenous knowledge, strategies, land use, Soum, Burkina Faso.*

P2-252

[C1.2-1] Pedodiversity and Ecological Services - Bridging Soil Geography and Land Use

Analysis of Dike Natural Subsidence Caused by Mining under River

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Abstract: The irregular dike foundation settlement caused by load difference, deformation of foundation and dike itself will affect the normal use of the upper levee, and endanger the safety of dike, thus in the process of dike strengthening, it needs a prior estimation for the natural subsidence of dike to avoid project waste and loss of profits. Currently, there are less specific studies about natural subsidence of soil embankment, this paper take one dike after mining under river in Shandong, China for example, use soil mechanics theory, analyze its subsidence reasons, types and calculation methods, get the natural subsidence of dike reinforcement soil with the method of unidirectional compression layered summation, determine the backfill soil condition by experiment and get the final dike settlement, then compare with the field monitoring leveling data, the result show that the estimation amount of dike natural subsidence and the field leveling data is consistent, it also reflects the rationality and feasibility of settlement calculation and has important significance to the dike collapse and governance.

Keywords：*natural subsidence; consolidation settlement; secondary compression; layer wise summation method*

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[C1.2-1] Pedodiversity and Ecological Services - Bridging Soil Geography and Land Use

Sedimentation Hazards and Sustainable Land Management: A Case Study of the Lobar Haor, Bangladesh

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The north-eastern corner Bangladesh is a flood-prone delta with thousands of haors (basins that are frequently flooded and prone to water logging) and beels (wetland bodies). The Lobar haor is situated in the Tahirpur, Sunamganj district of Bangladesh adjacent to Meghalaya Hills of India. Historically the Lobar haor was economically profitable producing many fish species and winter rice. However, over the last 20 years, due to irregular and excessive rainfall in the upper catchments, excessive sedimentation has resulted in over seven feet of additional silt filling the Lobar haor as well as the neighboring Digher beel. Over 2000 acres of formerly arable land has been rendered unproductive affecting more than 12,000 people. The sedimentation has dramatically reduced the livelihoods of the local people, but also has severely affected the environment and biodiversity. Many local people have been forced to change from agriculture to day-labouring (sand and stone collection), while in a few areas farmers struggle to grow ground nut, local rice and vegetables, but with very low yields.

Recently as a part of a Landcare approach, a number of Focus Group Discussions (FGD) have been conducted in this area which have identified possible solutions to overcome an adverse situation. We are now working with these communities to promote a new approach including organic farming using pest and drought resistant varieties, new crops and different compost preparation techniques to increase soil and fertility. The establishment of local farmer cooperatives is also being explored involving different stakeholders including local administration. Additionally new infrastructure is being investigated such as a barrage on the Bolai River to mitigate sedimentation and also deep irrigation pumps to facilitate improved irrigation. The objective is to achieve sustainable land management in the Lobar hoar with high level farmer engagement to improve their livelihoods in an eco-friendly environment.

Keywords：*biodiversity, land use, sedimentation, soil fertility*

P2-254

[C1.2-1] Pedodiversity and Ecological Services - Bridging Soil Geography and Land Use

Colluvial Deposits as Proxies for the Kind and Intensity of Human Activities in Southwest Germany

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A common theory to explain human migration is climate change triggering migration and the shift of farming places. The populated areas might have been changed or extended because of changing resources like a warming climate or soil erosion. But it has also to be taken into account that altered trading relations or changing religious attitudes might cause migration into and settlement of former not used areas. In the case of Southwest Germany people migrated from the Baar (more even areas, soils on loess, lower elevations) to the Black Forest with harsher environmental conditions (small valleys, acidic soils, steep slopes, higher elevation). Apparently the population in the Black Forest was low before the land acquisition of the Medieval period. Despite the low amount of Neolithic findings and few known settlements from the Hallstatt period, many grave-mounds, cereal pollen and macro remnants from prehistoric times are known, which point to settlement. The adjacent Black Forest was extensively settled with the beginning of the late Medieval period.

In our study we use colluvial deposits as archives revealing important aspects of the formative impact of humans on their environment and land use changes considering soils generally as an important resource related to human activities. We will use colluvial deposits as proxies for the kind and intensity of human activities. Additionally the colluvial deposits will provide valuable information about vegetation, climate history and pedogenic processes since the time of colluvial deposition. First results of AMS radiocarbon dating of SOC and charcoals show that thick lower colluvial layers date back to the third millennium BC. Above-lying colluvial layers date to the 11-12th and to the 13-14th Century. Around Villingen colluvial deposits could be found in approximately 60-80 cm depth dating to 1620-1500 cal BC and in about 50 cm depth dating to 427-543 cal AD. The age of the lowest colluvial layers are older than the widely accepted beginning of more intense settlement in Southwest Germany. Inferred from the periods of intensified colluvial deposition events other reasons than warmer climate may be responsible for migration from favored to disfavored regions.

Keywords：*colluvium, settlement, land use reconstruction, early history*

P2-255

[C1.2-1] Pedodiversity and Ecological Services - Bridging Soil Geography and Land Use

Retracing Signals of Historical Soil Erosion in Peatbog Archives as an Indicator for Landscape Resilience in the Context of Future Landuse Changes and Weather Fluctuations (tum-Czo, Ammer Mts.)

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As an example for recent research attempts within the Critical Zone Observatory of the Technical University of Munich (TUM-CZO), located in the Ammer Mountains of the Bavarian Alps, we present a project which deals with the investigation of possible soil loss triggers and dynamics in alpine landscapes. As soils represent the central part of the heterogeneous interaction system of the Critical Zone, they hold an essential relevance for a broad variety of up-to-date questions concerning the long-term sustainability of numerous natural resources and ecosystem services. Soil loss consequently causes serious, irreversible loss of vital soil functions and thus ecosystem services. Hence, determining risks of soil degradation and soil loss is a major task within the Critical Zone research. The reconstruction and analysis of past erosion incidents is an essential key to understanding the driving factors of soil erosion or landscape resilience as reaction to external triggers (both natural and human). Peat bogs containing interlayered strata of mineral colluvial fillings are ideal archives for such reconstructions. Within the Ammer catchment, we investigate a total of twelve peat bogs distributed across an altitude gradient from alpine to subalpine and lowland landscapes. In addition to the extraction of conventional drilling cores, Ground Penetrating Radar is used as a non-invasive method of highlighting the internal stratification of the peat bogs. Various dating techniques can be applied to both organic and mineral layers (14C, OSL, pollen analysis). Pollen analysis adds additional proxy data on vegetation and climate. The results then allow the correlation with well known, prominent climatical stages (e.g. Little Ice Age) and extreme weather incidents in the past as well as with historical records on land use. By this, valuable insight on characteristic regional landscape dynamics and thresholds is provided.

Keywords：*TUM-CZO, soil erosion, landuse change, resilience, peat bogs, altitude gradient*

P2-256

[C1.2-1] Pedodiversity and Ecological Services - Bridging Soil Geography and Land Use

Peculiarities of Tundra Soil in the Northeastern Yakutia

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The soils of Yakutia has developed in conditions of permafrost distribution. In north-eastern Yakutia in the deltas of large rivers (Yana, Kolyma, Alaseya, etc.) the tundra zone is divided into the northern and southern tundra. The northern tundra is presented by seaside meadow landscape and polygonal tundra. Semihydromorphic soils of polygonal tundra are presented by permafrost shallow and weak-gley tundra soils, forming in conjunction permafrost peat soils. These soils are formed by a combination of increased drainage of polygon sides and high humidity of the surrounding areas. In such conditions polygon sides serve as a detention of surface and ground water. The reaction of the soil - acidic. Content of organic matter in organogenic peat horizon is significant (64.6%), content of humus in mineral horizon is also high (up to 10%). Relatively high content of humus in the lower horizons probably related to the processes of retinization, which is defined as the process of movement of water-soluble organic matter to the permafrost surface, because soil formed under tundra vegetation have fulvic (mobile) humus composition. Also, the reason for this phenomenon, which is more likely, can be a soil active layer decrease and a large amount of intrasoil detritus. Soil is not saturated with bases (up to 17-22%).

Soils in the polygon depressions have a totally peat horizon in profile and therefore it have very small depth of thawing. Soil profile has very high organic matter content (32-69% ignition loss). The reaction of the soil is weakly acidic. Hydrolytic acidity is relatively high (30-52 mg equiv H+/100g), maximum of its distribution is in the lower and upper parts of the profile due to the similar distribution of the organic matter. Soil is weakly saturated by bases (26-37%), compared to the polygon rim soil the rate is higher and related to the influence of the natural water composition. Thawing depth is 24 cm.

On the southern subzone of tundra there are formed the permafrost tundra gleyic soils on the upland landscapes. This soil is located on relatively drainable tundra areas often well-defined hillocky microrelief due to the frost cracking of the surface. As a result occurs slightly convex polygons with diameter about 70-100 cm, partially or completely free of vegetation. The active layer depth is 65 cm. Slightly acidic reaction, which is close to the neutral. Content of organic matter in mineral part is low (up to 1.4 % of humus). Hydrolytic acidity is also small (4-4.8 mg equiv H+/100g). Soil has a middle base saturation (70%).

To the south, on the area of shrub tundra there are formed the permafrost tundra gleyic thixotropic soils with thawing depth of 52 cm. By the morphological point of view this soil has an average depth of coarse humified organogenic horizon and well visible thixotropy in mineral part of profile. It is well known that thixotropy is among those properties that cannot be diagnosed in soils during the dry periods. During the dry periods, thixotropy is not appear and it usually continues after periods of freezing and thawing. This phenomenon is typical for a wide range of tundra and mountain soils and described by a number of authors explored these soils within the Western and Eastern Siberia (Ivanova, 1965; Karavayeva, 1969; Ignatenko, Targulian 1986; Elovskaya et al, 1979). Undoubtedly, this phenomenon appears in the soils of the European North. But in general, this is the phenomenon that can lead to solifluction processes, has not yet fully evaluated in terms of the mechanisms of its generation. It is clear that within the colloid chemistry, this phenomenon is seen as a quick transition of the gels to the sol under the mechanical stress. Some researchers, in particular, Koshelev - Liverovskii (1964) attributed this phenomenon primarily with silty loam composition of soil and the absorbed cations character. It is also important remark of Elovskaya L.G., which also marked the appearance of thixotropy only in wet years. The reaction of thixotropic soils is acidic in organic horizons (pH 4.4) and close to the neutral in the lower part. Soil characterized by a high content of organic matter in the upper horizons (31.8%) and relatively low in lower horizons (3.1% humus). This soil is medium bases saturated (33-71 %).

Keywords：*tundra soil, yakutia, permafrost, peculiarities*

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[C1.2-1] Pedodiversity and Ecological Services - Bridging Soil Geography and Land Use

Post-Agrogenic Self-Restoration of Soddy Podzolic Soils: Results and Methods N.P. Sorokina, D.N. Kozlov, I.B. Kuznetsova

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Under discussion are results of experimental studies of the post-agrogenic transformation of loamy soddy podzolic soils.

The studies were performed in an area of about 100 km2 located on the southern slope of the Klin–Dmitrov Moraine Ridge in 2008-2010. Forests occupy 70% of the studied territory. The soil cover consists of various combinations of soddy podzolic soils with different podzolization, gleyzation and erosion degree.

The methodology of studies combines: 1) the historical-cartographic method (a series of maps of land use compiled in the 18th-20th centuries: the Map of the General Land Survey of the century, the military topographic maps of the 19th and 20th centuries on the scales of 1 : 10 000 to 1 : 50 000, and the high_resolution satellite and aerial imagery of different years) for creating chronosequences and 2) morphogenetic methods for studying the post-agrogenic changes in soil profiles. In the given studies a complex of methods was used including the soil morphological method, detailed layer-by-layer analysis of several properties (the humus and clay content, pH, spectral reflectance) in the topsoil (0-30 cm) with 2-3 cm interval and physical properties of soils (bulk density, water permeability, hardness) with 5 cm interval . The differentiation of the former plow horizon into the A and AE horizons (according to the differences in the humus content, colour, texture and acidity) served as the major criterion of post-agrogenic transformation of soils. 50 soil profiles have been studied in detail.

A chronosequence of soils comprising arable soils (cropland)—abandoned soils with meadow vegetation—soils under secondary forests of different age—soils under a conventionally initial forest was examined and the stages of the postagrogenic transformation of the automorphic soddy_podzolic soils were identified.

Stage1. Meadow overgrown with birch trees (10–30 years). This stage is characterized by the beginning of textural differentiation in the former plow horizon and the humus accumulation in its upper part. The A1 horizon (10-12 cm) with a humus content of more than 3% is formed (нere we underline that the humus content in arable soils is 1.5-2.0 %). The clay content somewhat decreases in the uppermost layer. The pHKCl decreases from 5–6 (cropland) to 4.0–4.5. Some decompaction of the soil mass (from 1.25 to 1.1 g/cm3) takes place in the newly formed A1 horizon. The residual features of the plowpan are preserved. A thin platy structure is formed in the AEL horizon.

Stage 2. The active soil restoration under the mixed spruce–birch forests (35 to 70-80 years). The humus content in the A1 horizon increases to 5%; the differentiation of the A1 and AEL horizons in color becomes more distinct. The distribution of the clay fraction is characterized by a minimum in the surface layer 10-15cm, which disappears by the end of this stage. The pHKCl is less than 4.0.

Stage 3. Quasi-virgin soil (>70–80 years). The humus content is more than 5% in the A1 horizon and sharply decreases in the AEL horizon; the bleaching of the AEL horizon is clearly pronounced. The clay content has a minimum in the EL horizon. The pHKCl

is 3.5–3.8 and does not differ from that in the soils under conventionally initial forests. The bulk density in the A1 and AEL horizons is 1.05–1.07 and 1.2–1.3 g/cm3, respectively. Most of the properties of the virgin soddy podzolic soils are restored, but the lower boundary of the former plow horizon remains at the depth of 18–20 cm.

Conclusion In the studies of the postagrogenic soil evolution, the intralandscape differentiation of the soil cover should be taken into account. It is reasonable to distinguish between three different chronosequences of the postagrogenic transformation of the soils: (a) for the automorphic soils of the leveled interfluves, (b) for the semihydromorphic soils, and (c) for the soils on slopes. To reconstruct the post-agrogenic chronosequences the digital elevation model and two maps are required including (1) the integral map of the land use history with indication of conventionally initial forests, croplands, and land abandoned for a long period of time and (2) the map of soil cover patterns with indication of zonal automorphic, semi-hydromorphic, and erosional soil combinations.

Keywords：*post-agrogenic transformation of soils, chronosequences, digital soil map, land use history, stages*

P2-258

[C1.2-1] Pedodiversity and Ecological Services - Bridging Soil Geography and Land Use

Soil Cover Patterns Influence on Ecosystem Services and Land-Use Efficiency in Case of Central Russia Native and Agro Ecosystems

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The essential spatial and temporal variability is mutual feature for most natural and man-changed soils at the Central region of European territory of Russia (CCR). The original spatial heterogeneity of forest and forest-steppe soils has been further complicated by a specific land-use 700-years history and different-direction soil successions due to environmental changes and human impacts. For environmentally friendly and demand-driven land-use planning and decision making the quantitative analysis, modeling and functional-ecological interpretation of representative soil cover patterns spatial variability is an important and challenging task that receives increasing attention from scientific society, private companies, governmental and environmental bodies in Russia.

Our long-term researches include the wide zonal-provincial set of representative ecosystems and soil cover patterns with different types and history of land-use (forest, meadow-steppe and agricultural ones) from middle-taiga to steppe zones with different level of bioclimatic continentality. The carried out 30-years region- and local-scale researches of representative natural and rural landscapes in Tver', Yaroslavl', Kaluga, Moscow, Vladimir, Kursk, Orel, Tambov, Voronezh, Saratov oblasts and Mordovia give us the interregional multi-factorial matrix of elementary soil cover patterns (ESCP) with different land-use practices and history, soil-geomorphologic features, environmental and microclimate conditions.

Succession process-based analysis of modern evolution of natural and man-changed soils essentially increases accuracy of quantitative assessments of dominant soil forming and degradation processes rate and potential, their influence on landscape and soil cover quality and ecosystem services. Their results allow developing the regional and landscape adapted versions of automated land evaluation systems and demand-driven land-use DSS.

The validation and ranging of the limiting factors of ESCP regulation and develop-ment, ecosystem principal services (with especial attention on greenhouse gases emissions, soil carbon dynamics and sequestration potential, biodiversity and productivity, hydrological regimes and geomorphological stabilization), land functional qualities and agroecological state have been done for dominating and most dynamical components of ESCP regional-typological forms – with application of regional and local GIS, soil spatial patterns detail mapping, traditional regression kriging, correlation tree models and DSS adapted to concrete region conditions.

The outcomes of long-term soil and land-use monitoring results statistical modeling together with the current lysimeter studies, GHG fluxes monitoring by exposition chambers (with mobile IR-gas analyzer Li-COR-820) and eddy-covariance stations show the essential amplification of erosion, de¬hu¬mification, CO2 and CH4 emission, acidification or alkalization, disaggregation and overcompaction processes due to violation of environmentally sound land-use systems and traditional balances of organic matter, nutrients, Ca and Na in agrolandscapes.

Due to long-term intensive and out-of-balance land-use practices even originally the most productive Chernozems and Dark Grey Forest soils begin to lose not only their unique natural features (1,2-0.6 m of humus horizon, 4-6% of Corg and favorable agrophysical features), but traditional soil cover patterns, ecosystem services and agroecological functions controlling the terrestrial ecosystem carbon and GHG fluxes balance, their water balance and landscape stability, the native and agro ecosystems biodiversity and stable productivity.

Key-site monitoring results and regional generalized data showed 1-1.5 % Corg lost during last 50 years period and active processes of CO2 emission and humus profile eluvial-illuvial redistribution too. Forest-steppe Chernozem ecosystems are usually characterized by more stable soil cover patterns than forest or steppe ones. The ratio between erosive and biological losses in humus supplies can be ten¬tatively estimated as fifty-fifty with strong spatial varia¬bility due to slope and land-use parameters. These processes have essentially different sets of environmental consequences and ecosystem services that we need to under¬stand in frame of environmental and agroecological problems development prediction. A drop of Corg content below threshold “humus limiting content” values (for different soils they vary from 1 to 3-4% of Corg) considerably reduces effectiveness of used fertilizers and possibility of sustai¬nable farming there.

These problem environmental and agroecological situations can be essentially improved by climate-smart agriculture practice development with DSS-based landscape-adaptive land-use systems and organic farming stimulation with environmentally friendly technologies. Developed on the basis of different-scale soil cover patterns mapping, long-term key plot investigation, land quality and land-use evaluation, the functional-ecological typology of the zonal set of ESCP with the regionally adapted soil forming and degradation processes models and potential assessments give us good information-methodical support for efficient land-use practice design with the ecosystem services control as principal part of Environmental Impact Assessment procedure.

Keywords：*Agroecology, DSS, ecosystem services, land quality, land use control, soil cover patterns, processes*

P2-259

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Minerals of Coarse Fraction and their Distribution in the Podzol Profile (Komi Republic, RF)

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We have studied mineralogical composition of the coarse fraction in the illuvial-iron podzol (Subpolar Ural, northen taiga, N65.030780°E57.298520°, absolute height 79m, profile A0-E-B1-Bfe-BC). The soil was developed on sandy depositions in autonom ous landscape in the pine forest under lichens (Cladonias, Cetrarias) and moss cover. The soil under study has well-developed and thick O horizon.

The weights of the coarse fractions in all of the horizons were over 48 g per 50 g of soil. Therefore, amounts of clay minerals were small and hypergenesis process is weak in the profile under the study.

Granulometric fractions with the grains sizes 1-0,25 mm, 0,25-0,1 mm, 0,1-0,01 mm and <0,01 mm were obtained by the Gorbunov method [Ivanov 1996]. Mineralogical composition of each fraction was studied by immersion method using polarizing microscope. For the determination of the light minerals (quartz and feldspars) we used immersion solution composed of vaseline and anise oils with index of refraction 1,544. For the determination of heavy minerals glycerin was used.

It was found that 0,1-0,25 mm size fraction dominated in all of the horizons. The content of 1-0,25 mm size fraction increased down the profile and the content of 0,1-0,01mm size fraction decreased respectively. It was found that weight content of heavy minerals increased down the profile. Among the heavy minerals epidot and garnet were predominant. The content of epidot grains increased in the deep horizons. In the eluvial horizon E epidot was predominant in the 0,1-0,01 mm size fraction. The content of garnet as another main component of the heavy fraction was almost universe in all of the horizons and was somewhat higher in 0,25-0,1mm size fractions. The content of hornblende grains increased down the profile. In the upper horizons the mineral content was somewhat larger in 0,1-0,01 mm size fraction.

The content of other minerals such as ilmenite, magnetite, goethite, rutile, sphene, zircon was lower than 4%.

Thus, it was found that in the eluvial horizon the content of relatively unstable minerals (hornblende, epidot) was lower than in the deeper horizons. This may be due to their disintegration and weathering during podzol formation.

Among the light minerals quartz and feldspars predominated. The light minerals content decreased down the profile. In the upper horizons (E, B1) their dominant grain size was 0,1-0,25 mm. In the lower horizons 0,1-0,25 mm and 0,25 -1 m size fractions dominated. We did not found any sound differences in the distribution of quartz and feldspars in the profile. Thus it can be concluded that in the young soils developed in the cold humid climate the processes of weathering do not cause differentiation of light minerals in the profile, but alter the morphology of grains.

Thus, based on the results obtained we conclude, that one of the main reasons for the observed differences in the content of certain groups of primary minerals in the size fractions is their physical disintegration in the E horizon. This disintegration cause transition of primary minerals from the fractions with larger grain size to fractions of smaller grain size.

Keywords：*podzol, soils mineralogy, weathering, epidot*

P2-260

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Genesis, Mineralogy and Classification of Highly Calcareous Soil of Southern Iran

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Study of genesis, classification and morphological, physico-chemical, Mineralogical characteristic and land suitability for main crops of Kaftar basin from Eghlid suburbs for Fars of Highly calcareous soil of southern Iran with 10000 ha extent Province as affected by topography were carried out. By Geosen Method, the area's temperature regime is mesic and the soil moisture regime is xeric. Five physiographic units, namely gravelly colluvial fans, Piedmont plains, Low lands, Mountains and Hills were identified. Based on the results of field observation and laboratory Analyses it seems that topography is the main factor affecting soil formation at the study area. Entisols, Inceptisols, Vertisols and Alfisols, were four order that have been found. X-ray diffractograms of clay fractions of representative soils showed that similar minerals were present, although differing in relative abundances.

Keywords：*Genesis, mineralogy and classification*

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[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

The Effect of Topography on Soils Properties and their Classification in the Chelgerd Region, Iran

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Topography as a soil-forming factor influences soils through different ways. This study investigates the effect of aspect and slope position on some of soil physical and chemical characteristics, clay mineralogy and soil type in the Chelgerd area, Chaharmahal-Va-Bakhtiari province, Iran. The efficiency of two soil classification systems, Soil Taxonomy (ST) and World Reference Base (WRB) was also discussed. Three slope positions (top, middle and bottom) in seventeen parallel transects along the north and the south-facing aspects were selected and topsoil samples from 0-20 cm depth were sampled. Soil characteristics including soil bulk density, gravel content, particle size distribution, pH, EC, organic carbon, calcium carbonate equivalent were determined. The classification of the representative pedons located on three positions of each aspect was identified according to American Soil Taxonomy (ST) and World Reference Base (WRB). Selected samples from surface and subsoil horizons of each pedons were also considered for clay mineralogy studies. Results showed a significant difference for all of the soil properties between two aspects except clay content. In the south-facing slope, most of the soil properties showed a significant difference between different slope positions whereas these significant differences were not observed in the north-facing slope. Aspect and slope position could not almost affect the type and relative amount of clay minerals. Soils located on the north-facing aspect are classified as Vertisols whereas soils in the south-facing aspect are classified as Entisols and Inceptisols. Comparison between two classification systems shows American classification system is more useful to exhibit soil characteristics than WRB classification in our study area.

Keywords：*Aspect, slope position, soil properties, clay minerals, soil classification*

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[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Early Alteration of Pristine Tephra Grain Induced by Microorganism

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Initial stages of rock alteration in the biosphere are affected by living organisms such as bacteria, fungi and lichens. All of these microorganisms are known to have an impact on the chemical stability of silicate minerals. It has been indicated that microbial action is mineral selective and the effect on the dissolution of minerals influenced by temperature, pH and the type of organic matter available. Although numerous studies have been carried out to better understand the interaction between plants and silicate dissolution by bacteria, plant nutrients release from pristine tephra materials is not yet studied. Understanding the controls on tephra dissolution rates is crucial for improving our knowledge to characterize biochemical weathering and element cycling on the volcanic region.

Two different tephra samples from Mt. Talang of West Sumatra and Mt. Merapi of Central Java, Indonesia were used. Both of samples were collected immediately after eruption, volcanic ash material of Mt. Talang on April 12th, 2005, while of Merapi on June 16th, 2006. The Merapi Volcano, is a 2968 m high, basalt to basaltic-andesite stratovolcano, and is considered as the Indonesia's most active and dangerous volcano. The geographical position of the Merapi summit is at 7° 32.5' S and 110° 26.5' E. Mt. Talang is an active strato volcano in the western part of Sumatra. Summit elevation of Mt. Talang reaches 2896 m above sea level and is located at 100° 40' 41.93' E and 0° 58' 40.81' S.

A series of dissolution experiments was performed to assess the role of bacteria and fungus in dissolution of cations and anion from pristine tephra materials in a closed-batch reaction vessel by continuous shaking in the dark at room temperature for 15 days. Bacillus cereus and aspergillus spp were sampled and cultured from volcanic soils and isolated. They were used to dissolve cations and anion from tephra materials. Solution leachates were collected accordingly.

The amounts of dissolved cations and anion and leachate pH were monitored after 3 hours, 3, 7 and 15 days, respectively. Different behavior in leachate pH was observed. The leachate pH from Mt. Talang tephra decreased with time by 0.45 units, but the leachate pH of the Mt. Merapi tephra increased by 0.54 units after 15 days. The release of cations from both types of tephra was in decreasing order of K>Fe>Ca>Mg. The rate of initial dissolved P was high and dropped to about 20% after 15 days in tephra materials from Mt. Talang and down to 60% at the end of experiment for samples from Mt. Merapi. Changes in the solid tephra materials were observed from initial contact time to the end of the experiment. The pH of tephra materials increased with time and higher solid pH values were observed for samples from Mt. Merapi but not with those of Mt. Talang. The amount of extracted P increased with time. The amount of exchangeable Ca decreased from 4.1 to 1.7 and from 1.2 to 0.7 cmol(+) kg-1 for samples of Talang and Merapi. Significantly large amount of K was dissolved from tephra materials by bacteria. The experimental results presented here indicated that bacteria can significantly affect tephra dissolution. Evidently bacteria have important impacts on tephra dissolution. The occurence of bacteria and fungal after deposition of tephra materials are able to release plant nutrients, thus stimulate plant growth and speed up ecological recovery aftermath of volcanic disaster.

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[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Global Changes of the Soil-Forming Process in the North Caucasus Chernozems in the Argocenosis Conditions

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Biochemical cycles of matters in natural ecosystems are close to a closed type. Farm production changes radically the mechanism of natural ecosystems functioning. First of all, 20-80% of all biological products are alienated as food, forage, fuel or organic raw material. It leads to gradual impoverishment of agrobiocenosis of potential energy resources and elements of mineral nutrition.

Developing good conditions for field crops in topsoil a man ”trained” them not to cultivate underlying levels, thus caused rapid degradation of mineral base of the topsoil level.

The researches is carried out on main subtypes of the North Caucasus chernozems.

Soil formation is an interaction process of living and inert matter. Primarily, vegetation kingdom changes greatly in agrocenosis. Virgin herbage is various and periods of germination, flowering, ripening, die-off take turn during vegetation.

There is one crop on arable land, its vegetation phase takes turn successively. It leaves its mark on the periodicity of organic matter supply with root fall and root release, intensity which depends on the development phase of a crop. If to consider plant mass, there is no comparison between virgin and arable land. If to account average quantity of crop yield in fodder units (f.u.), it is in excess virgin land in 10 times or more. Natural grasses yield is 4-6 t/h of fodder units on the average on carbonate and noncarbonate chernozems, on the arable land ? up to 40-42 f.u. for wheat, 35-38 f.u. for barley, 70-80 f.u. for corn. All biomass is in its place on virgin land, mineralizes, mineralization products are foods for next plant generations. Cultivated production is alienated together with yield on the arable lands. 45-103 kg/h of nitrogen, 16-40 kg/h of phosphorus, 60-120 kg/h of potassium are taken out on different chernozem subtypes. There is no full return of microelements with organic and mineral fertilizes. A great set of microelements is lost from the soil for ever.

It is necessary to think what we are doing when we apply mineral fertilizers, if we increase soil fertility or feed plant? It is not the same. When applied fertilizers we create a favorable nutritious background for grown plants, increase their yield capacity and provoke taking out additional portions of nutrition which are not taken out with fertilizer. So unfavorable nutrition conditions are created for the plant generations. To avoid these unfavorable conditions we try to apply more fertilizes, thus cause a new taking out, worsen nutrition conditions for the next plant generations. Under agrocenosis conditions this chain has no end. The result is soil fertility deterioration.

Another component of living matter is soil micro flora. Total number of microorganisms in chernozems on arable land exceeds virgin lands greatly. Natural cenosis have comparatively stable indices during vegetative periods. There are seasonal fluctuations in number of microbial communities. The difference between minimum and maximum indices is two-three times on the average on virgin land, 12-14 times on arable land. The greatest difference falls at the phase of active growth and plant development and the number of microbes in agrocenosis exceeds a similar index in 8-10 times or more on virgin land.

Change of oxidation-reducing (ORP) and pH potential also shows changes in soil-forming processes . When studied these indices on the North Caucasus chernozems, it was exposed indices differ greatly between natural and anthropogenically changed lands. On virgin land, Eh and pH values change insignificantly both during twenty-four hours and a season and range between Eh=450-500mB and 8,1-7,5pH in carbonate chernozems, Eh=500-550mB and7,0-6,6pH in noncarbonated chernozems. Difference between morning, afternoon, spring, summer ORP values is 80-150mB when increased plant biomass and their root activity on arable land. Ph may lower during twenty-four hours in the zone of rizosphere from 8,2 to 6,5-6,7 on carbonate chernozems in the phase of active growth and plant development, on noncarbonate chernozems from neutral (6,9) to acid (5-7) values.

Carried out research shows a great tension of biochemical and physical-chemical processes in agrocenosis in comparison with natural lands. It leaves its mark on the process of soil formation .Weathering speed and changes of soil mineral base increase. Rearrangement of functional links of biogeochemical processes, changes of soil properties and impoverishment of nutrition elements takes place.

P2-264

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Effects of Land Use/cover Changes on Soil properties in a Dryland Watershed of Hirmi and its Adjacent Agro Ecosystem: Northern Ethiopia

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This study aimed to determine effect of land use / cover changes on spatial variability of selected topsoil (0-20 cm) properties in Hirmi watershed and its adjacent agro- ecosystem, Northern Ethiopia. Disturbed and undisturbed soil samples were collected from four major land use/cover categories: natural forest, plantation forest, grassland and cultivated land. The soil in natural forest was used as a reference to assess extent of changes in soil properties. A one way analysis of variance and Pearson's correlation coefficient were used to test mean differences of the soil physico-chemical properties and determine their degree of associations. The results showed that land use/cover changes significantly affected a number of soil physico-chemical properties. The sand, silt, clay, field capacity, permanent wilting point, soil organic matter, total nitrogen, soil pH, exchangeable potassium, calcium, magnesium contents showed significant variations between the natural forest and the other land use/cover types ($p<0.05$) whereas available phosphorus exchangeable magnesium, cation exchange capacity, bulk density, permanent wilting point and total porosity were significantly different between the cultivated land and other three land use/cover classes ($p<0.05$). The contents of cation exchange capacity, exchangeable magnesium, bulk density, water holding capacity, field capacity, permanent wilting point and total porosity were also significantly different ($p<0.05$) in the soils of the grassland. The distribution of particle size classes revealed an increase in sand and a decrease in clay contents following the conversion of natural vegetation to other land use/cover categories. It is suggested that integrated intervention practices such as plantation trees and hillside terracing can resolve the unfavorable changes in soil properties.

Keywords：*Keywords: Land use/cover change; Soil properties; Dryland, Hirmi, Northern Ethiopia*

P2-265

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Translocation of Silicon and its Isotopic Characteristics in Granite-Derived Soils in a Typical Subtropical Ecosystem

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Silicon (Si) is one of the most important elements of the Earth surface. Biogeochemical cycling of Si influences the processes of weathering, leaching, plant uptake and transformation. Although some researches have been done on Si translocation in Earth surface systems, there are disputes about the mechanisms of Si transformation and translocation, source identification of Si, the role of plants, and Si as an indication of soil evolution. The Si isotope (δ30Si) tracing method may help us understand Si biogeochemical behavior and its implications for soil evolution.

A typical forested watershed (F, 359 ha) and two forest-agriculture watersheds (FA1, 72 ha and FA2, 101 ha) located in southern Anhui Province, subtropical China were selected to study Si cycling. The main crop was rice (FA1, 18%; FA2, 24%) and the main forests pecies were pine, fir, chestnut, bamboo, shrubs and grass. The dominant soil types are Lithic Dystrudepts (Inceptisols), Lithic Udorthents (Entisols) and Anthraquic Eutrudepts (Inceptisols); these last are better recognized in Chinese Soil Taxonomy as Hapli-Stagnic Anthrosols. Si contents and δ30Si values were determined in the rock, soil, plant and water.

In the young soils derived from granite in the three watersheds, the bulk soil δ30Si values were higher than those in mature soil from basalt. The δ30Si values were related to the degree of soil evolution, and tended to be more negative with the increase of clay, active iron and free aluminum. Furthermore, the δ30Si values of clay were significantly more negative than those of silt, sand, phytoliths and bulk soil. The δ30Si values of clay and silt were influenced by degree of soil evolution, while that of sand was similar to quartz.

There was significant Si isotopic fractionation among rock, soil, plant and water. The δ30Si values of most plant organs, especially tree trunks and rice straw, were more negative than bulk soil and rock. However, the dissolved δ30Si (δ30Sidissolved) values were positive in stream water, which resulted in more negative soil δ30Si values because of the mass loss of dissolved Si in stream water. Therefore, in soils derived from base-rich primary minerals, desilification was strong, leading to a large δ30Si value fractionation between soil and stream water. This suggests that δ30Si value fractionation can reflect mineral weathering and soil genesis.

Plants preferentially take up28Si from soil, which contributes to the positive δ30Sidissolved values in the stream water. Further fractionation of Si isotopes within plants results in leaves having higher δ30Si values than other parts, but still lower than δ30Sidissolved. Thus, the Si returned with litter, i.e., Si in phytolith, was higher δ30Si values than in other soil components. Therefore, resilification by plants does not decrease soil δ30Si values.

The positive high δ30Si values in stream water indicate that Si in streams mainly originated from weathering of primary silicate minerals, with minor contributions from litter phytoliths. Secondary clay minerals with highly negative δ30Si values indicate that the neo-synthesizing process dominated clay formation, with only a little coming directly from weathering. This is a different mechanism from what is traditionally considered the dominant mechanism of clay formation.

This study showed that Si isotope analysis is able to reflect Si translocation paths and soil formation mechanisms. It thus extends the use of Si translocation analysis in soil genesis studies.

Acknowledgements: This study was financially supported by the National Natural Science Foundation of China (No. 41071141), and the International Foundation of Science (C/4077-1, 2).

Keywords：*Key words: Si translocation; Si isotopes; Soil formation; Silicate weathering; Soil evolution*

P2-266

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Genesis of Soils by Solodization around Degraded Saline Lakes of Pantanal Wetland, Brazil

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A distinctive feature of the Nhecolândia, a subregion of Pantanal wetland, is the co-existence in close proximity of approximately 7000 freshwater lakes and 1500 saline lakes. Freshwater lakes are seasonally reached by the surface freshwaters that flood the Pantanal, whereas the saline lakes are only fed by subsurface groundwater. The large geochemical and hydrological variability between these lakes influences the genesis of different soil classes: acid, sandy, and structureless soils (Arenosols) are formed around the freshwater lakes; and entirely alkaline soils, with clay-enriched and low permeable natric horizons (Btn) (Solonetz), are originated around the saline lakes, mainly by solonization. Currently, natural changes in the hydrological dynamics and anthropic-induced changes in the land use have allowed the input of freshwater in the saline lakes, causing their degradation and the transformation of their alkaline soils. In our study, soils in the surrounding upland of a degraded saline lake were surveyed in the field and investigated in the laboratory through particle-size and chemical analyses, in order to understand the effects of freshwater introduction in the soil transformations. Near the lake, the surveyed soil has the following sequence of horizons: brown, sand A; pale brown, sand AB; very dark gray, sandy loam, and organic-rich Bh; gray, loamy sand Btng; and green, sandy loam, and impervious Btnxg. The pH is slightly alkaline, neutral and very strongly acid in the A, AB and Bh, respectively, and strongly alkaline below. Exchangeable Na+ is higher than 15% only in the A, Btng and Btnxg and exchangeable Al3+ and H+ are markedly higher in the Bh horizon. This soil presents important morphological and chemical differences from the saline-sodic soils typically found around the preserved saline lakes, such as the presence of the Bh horizon and lower pH and exchangeable Na+ accompanied by higher exchangeable Al3+ and H+ in the upper horizons (A, AB and/or Bh). These features indicate that the solonization process, which is responsible for the origin of the Solonetz soils of the preserved saline lakes, was replaced by the solodization around the degraded lake, producing a Solodized-Solonetz soil. The seasonal inputs of freshwater in the degraded lake is likely triggering this change of pedogenetic processes. However, the slightly alkaline pH and the high exchangeable Na+ values of the A horizon suggest that the solonization is still incipient and is probably occurring by slow leaching of bases due to oscillations of the brackish water table around the degraded lake. The remnant presence of sodium in the soil must be sufficient to provoke the organic matter dispersion, which likely migrates downward and precipitates in the bottom of the lake depression and over the low permeable natric horizons, giving rise to the Bh. The major source of the organic C around the degraded lakes should be the production of plant biomass through the destruction, by seasonal flooding or deforestation, of the dense vegetation that generally occurs tens to hundreds of meters away from the saline lakes. The formation of a subsurface and well-developed organic-rich horizon overlying Btn horizons was mainly observed in the former USSR, where podsolization was coupled with solodization to explain the genesis of this salt-affected soil.

Keywords：*Solodization, organic matter accumulation, salt-affected soils, Solodized-Solonetz*

P2-267

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Slope Deposits of Different Genesis and Ages in the Colorado front Range (rocky Mts.) and Their Significance For Chemical Weathering Fluxes Within the Critical Zone (cz)

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The Colorado Front Range is divided in five altitudinal belts reaching from the alpine tundra (> 3.450 m a.s.l.) down to the plains (> 1.710 m a.s.l.). Our investigations are dealing with different kinds of slope deposits, their genesis and age. The critical zone is the heterogeneous carapace of soil and weathered rock, and the ecosystems they support. Understanding the evolution of the critical zone, and its sensitivity to perturbations, requires an un- derstanding of its architecture and the processes that produce this architecture. The Boulder Creek Critical Zone Observatory (BC CZO) is designed to understand how weathering (both physical and chemical) and transport pro- cesses control the structure of the critical zone, and to explore the impact of critical zone structure on hydrological, geochemical and biological functions of the landscape. Slope deposits are crucial elements of the critical zone. The 1.160 km2 Boulder Creek watershed in Colorado's Front Range encompasses strong contrasts in erosional regimes, and therefore contains critical zone architectures that range from dominantly bare rock to deeply weath- ered profiles. Through the late Cenozoic, a slowly eroding rocky upland comprising Precambrian crystalline rocks has been etched in its headwaters by glaciers, and bitten into by headward migrating stream knickzones. This has produced a landscape in which the critical zone is captured in three states. Each of these is represented in a focus subcatchment in the BcCZO where the critical zone will be characterized in detail. The slope deposits show characteristic variations within the subcatchments. Fundamental characteristics of the critical zone, together control the passage of water, the chemical processes operating, the material strength, and the function of subsurface ecosystems. Slope deposits of different genesis and ages play a decisive role.

Keywords : *climatic change, Colorado Front Range, slope sediments, weathering, soil formation, numerical dating*

P2-268

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Does Pedogenetic Carbonation Play Insignificant Role in Atmospheric CO2 Sequestration?

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Pedogenetic carbonates represent an important terrestrial carbon pool (Schlesinger, 1985; Lal, 2008). However, it was thought that pedogenetic carbonation played insignificant or no role in atmospheric CO2 sequestration (Capo and Chadwick, 1999; Dart et al., 2007) because pedogenetic carbonate formation was only the result of dissolution and re-precipitation of the primary carbonate minerals present in the soil parent materials or entering into soils by atmospheric deposition (Dart et al., 2007).

While there is no doubt that this is a pathway for the formation of pedogenetic carbonates, it does not explain the presence of pedogenetic carbonates in highly alkaline soils that are widely distributed in arid and semi-arid regions. If the pedogenetic carbonates were formed through the reworking of calcareous parent rocks or dust-derived carbonates, the soil pH should not exceed 8.5 that can possibly be raised by dissolution of the primary calcium carbonates. The generation of high alkalinity (rise in pH to greater than 8.5) can only result from the weathering of alkali metal silicates.

Therefore, the presence of highly alkaline soils indicates the occurrence of silicate weathering although this may not necessarily reflect in-situ weathering within a soil profile. From a catchment-scale perspective, silicate weathering products (NaHCO3 and NaOH) present in the soil at a given location can derive from runoff. It is also likely that in-situ weathering of alkali-generating silicates took place during past wet episodes in the present desert areas.

Strontium isotopic signatures have been used as primary evidence to support the hypothesis that Ca of atmospheric sources controls the pedogenetic carbonation in arid and semi-arid regions (Capo and Chadwick, 1999; Dart et al., 2007; Chiquet et al., 1999; Hamidi et al., 2001; Van der Hoven and Quade, 2002). The utilization of 87Sr/86Sr as a tracer for Ca sources in ecosystems is based on the following theoretical assumptions (Van der Hoven and Quade, 2002): (a) There is no significant fractionation between the strontium isotopic species as Sr passes through various phase transformations, such as precipitation or dissolution; (b) Because Sr and Ca have similar ionic radii, their chemical behaviours in the environments are also similar to each other and consequently, Sr can be used as a chemical proxy for Ca. Nevertheless, there have so far been no serious efforts made to test the validity of these hypotheses in alkaline soil environments.

We have investigated alkaline soils from over 200 locations in the Libyan Sahara and the Murray-Darling Basin, Australia to test the validity of the second theoretical assumption mentioned above by investigating 87Sr/86Sr ratio, chemical behaviours of Sr, Ca, Mg and other relevant elements in these alkaline soils, as well as Sr, Ca and other major chemical constituents in rainwater samples collected in the region where alkaline soils were selected for investigation.

The results suggest that calcium and strontium behavioured differently in the investigated alkaline soil systems. There was also a marked difference in geochemical behaviour between the two elements during the course of atmospheric transport from the ocean surface to the land surface. Therefore, 87Sr/86Sr provided no reliable indication of the Ca source to form pedogenetic carbonates in the investigated alkaline soils. This raises concerns over the suitability of strontium isotopic signatures in tracing Ca source for pedogenetic carbonation in alkaline soils. Therefore, the truth of the statement that pedogenetic carbonation played insignificant or no role in atmospheric CO2 sequestration is questionable.

Keywords：*Pedogenetic carbonate, carbon sequestration, alkaline soils, strontium isotopes, weathering, desert*

P2-269

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Soil Formation along a Catena in South-Eastern Caspian Sea Lowland

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Catena is defined as the range of continuous soil series which are at a toposequence and also called drainage sequence. The main objectives are: 1. To study the combined effects of topography and drainage conditions and water table depth on formation and evolution of soils, and 2. investigating the hydromorphic and halohydromorphic soils of Miankaleh lowland area as wildlife habitat and tourist attractions. The study area is in the south-eastern Caspian Sea with a temperate climate, xeric soil moisture regime and thermic soil temperature regime. Three geomorphic surfaces determined in the area are consists of hillslopes, alluvial plains and lowlands. North-facing slope of Alborz mountainranges are covered by forests and low hills mainly of loess deposits which extends to north to low lying areas near Miankaleh wetland with saline alkaline water table near soil surface. Five representative pedons were investigated using present soil maps of the area along North-South transect. The low lying soils near sea were classified as Aquisalids and Halaquepts, and Gleization has occurred. Based on field observations and previous studies it appears that this region has come out of the water during the past century. In the alluvial plain in agricultural lands Haplaquolls and Haploxerepts were dominant with high organic matter accumulation. In Haplaquolls accumulation of clay and Gleization was observed. In Haploxerepts vertic conditions was dominant. Finally in hillslopes of the north-facing slope of Alborz under forest vegetation Calcic Haploxeralfs was formed with argillic horizon and decalcification has occurred. Micromorpological studies confirmed the formation of clay illuviation horizon in soils under forest. The highest soil evolution is related to Alfisols in forest covered hillslopes. Soils of lowland had electrical conductivity (EC) of 71.30 dSm-1, and the minimum EC (0.46 dSm-1) was observed at hillslopes. Soil pH of all pedons was about 7 and for Haplaquolls was about 9. The results of mineralogical and micromorphological observations will also be presented.

Keywords：*Catena, Lowlands, Soils, Miankaleh, Iran*

P2-270

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Effect of Slope Aspect on Soil Formation on a Loess Hillslope in Golestan Province, Iran

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In order to study the effect of slope aspect on the soil formation, four soil pedons were dug and described on three different slope aspects on a loess hillslope in Toshan area of Golestan Province, Iran. All pedons were selected on the same elevation and the soil moisture and temperature regimes are xeric and thermic, respectively. The soil samples were taken from all horizons for physico-chemical analysis, mineralogy and micromorphological studies. The texture of the original loess is silt loam. These soils were classified as Inceptisols and Mollisols in East, Alfisols in North-East and Entisols in South-East slope faces. Illite and chlorite are dominant minerals in loess parent material. Illite and chlorite can transform to smectite in the presence of more soil available-moisture mainly due to leaching and release of K+ from their structures. The result of clay mineralogy in Entisols profile showed the dominance of illite and chlorite similar to the parent loess. East and North-East aspects provided more moisture resulted in the formation of smectite and vermiculite in Alfisols and Mollisols, respectively. In Alfisols, micromorphological investigations revealed that thick and laminated clay coating were observed within speckled b-fabric matrix. The main pedofeatures observed in the Bt horizons were clay coatings and decalcified zones in which occurrence and preservation of clay coatings were more pronounced with illite and smectite as the dominant clay minerals. The results showed good correlation between decalcification, presence of speckled b-fabric, thickness and orientation of clay coating with slope aspect.

Keywords：*soil genesis, clay mineralogy, loess, micromorphology, slope aspect*

P2-271

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Arsenic Sources in Soils Of Bijar Region, Kurdistan Province, Iran

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In order to investigate the sources and assessment the role of soil characteristics in soil contamination with arsenic, 229 soil samples from 83 profiles in different landforms and 58 surface soil samples were collected from Bijar area. Further to routine physical and chemical experiments, iron oxides and arsenic content of all soil samples were measured. By means of evaluation the potential of arsenic contamination of the studied area, spatial variability of soil arsenic was determined according to IDW approach. Statistically topsoil arsenic concentration showed significant correlations with clay content (r=0.77), sand (r=-0.45), silt (r=-0.48), CEC (r=0.65), and Fe oxides (r=0.65) at 0.01 probablity level. Subsoil arsenic concentrations also showed similar correlations with soil properties. Igneous iron rich rocks and mudstone showed significantly higher arsenic compared to the other rocks. According to the obtained results arsenic has translocated from the arsenic rich rocks (igneous iron rich rocks and mudstone) at the upper to the lower altitudes by erosion-sedimentation processes or dissolution. The maps obtained by IDW approach also confirmed the mentioned trends. The measured arsenic contents in the studied soils are hazardous for human and ecosystems and there is strong need for specific management practices.

Keywords：*Arsenic, Bijar, IDW, parent materials, physico-chemical properties*

P2-272

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Soil Genesis on Different Slope Positions in a Loess Hillslope in Golestan Province, Iran

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In order to study the effect of slope position on soil genesis, five pedons have been studied on a loess hillslope in Golestan Province, northern Iran. The soils have formed on summit (SU), shoulder (SH), back slope (BS), foot slope (FS), toe slope (TS) positions under farming land use with one control pedon in forest land use. The soil moisture and temperature regimes are xeric and thermic respectively. The soil samples were taken from all horizons for physico-chemical, mineralogical, and micromorphological studies. The texture of the original loess is silt loam. These soils were classified as Inceptisols in SU, BS, FS and TS, Alfisols in SH and Mollisols in control pedon in forest land use.

The slope position and aspect and land use are the main effective parameters on the distribution and amount of smectite and vermiculite clay minerals in hillslope area. Environmental conditions such as landscape and drainage influenced the physicochemical characteristics and expansive properties of clay minerals which consequently affected micromorphological properties such as, void, microstructure, b-fabric and clay coatings. Formation of the mollic epipedon in the forest land (control pedon) confirms the accumulation of organic carbon and lower erosion in the surface soil. Micromorphological investigations revealed that the forest soils had strong granular and crumb microstructure with a high porosity indicating the presence of high amount of organic matter in contrast to other pedons. Mineralogical investigations showed presence of vermiculite in control pedon. There was no significant difference in the type of clay minerals on different slope positions but the amount of clay minerals showed some differences. More vermiculite was present on the summit position mainly due to the higher infiltration and leaching conditions.

Keywords：*clay mineralogy, loess, micromorphology, slope position*

P2-273

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Soil Mineral Transformations, Weathering Rates and U/th Mobility in Moraine Deposits in an Sub-Alpine Environment in California, USA

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During the Pleistocene, there was widespread glacial activity throughout the Sierra Nevada of California. Today, many of the deposits left behind by these glaciers constitute an important fraction of the land surface especially in sub-alpine and alpine environments. In order to better understand weathering pattern and rates in these granitic materials we have described and collected soil samples at 24 sites (~170 individual soil horizons) located at the crest of 3 moraine complexes in the west site of Lake Tahoe, California (39°02'18" N, 120°.08'21"W). These moraine complexes were deposit during MIS6 (Tahoe-age) and MIS2 (Tioga-age). Additionally, we collected 21 rock samples from boulders that were used as parent material proxy. All these materials were subject to various geochemical and mineralogical analyses including: quantitative X-ray diffraction (XRD), XRD in oriented clay fractions, total major oxide composition by ICP-ES, exploratory p-X-ray fluorescence, Inducted coupled plasma -mass spectrometry (ICP-MS) on selective dissolutions (ammonium oxalate, citrate bicarbonate dithionate, and tiron), and clay quantification by differential scanning calorimetry (DSC). Despite these moraines are all mapped as member of the rockbound valley granodiorite, our rock analyses show that there is large variability in their mineralogical and chemical composition. The later has had a long lasting effect on the mineralogical and chemical composition of the soils that were produced from these materials, suggesting that future research on glacial deposit weathering should always consider it in their calculations. One of the most distinct characteristics of Tahoe-age and older deposits is the presence of a weekly-cemented duripans. We explored these features using petrographic microscopy, FTIR microscopy and electron microprobe microscopy. These features display distinctive post depositional characteristics, including coatings on pores and rock fragments with secondary minerals like gibbsite and amorphous silica. The soils in these deposits also show strong weathering on plagioclase grains and an overall depletion of this mineral on bulk samples. Biotite grains display classical exfoliation patterns and they are relative more Si, Mg and K depleted, and Al enriched in older deposits. Mass transference coefficient indicates that Al is relative enriched in the older soils (Tahoe-Age) and it's deposited in the form of crystalline Gibbsite. On the contrary Silica has been depleted in the surface and accumulated at deeper depths in amorphous form (amorphous silica). Fe is significantly enriched in surface horizons in older deposits probably as a result of biological pumping. We also explored the total amount of Uranium and Thorium in selected samples (ICP-MS and pXRF) in order to better understand the mobility and potential accumulation of these elements. Both elements seem to be enriched in gibbsite and opal rich phases, which explain why older deposits tend to present higher concentration of these elements in subsurface horizons. Small variations on the ratios among major minerals (quartz, plagioclase, orthoclase and biotite) and minor minerals (hornblende, epidote, titanite, etc.) seems to have long lasting effects on the current mineralogical and geochemical makeup of these soils.

Keywords：*moraine, weathering, mineralogy, duripan, granite*

P2-274

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Spatial Pedogenic Process Distribution in the Soils of Oued Righ Valley (north East Sahara) an Morphoscopic and Mineralogical Approach

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Modern soil characterization was primarily due to the nature of soil development that has generated and pedo-climatic conditions that govern their operation. In hyper arid regions the cultivation of these areas should not be subjected to analog evaluation criteria based only on a characterization of soils from physicochemical data, however, especially as some analytical methods are found to be deficient for saline soil accumulations especially gypsum (when size fractionation, the dosage of exchangeable bases and finally the rate of gypsum) but a complete geomorphological soil analysis or associate have precise knowledge of the landscape as the evolutionary aspect of these soils and the results between the processes of soil formation and morphogenesis. It becomes imperative to link the old environment and current through geomorphological surveys, microscopic and diffractometric

Agglomerated in the form of a string, the oasis of Oued Righ valley extending nearly 150 kilometers from north Thiour Oum to El Goug in South. They are considered the main agricultural area of the eastern Sahara northern of Algeria. Despite being under the influence of a dry and arid climate, this is made possible by the exceptional presence of water pumped and artesian . These oases are composed of small properties that rarely reach a hectare, the product of such small surfaces that can not be sufficient if the operation is highly intensive. Unfortunately, and contrary to appearances, the farm Saharan Africa is traditionally extensive type.

All these palm although they are different in their importance and purpose, they are cratered by their fragile ecosystem threatened rupture due to numerous factors: the aging of the palm, the non-respect of the planting density, the abusive exploitation without substantial restitution or rotation ... etc.. Given the incessant need a rapidly growing population, the introduction of new irrigation schemes is imperative to maintain the socio-economic balance in the region.

The study of recent training is essential in this regard and it must be conducted in both the direction of the morpho-pedological, geomorphological and hydrogeological analysis and must be systematically company because it is intimately related. It appears essential to any made in test development of Saharan regions.
Based on this principle, our study is associate mineralogical aspects of soils and microscopic SEM taken from different geomorphological levels identified through a study conducted in collaboration with the laboratory of GEGENA Department of Geography at the University of Reims, France .

For this we adopt a sequential approach following geomorphological changes.This study identified 05 geomorphological level starting from the base level of the major chotts

Under microscopic and mineralogical results on samples taken from different profile types in geomorphological levels it seems that the distribution of clay minerals in landscape mode exclusively obeys distribution managed by the wind.
The mineralogical diversity found in the procession of each level is contrasted with the law of geochemistry whatsoever for samples of the same level or those of neighboring levels. This observed discontinuity between different levels does not seem governed by encouraging a possible reorganization process downstream silicate minerals initially degraded upstream except for gypsum and attapulgite. Indeed geochemical environment of this Saharan region can allow such changes given the very marked rainfall deficit. Thus the presence of a mobilizing agent whose action exceeds the limits even bottom Sahara is responsible for this relatively random distribution in the landscape of the valley. Against by we found that some minerals such as illite, whose peaks diffractometer have better amplitudes to lower levels due to the proximity of groundwater rich in basic ions that contribute to their conservation and the evolution of their crystal lattices

Keywords：*Mineralogy, Sahara, geomorphology, gypsum, salt,clays*

P2-275

[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Rates and Controlling Factors of Magnetic Depletion and Enhancement Processes during the 1000-Year Evolution of Paddy and Non-Paddy Soil Chronosequences

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Dynamic changes of soil magnetic properties during paddy soil evolution are poorly known. Patterns of change in contrast to those in non-paddy counterparts may illustrate how paddy cultivation affects pedogenesis. Therefore, we studied chronosequences of paddy soils (with 50, 100, 300, 700, and 1000 years of cropping history) and adjacent non-paddy soils (with 50, 100, 300, and 700 years of cropping history) near Hangzhou Bay, China, both derived from calcareous marine sediments under nearly identical climate conditions and on the same landscape. The dynamic changes in magnetic susceptibility (χ) and other magnetic parameters as well as iron oxides and general chemical properties of the paddy and non-paddy profiles were compared to determine the rates and controlling factors of magnetic depletion and enhancement during the 1000-year soil evolution. Paddy management resulted in accumulation of SOC in the surface horizon, decalcification, profile differentiation of Fed and Fet, higher Feo in the surface horizon, and significant decreases in χ and other magnetic parameters. Statistical analyses indicated that soil magnetism is more sensitive to paddy management and more easily changed than other soil properties. During the 1000 year of paddy soil development, χ losses over 0–100 cm depth increased gradually from 24% to 55% as the cultivation history increased from 50 to 700 years. The mean rates of χ decrease at different time scales showed a rapid decline within the first 50 years of paddy cultivation, after which the declination rate decreased. The significant decline in χ within 50 years is probably due to the rapid depletion of ferrimagnetic fine-grained maghemite during soil waterlogging and reduction, which can be attributed to the management-induced change of soil water regime. In contrast, a significant decrease of hard isothermal remanent magnetization (HIRM) occurred only after 700 years paddy cultivation, which matches the leaching of CaCO3. The magnetization reduction of the paddy soils after 700 years paddy cultivation is probably due to the rapid depletion of the antiferromagnetic mineral goethite after the leaching of CaCO3. Magnetic enhancement in the surface horizon in the non-paddy soils does not show increasing trend against time at a millennium timescale mainly due to high amounts of CaCO3 in these soils. We show that magnetic properties of these soils derived from calcareous marine sediments are mainly controlled by the unique anthropic soil moisture regime and soil carbonate status.

Keywords：*Paddy soils; Chronosequence; Soil magnetism; Iron oxides; Pedogenesis*

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[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Soil Profile of Yellow-Brown Earth Overlying Red Clay in Southern Anhui Province: A Pedogenic Response to the Last Glacial-Interglacial Cycle in Mid-Subtropical China

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Soil profile of Yellow-brown Earth (YBE) overlying Red Clay (RC) is commonly seen along the Yangtze River in mid-subtropical China. To study its paleoclimatic implications, one YBE - RC profile in Langxi county, southern Anhui Province, were dated with the optically stimulated luminescence (OSL) method in detail. The results indicated that the dual – layered profile is actually a pedogenic response to a great climatic change during the Last Glacial – Last Interglacial cycle: The YBE is homogenous to the aeolian Xiashu Loess, which is widely distributed along the Yangtze River, Southeast China, and was dated from 12.2 ka B. P. to 57.1 ka B. P.; and the underlying RC was dated approximately from 60 ka B. P. to 132.8 ka B. P. This fully suggests that the YBE is really the Last Glacial loess, correlated with the Malan Loess in the Chinese Loess Plateau, Northwest China; and the underlying RC was mainly formed during the Last Interglacial, correlated with the first paleosol (S1) in the Chinese Loess Plateau. Two sub-class events of the Last Glacial, the Last Glacial Maximum (LGM) and the Last Glacial Optimum (LGO), correlated with the marine oxygen isotopic stage (MIS) 2 and 3, could be separated and identified in the YBE. Likewise, the RC could also be divided into the Uniform Red Clay (URC) and Reticulate Red Clay (RRC). The URC was formed during the transitional time from the Last Interglacial to the Last Glacial; and the RRC mainly during the Last Interglacial, MIS 5. The RC is highly weathered but still shows aeolian-dust characteristics. The duplicate information implies that the paleoclimate during the Last Interglacial is instable and might also oscillate between warm and cold. However, sub-class paleoclimatic events, potential correlated with MIS 5 a – 5 e, cannot be identified in the RRC, possibly due to the overlapped paleoclimatic information caused by highly chemical weathering. A great climatic transfer during the Last Glacial – Interglacial cycle left soil parent materials diversified in the study areas and hence caused the parallel distribution of different zonal soils in a small scale. Two surface soils, Yellow-brown Soils (Acrisols), derived from the YBE, and Red Soils (Plinthosols), derived from the RC, often coexist in the areas. The Red Soils are really relict and not correlated with the current soil-forming conditions. Sometimes, the influences of paleoclimatic changes on soil genesis are so significant that it should never be neglected.

Acknowledgements: This work was supported by the National Natural Science Foundation of China (No. 40971126).

Keywords：*Red clay; Paleoclimatic changes; OSL dating; Soil genesis; Last Glacial-Interglacial cycle*

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[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Carbon Dating of Latosols (oxisols) and Implications to Soil (bio)genesis in Cerrado (savanna) Areas in Brazil

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Latosols (oxisols) cover more than 65% of the Brazilian territory, and are characterized for their deep weathered nature and varying kaolinitic to oxidic mineralogy. Little is known about the 14C dating of Latosols in relation to soil genesis interpretation, despite much effort has been devoted to paleoenvironmental inferences of carbon dating of Brazilian soils. In this study, we aimed to present new 14C dating of Latosols under cerrado, assisted with the use of ∂13C profiles for the determination of plant dominance along the studied Latosol's cores and calculating of turnover rates based on a broader database. The biological turnover rate for Brazilian Latosols, calculated for the soil humin, a more stable pool, showed a range of 1.00-3.00 mm y-1, with little differences between depths and age of soil carbon. The biological incorporation of carbon in Latosols is remarkably similar since the early Holocene for different localities in Brazil, despite varying climatic conditions in Savanna and forest areas

Keywords：*Latosols, carbon dating, pedobioturbation*

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[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Effect of Mineral Dissolution on Hydraulic and Transport Properties of Floodplain Soils

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Biological and physicochemical processes in soils, like root growth, mineral precipitation and dissolution, or colloidal dispersion and flocculation may result in not only temporal changes of the soil structure. Such effects will in turn affect the pore network architecture, the hydraulic and the transport properties. Using soil column experiments, we studied the influence of mineral dissolution on the hydraulic conductivity, the water retention characteristic and the apparent dispersivity. Two undisturbed soil cores packed with a calcareous floodplain soil from the Danube were flushed with a perchloric acid solution (10-2.5 M). Batch experiments were conducted as reference and for estimation (soil to solution mixture of 1:5 and 1:10). Before and after the acid treatment we investigated the pore network by computer tomography (CT) (UFZ Halle, Department of Soil Physics) and measure the hydraulic and the transport properties.

The soil background solution reveals values of 200 to 300 µS?cm-1 for the electric conductivity (EC) and a mean pH of 7.8. In batch experiments pH values around 7.4 were reached in a 1:5 soil to acid solution ratio and EC values of 800 µS?cm-1 occurred. During the percolation with acid the pH values decreased to 7.5 and EC values around 600 µS?cm-1 were measured in the effluent. In the batch solutions with perchloric acid, higher concentrations of calcium and magnesium were measured, than without. This is due to the calcareous soil we used. Analysis of ion concentrations from the column experiments are still in progress.

Transport experiments (sodium chloride as tracer) show a fast increase of the solution concentration which points to dominance of preferential flow, most likely along macropores, which are related to old roots. Whereas leaching of the solution is retarded. Only weak effects on dispersivity occurred, modeling dispersivity yields changes between 3.2 cm (± 0.9 cm) and 5.3 cm (± 2.3 cm) before and after acid percolation. Because of the high standard deviations these values are less reliable.

In the water retention characteristic we observe only small changes as well. A slight increase of the saturated water content was measured after acid percolation. At low tension in the range of the field capacity (pF 1.8 to 2.5) a tendency to lower water contents after acid treatment is observable. However, we can't exclude that these changes are within range of the hysteresis effect.

CT images after the acid percolation still have to be measured.

Percolation with a high concentrated acid, for nearly a month, only leads to weak effects in the transport properties as well as in the water retention. This means the soil we used shows a high resistance against disturbance and can be referred as a good resilient water conductor. Due to a predicted increase of flooding events this could be an important fact considering floodplain soils.

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[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Testing a New Method For Sequential Si-Extraction on Soils of a Temperate-Humid Climate

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A new method for sequential Si extraction from soils was tested on four petrographically different soil types in SW-Germany. Typical for soils developed since the Pleistocene, most of the Si is bound up in primary and secondary silicates. The second highest proportion of extractable Si is in mineral subsoil horizons from minerogenic (non-biotically precipitated) amorphous silica; in organic layers (O horizons) and mineral topsoil horizons (Ah horizons), it is found as biogenic amorphous silica. Clayey horizons (subsoil horizons of Luvisols and Stagnosols) and topsoil horizons accumulate amorphous silica. Amounts of Si from bio-opal comprised up to 14% of the total Si content in the Oa horizons of the studied soils. The lowest amounts of Si were in the mobile and adsorbed Si fractions. Although some methodological limitations were identified and discussed, the new sequential Si extraction method made it possible to separate different Si fractions in soils of this temperate-humid climate.

Keywords：*silicon, sequential extraction, bio-opal, silica*

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[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Characteristics and Genesis of Two Profiles Developed From Amphibolite Complex Rocks in Southwestern Nigeria

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Limited data have been published on the nature of soils in geologically active humid tropical soils of Southwestern Nigeria. The study evaluated the characteristics and formation of two weathered soil profiles in rain forest region of Southwestern Nigeria. The two soils developed from mafic rock (Amphibolite). Results revealed that the soils have generally similar morphological characteristics, particularly in terms of colour (2.5 YR-10 R), and structure (granular to subangular blocky), although the Mokuro profile has higher clay content than the Ajindo profile. Both soils have similar chemical properties (e.g. acidic, low exchangeable bases) except that the Ajindo profile has higher CEC values and higher exchangeable Ca content, resulting in a higher base saturation in the upper horizons. They also have high dithionite-extractable Fe contents and very low oxalate/dithionite ratios and are dominated by kaolinite, goethite, hematite, and quartz in the clay fraction. Apparently as a result of its more weatherable mafic parent rock and more stable geomorphic surface, the Mokuro profile shows more advanced weathering and soil development than the Ajindo profile. The Mokuro profile has higher Ti and Cr contents inherited from its mafic parent material. The study reveals that on the geologically active humid tropical soils of Southwestern Nigeria, the characteristics and genesis of weathered soils are greatly affected by the geochemical characteristic of the parent rock material.

Keywords：*humid tropical soils, weathering, mafic rock, amphibolite*

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[C1.3-1] Weathering and Soil formation in Response to Environmental Changes

Changes in Soil Mineral Composition by Surface-Piled Saprolite

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Slopes in highland are vulnerable to soil erosion. Lots of farmers in South Korea pile up 20 to 30 cm of granite- or granite-gneiss-weathered materials on top of arable lands every three to five years to compensate eroded soil; sometimes it also contributes to discontinuing soil-borne disease. Immediate increases of infiltration and percolation rates are expected when weathered materials with coarse texture are added. It has been, however, reported that soil drainage became poorer with addition of weathered materials in a long-term. In this study, we analyzed mineralogical characteristics of weathered materials and objected their micro-morphology to investigate processes causing poor drainage. Soil samples were collected from plow pan, usually located at approximately 20 cm soil depth and at the lower part of piled weathered materials, in arable lands in Hoenggye 5-ri, Daekwanryeong-myeon, Gangwon-do (N37.7, E128.7) in which weathered materials were added 2 years (2yr), 4 years (4yr), and 8 years (8yr) ago; weathered materials were transported from similar areas and carrot has been grown for all farms. The saturated hydraulic conductivity decreased over time. The X-ray diffraction (XRD) analysis indicated that strength of feldspar decreased over time and the reverse was true for illite. Based on soil thin section pedography, size of feldspar in 4yr and 8yr was smaller than that in 2yr likely due to weathering. The ratio of clay filled in macropores to that in total pores also increased over time. Conclusively, deteriorating drainage conditions in farms with weathered materials over time was caused by accumulation of clay particles in macropores interrupting of water movement.

Keywords：*surface-piled saprolite, soil mineral, microstructure*

P2-282

[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

Sampling Design and the Predictive Accuracy of Pedotransfer Functions

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Direct measurements of many soil properties, such as permanent wilting point (PWP), is time consuming and expensive. Pedotransfer functions (PTFs) help overcome these limitations through the development of a functional relationship of any such costly-to-measure soil property with other potentially correlated but more easily and economically measurable soil properties. The data required to develop these PTFs are invariably generated using nested spatial sampling designs in order to capture the inherent range and distribution of values of these soil properties in a target agro-ecological region. A review of the published literature on PTFs suggests that the development of PTFs does not seem to usually account for the spatial structure of the nested sampling design. Taking PWP as one example PTF, the results of this study demonstrated that ignoring the nested spatial sampling structure leads to (i) spuriously low standard error (SE) of the effects of X-variables in the fitted PTF, and (ii) spuriously low root mean square error (RMSE) that leads to spuriously high predictive accuracy of the fitted PTF models. Accounting for the nested spatial sampling structure eliminated these undesirable consequences, and additionally provided information on the relative magnitude of random (spatial) variation at different levels of nested sampling hierarchy to help devise optimal sampling strategies for future data collection.

Keywords：*Soil water retention, soil type, PTFs, nested sampling design, predictive accuracy*

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[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

Analysis of the Spatial and Depth-Wise Variation of Soil Properties Based on Horizon-Sampled Data

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As soil scientists, we are interested in both the spatial distribution of soil properties, and their depth-wise variation. Datasets for studying this variation typically consist of samples from many spatial locations, at several different depth intervals. Within a particular study, these depth intervals may be fixed (e.g. 0 – 10 cm, 10 – 20 cm, and 20 – 30 cm), or else they may be defined according to soil horizons and therefore vary between locations in the study. It is then the task of the data analyst to 'harmonize' these data so that useful and reliable conclusions may be drawn for soil depths of practical interest. For example, the GlobalSoilMap.net project specifications dictate that soil properties should be mapped for depth intervals of 0 – 5 cm, 5 – 10 cm, 10 – 30 cm, 30 – 60 cm, 60 – 100 cm and 100 – 200 cm. In this work, we consider a statistical method to reliably perform this harmonization.

Various approaches have been adopted previously to perform this task: a common approach is to fit splines to the profile data for each site, use the spline to infer 'data' for the soil property at the depth of interest, and then proceed with the analysis as if the value were known without error. This process does not account for the uncertainty in the value inferred from the spline, and could lead to misleading conclusions.

Other approaches to the problem include 3-D geostatistics. However, this has been applied as if the data collected from soil depth intervals were concentrated at a single point, at either one of the bounds of the sampling interval, or at the interval's mid-point. This approach also fails to properly represent the support on which the data were originally collected (over an interval, rather than from a point), and could again lead to unjustified conclusions.

In this work, we investigate a 3-D geostatistical approach that properly deals with the sampling support of profile data. Our methodology is based on the 'area-to-point' kriging model to represent the uncertainty from depth interval-sampled data. This is combined with standard kriging approaches for the horizontal spatial distribution. Thus, a statistical model for the complete dataset (all spatial locations and all depth intervals) is defined, with the support of each datum (a combination of spatial location and depth interval) properly represented. Parameters for this statistical model are fitted using standard techniques (REML), and predictors (E-BLUPs) at any desired depth or depth interval are calculated, along with their associated prediction variances.

We test the approach on data from the Murray-Darling basin in eastern Australia, where interest lies in mapping various soil properties that could have an effect on water salinity of the nearby Muttama Creek. Soil cores (to a depth of 1 m) were collected from 56 spatial locations over the Muttama catchment, and each core was divided into horizons, giving a total of 192 samples. The samples were analysed for pH, EC and particle size, and we consider mapping these properties, along with their attendant prediction uncertainties. We use this case study to compare approaches for mapping based on horizon-sampled data, illustrating their differences, and in particular focussing on their representation of uncertainty.

Keywords: *geostatistics, sample support, uncertainty, 3-D mapping*

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[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

Spatial Uncertainty in 3D Modelling of Soil Properties

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Information regarding soil properties across landscapes is critical for better soil and environmental management and for climate regulation and adaptation policy. Soil properties vary in space and time. The prediction of heterogeneity and the associated uncertainty are important for decision making in management and policy. In this study the continuous vertical and lateral distributions of relevant soil properties in Scottish soils were modelled with a 3D- GAM+kriging approach. A dataset of about 26,000 horizons (7,800 profiles) was available for this study. A validation set was randomly selected as 25% of the full dataset. The 3D-GAM+kriging approach involves 1) modelling the trend with full 3D spatial correlation, i.e., exploiting the values of the neighbouring pixels in 3D-space, and 2) 3D kriging to interpolate the residuals. In the trend modelling numerous covariates derived from globally available data, such as MODIS and SRTM, are considered. This approach allows the assessment of the uncertainty of both the trend and of the error. The resulting estimates showed low RMSE values, good R squared and an accurate reproduction of the spatial structure of the data.

Keywords：*spatial uncertainty, soil properties, national scale, 3D modelling*

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[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

Prediction of Soil Organic Carbon and Texture in Complex Areas Using Vis-Nir Spectroscopy

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The soil organic matter (SOM) and texture are two attributes of fundamental importance for inferences on the quality and land use. With an increasing demand for food and energy, knowledge on the physical and chemical properties of the soil becomes a pressing need. New technologies for predicting soil properties have been investigated, among them stands the Vis-NIR spectroscopy. This may be an alternative technique for quantifying these attributes in a large volume of soil samples, since it is faster and does not generate chemical waste. A broad range of soil characteristics must be taken into account when developing a soil-property prediction model. In the study area, located in the central region of Rio Grande do Sul state (RS), Brazil, shows that the regional geology is complex which includes igneous and sedimentary rocks. The landscape is hilly varying from steep to shallow with variable soil depth although shallow soils tend predominate. These aspects show that this region is broadly heterogeneous in relation to geology, topography and soils. Therefore, the aim of this study was to develop models, using multiple linear regression analysis (MLR) to predict the clay, sand, silt and SOM using Vis-NIR spectroscopy. Samples from 0.00-0.20 m were collected from 303 different points. Soil radiance was measured with an FieldSpec Pro Spectroradiometer in the Vis-NIR range with 2-nm spectral resolution between 400 and 1000 nm and 4-nm resolution between 1000 and 2500 nm. The reference standard was a Spectralon panel. Logarithmic transformation preprocessing was used to normalize the distribution before performing the regression method in the texture and SOM values previously determined in the laboratory which provided better predictions for multivariate analysis. The whole data set, n=303, was randomly divided into 213 samples (~ 70%) for calibration and 90 samples (~ 30%) for validation. Prediction model for Log (Clay), Log (Sand), Log (Silt) and Log (SOM) by MLR were determined. The results show that the best fit of the model prediction was achieved for Log (Sand) with R2 of 0.77 and RMSE of 0.112 for the calibration samples. The result for the Log (Clay) shows an R2 value of 0.71 and RMSE of 0.148. The Log (SOM) obtained an R2 of 0.70 and RMSE of 0.178. For Log (Silt) a lower prediction with an R2 of 0.67 and RMSE of 0.190 was found. Statistics show that the prediction model for Log (Sand) had the best performance, followed by Log (Clay), Log (SOM) and Log (Silt) with the worst performance. It is possible to affirm that the predictive ability of the models was adequate and that the choice of multivariate technique in this study proved to be effective. By using data from Vis-NIR spectroscopy even in a complex area with different soil attributes, the performance of the models was not compromised. Only the Log (Silt) has not reached the expected prediction above 70% of the variance, being considered satisfactory from a pedometric viewpoint.

Keywords：*Digital soil mapping, proximal remote sensing, pedometrics, soil spectral reflecatance*

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[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

Grey Incidence Analysis (gia): A New Local Method for Modeling Chinses Soil Vis-Nir Spectral Library to Predict Soil Total Nitrogen Content

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This paper introduces a new approach called grey incidence analysis(GIA), by which high accuracy prediction model can be established combined with partial least squares regression(PLSR) to deal with Chinese soil library and estimate soil total nitrogen content in local area. Using spectral matching algorithm such as Mahalanobis distance, spectral angle model (SAM) and spectral correlation fitting(SCF), fuzzy k-means clustering method only based on the spectral data without considering soil total nitrogen content in the library. Soil total nitrogen content have grey uncertainty relationship with each vis-NIR spectral band(400-2500nm). Compare with traditional mathematical statistics analysis, grey incidence analysis overcomes the shortcoming of ignoring the relationship among the variables . This method combine the soil total nitrogen value with spectrum data when performing spectral matching. In this study, 1661 soil samples in the library were collected from 13 provinces in China, which include Tibet, Xinjiang, Heilongjiang, and Hainan. The samples represent 17 soil groups of the Chinese Soil (Genetic) Classification System. After air-drying and sieving, the diffuse reflectance spectra of the samples were measured under laboratory conditions in the range between 400 and 2500 nm using a portable vis?NIR spectrometer. Hyperspectral inversion model was built based on 104 paddy soil samples in Zhejiang province to predict the soil total nitrogen content. The results show that the GIA-PLSR method presents great potential for predicting soil total nitrogen content in large soil vis-NIR library. The prediction accuracy: R2=0.897, RMSEP=0.028, RPDP=3.151. This study also show that soil vis-NIR distance matrics combined with TN value can be used to further improve the prediction performance of spectral models.

Keywords：*Grey incidence analysis,partial least squares regression,Chinese soil library,total nitrogen*

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[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

Probability-Based Harmonization of Digital Maps to Produce Conceptual Soil Maps

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There are three conceptually edited soil maps in Hungary with nationwide coverage. The first one was published in 1953 at a scale of 1:200,000 by using more detailed previous maps (Kreybig maps). The second one (AGROTOPO) was published between 1983 and 1988 on 1:100,000 sheets and also relied on the Kreybig soil maps. This was released in digital form in the early 1990's. The third one (genetic soil map) was compiled by the experts of the agricultural extension agency of the agricultural ministry in 1984 at scale of 1:200,000. It was digitally published in 2008 and it was edited independently from the Kreybig soil maps.

All the three soil maps have advantages but also serious drawbacks. The first map was not digitized and does not contain soil units of the recent Hungarian soil classification since it is older than the recent classification system. It contains several soil categories (texture, chemical reaction, fertility constraints) but also other categories (land-cover: forests, temporarily flooded areas). However, it is the most detailed regarding its spatial resolution despite the nominal scale. The AGROTOPO has only a rough spatial and thematic resolution because it contains 31 various soil categories of the nearly one hundred soil sub-types in Hungary. However, it has a complete coverage of the whole country and it has several data layers (parent material, texture, soil reaction, clay mineral assembly, organic matter content etc.). The genetic soil map provides a complete display of the Hungarian soil classification and contains data on parent material, texture and chemical reaction but does not show soil data for forests. The topology of the AGROTOPO is satisfactory but it is not so for the other two maps.

Our hypothesis was that the drawbacks of the individual maps can be corrected with help of the other maps and with ancillary data. Therefore, we have digitized the oldest soil map and conducted a study on harmonization of the soil maps for an area of 266 sqkm at Keszthely near Lake Balaton by using CHAID classification method and CORINE land cover database, digital map of surface geology, digital elevation model and derived slope categories as ancillary data.

The individual maps for the study area contained 7-38 categories. After intersecting all the seven maps, the resulting file contained more than 50,000 polygons and nearly 14,000 category combinations. We have calculated theoretical areas for all category combinations as if the categories would be completely independent from each other and we have related the real areas to the theoretical ones. Most of the real areas far exceeded the theoretical values but slightly more than 2000 category combinations occurred on smaller areas than expected. We have calculated a chi-squared probability variable for each category combinations so that the differences between real and expected areas were squared then divided by the expected areas and finally the natural logarithm of the result was calculated. We have classified the more than 2000 less represented category combinations separate from the majority of the combinations with CHAID classification method because the calculated probability variable was significantly different for the two groups.

The classification resulted 30 final nodes for the majority of the category combinations and 17 final nodes for the less associated combinations. The classifications were successfully validated with split-sample method.

The 17 new categories happened to be misclassified or topologically wrong polygons which were amalgamated into the neighbouring polygons based on similarity. The resulting 30 new categories were interpreted as soil categories based on the three original soil maps and soil type definitions of the Hungarian soil classification system. The final conceptual map had complete coverage and contained nearly 800 polygons instead of the 23-97 polygons of the original soil maps.

The proposed method proved to be very effective in eliminating misplaced and misclassified soil polygons, in predicting new polygons based on ancillary data and in aggregating diverse categories thus it should be included in the tool set to compile a new nationwide conceptual soil map for Hungary. The conceptual soil map is still have to be validated with field samples.

This study was supported by the project TÁMOP-4.2.2.A-11/1/KONV-2012-0064 and realized with the support of the Hungarian Government and the European Union, with the co-funding of the European Social Fund.

Keywords：*Hungary, digital soil mapping, legacy soil data, ancillary data, chi-squared probability variable, , CHAID classification*

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[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

Cybersolim: An Easy and Fast Online Digital Soil Mapping Prototype System

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Digital soil mapping involves complicated soil inference models and fussy data preparation; the soil maping software tools are needed. The digital soil mapping tools could be divided into two types: 1) the first ones are geostatistics tools, such as Gstat, ArcGIS Geostatistical Analyst, GS plus, etc. 2) the second ones are special tools, such as FuzME, SoLIM Solutions, ArcSIE, TAL, etc. But there are some problems in the application of existing tools: 1) the modeling work flow (including data preparation flow) depends on user itself, so it is very difficult for the non-specialists to use. 2) the softwares are usually stand-alone version, which need to be downloaded, and the installation and setting are tiresome. 3) the computer programs of tools are serial, the efficiency will be very low when the data size or the amount of computation is huge. So the existing tools cannot meet the users' demand for digital soil mapping applications. To overcome the limitations of the exting Digital Soil Mapping softwares, this paper proposed an Online Digital Soil Mapping Prototype System (SyberSoLIM) leveraging a combination of such methods and techniques: 1) knowledge-driven method, the knowledge of work flow is expressed in the semantic net format, and an inference engine is designed to assist users with soil mapping in a heuristic fashion; 2) web GIS and web service. The tool is a B/S system, so users can implement mapping procedure by only using a brower. The computer program is wrapped as web service, which can be shared and combined on internet; 3) parallel computing, the .NET4 TPL library is used for parallel computing realization to increase computational efficiency. The soil mapping application in Xuancheng City of Anhui Province proved that this system is more convenient, easier in user experience and higher in mapping productivity than other Digtal Soil Mapping softwares. CyberSoLIM offers an easy and efficient way for non-specialists to understand and participate in digital soil mapping.

Keywords：*digital soil mapping, knowledge-driven, parallel computing, online Mapping System*

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[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

A Multi-Grade Representative Sampling Strategy Using Auxiliary Environmental Variables for Regional Soil Mapping: A Case Study in Xuancheng, Anhui, China

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Sampling design strategies play an important role in digital soil mapping and influence accuracies of the mapping results. Efficient sampling strategies are required for regional soil mapping since sampling over a large area will cost high. Purposive sampling strategies which aim to sample on few representative samples for an area could be appropriate for regional soil mapping. A multi-grade representative sampling method which is to extract samples with different representative grade representing spatial variations of geographic feature at different scales in a stepwise fashion has been developed, and applied efficiently for mapping soil type in a study area at a watershed scale. In this paper, we employed and evaluated the multi-grade representative sampling strategy using auxiliary environmental data for mapping soil properties in a study area of 5900 km2 in Anhui Province in China. A parent lithology data layer was used to stratify the study area firstly, and fuzzy c-means clustering was conducted on two climate and four terrain variables to design representative samples. Soil texture and soil organic matter content at two soil layers of 0-20cm and 20-40cm in depth were mapped using an average weighted mapping method with fuzzy membership values as weights. The evaluation results based on an independent validation points set showed that this sampling method was effective, and mapping errors were decreased when adding samples of lower representative grades in turn. And the accuracies of soil texture classification for the first and second layers were 59% and 68.9% respectively. We also compared the predicted soil organic matter maps based on the representative sampling points with that based on legacy soil data (conventional soil maps or /both typical soil profiles from the second national soil survey of China). The results showed that the predicted soil organic matter maps based on the representative sampling points had much higher accuracies. It was concluded that the mulit-grade representative sampling was an effective sampling approach for regional soil mapping.

Keywords：*A mulit-grade representative sampling method; Representativeness grade; Fuzzy clustering; Regional S*

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[C1.5-2] Quantification and Application of Uncertainty in Pedometrics

Uncertainties Assessment of Semivariogram Parameters and Maps Comparison for Soil Properties with Different Nugget Effects

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Spatial variability modeling of soil properties on a certain territory is usually based on sample data. The high cost of field information provokes the reducing of sampling points that leads to the results uncertainty increasing. Uncertainties assessment of semivariogram parameters and maps comparison was conducted on the territory of Bryansk Opolje, the unique steppe landscapes in the boreal zone of Russia. The history of Agriculture counts here more than 1000 years. Soil cover of the territory is very complicated. The main soil units are agrogrey soil and agrogrey with the second humus horizon (Phaeozems Albic). The soil cover is disturbed by the expression of erosion processes and effects of land reclamation performed in the area in 80th. The soil unit changes occur at distances from 10 to 100 m. Soil samples (n=277) were randomly collected on the area of 12 ha at the depth of 0-20 cm. Organic matter content (MOC) and specific surface were determined in all samples. Bootstrap modeling was performed: 20 subsets of 200, 150, 100 and 50 points were randomly selected from collected data. For every subset semivariogram parameters were estimated, maps were made using inverse distance method and ordinary kriging. Correlation coefficients were used for maps comparisons. The analysis of all collected data has shown the following peculiarities. Ranges for both soil properties are practically equal, respectively, 72 m for MOC and 73 m for the specific surface. Spatial parameters of the properties are quite different: the ratio nugget/ (nugget +C1) was 63% for OMC, and was 26% for the specific surface. Thus, the spatial dependencies at distances up to 73 m consist for OMC only 1/3 of the total variation, and 2/3 of the total variation for the specific surface. The correlation coefficients between the maps made using ordinary kriging and the inverse distance method were expectedly high: 0.89 for OMC and 0.92 for the specific surface. Bootstrap - simulation showed that for the specific surface range is predicted by subsets of 100-200 points with the accuracy of 10-15%; range varies from 21 m to 110 m for the subsets of 50 points. Range was the least stable semivariogram parameter for OMC: the range was estimated with bias for the most part of subsets irrespectively to their volume. Range equals zero in few cases for any volume of subsets. Some cases of bid over estimation of the range are observed for subsets of 100 and 50 points. Only subsets of 200 and 150 points give good estimates of nugget effect for the specific surface. To obtain good estimates of nugget effect for OMC requires a minimum of 200 points. Maps comparison showed that similar dependencies on subsets volumes are observed for the inverse distance method and for ordinary kriging. Correlation coefficients of 200 points subsets range from 0.80 to 0.95 for the specific surface and from 0.52 to 0.92 for OMC. The same trend is observed for subsets of 150 points. Sampling with the 100 points volume may be acceptable for the specific surface, since the correlation coefficients ranges from 0.44 to 0.75, and the median value is equal to 0.67. One of OMC maps was confluent for 100 points subsets: only an average value was shown; and additionally correlation coefficients between 3 maps were equal to zero. Even the worst situation is observed for the 50 points subsets: correlation coefficients median is 0.16 for OMC, and it is 0.40 for the specific surface. Thus, for soil properties with a significant nugget effect (30-60% of the total variation) only sets of 200 or 150 points gave sustainable results to estimate semivariogram parameters and gave comparable maps. Sets of 50 points in both cases, gave the unstable results. The study was supported by the RFBR grant N 13-04-00480

Keywords：*influence of sample size, semivariogram, maps comparison*

P2-291

[C1.6] Paleopedology

Soil Micromorphology from Bronze Age Indus Settlements and Surroundings: Reconstruction of Mid-Holocene Environmental Conditions in Nw India

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This paper presents the results of the investigations of soil/sediment sequences associated with a series of Indus archaeological sites in the plains of northwest India dated to between c.3000 and 1500 BC. The on-site micromorphology from the sites of Alamgirpur in western Uttar Pradesh, Masudpur I (Sampolia Khera), Masudpur VII (Bhimwada Jhoda) and Burj in Haryana have been considered along with their off-site counterparts, with the addition of some off-site data from Rakhigarhi and Kunal. These two strands of micromorphological data have been compared and contrasted to provide understandings of the pre-existing and contemporary landscapes and the site formation processes. These have helped not only to understand the nature of human responses to the environment and vice-versa, but also to interpret the nature of some on-site activities during Indus times. The paper concentrates on the 1500 year time-frame within which the nascent Indus Civilisation had its steady rise into an urban phase and towards the end of which (after c.2000 BC) its major cities were abandoned. It was not until well after c.1000 BC that large urban centres re-emerged on the Gangetic Plain.

Robust data from micromorphological and geochemical analyses and have revealed important results about soil formation processes with inferences for the nature of developing relationships between the humans and their environment. In particular there is evidence for lengthy periods of accumulation history on-site, and the identification within the sampled sequences, of several activity areas such as open spaces used for crop-processing or midden areas interrupted by occasional disturbed layers, all filled with settlement-derived debris and with evident periods of abandonments. It is apparent that the site of Alamgirpur was established on a levee terrace related to a former floodplain, which was little affected by seasonal inundation and alluvial deposition. Burj was built on the margin of an aggrading alluvial floodplain system, more or less continually affected by the slow, seasonal deposition of overbank flood deposits associated with monsoonal rains and flooding leading to the seasonal accumulation of alluvium. The bedded sand deposits beneath the Indus sites such as at Kunal, Masudpur I (Sampolia Khera) and Rakhigarhi are probably former channel fill deposits surviving as low sinuous ridges whereas Masudpur VII (Bhimwada Jodha) was built on a dune system.

These geoarchaeological evaluations have indicated that there is a varied hidden landscape context for each Indus settlement, which indicates a symbiotic relationship with the alluvial, riverine and monsoonal environmental system.

Keywords：*soil micromorphology, site formation processes*

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[C1.6] Paleopedology

Climate Change and Human Impacts on the Soils of Koufonissi, Cycladic Islands Greece

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There has been a long standing debate in soil geomorphological circles as to the relative influence of climate and human factors in soil system changes and sedimentation. Since classical times authors have claimed that humans have been responsible for profound landscape changes including desertification. More recently some see climate change as the most influential vector in soil change. This view was most eloquently articulated by Claudio Vita-Finzi during the nineteen sixties.

This presentation documents research carried out in the Cyclades Greece. Erosion had been responsible for the degradation of much of the islands soil resource. When and why this happened was an important component of the research. A number of sedimentary and soil sequences found in valleys on the island of Koufonissi were observed to have archaeological material within their fill. It appeared that most of this material correlated to times when demographic expansion was having negative impacts on the landscape. These sedimentary and soil sequences provided an excellent opportunity to investigate a local case study and to see if it conformed to wider regional patterns.

The soils were characterised and mapped by soil survey and through the use of soil micromorphology. Sediments were dated where possible using OSL. The results were highly interesting in that they appeared to indicate that climate change had been the most important factor in changes seen in the soil system.

Keywords：*micromorphology, soil survey, soil classification, landscape evolution,*

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[C1.6] Paleopedology

Deep Soil Carbon: Why Should We Care?

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Stores of deep soil organic carbon have been largely ignored in carbon accounting despite the fact that significant amounts of carbon can accumulate, particularly, in deep weathering profiles and sediments. Recent reports from south Western Australia where trees in the Jarrah forest exploit the root channels of former trees to access ground water up to 40 m below the surface (Dell et al, 1983) show small amounts of organic carbon occur to depths of up to 35 m (Harper and Tibbett 2013). This is up to 5 times more carbon than currently reported in project and national inventories. As the published work only reports on the total carbon content; we examined the distribution and composition of carbon in deep soils.

The following questions about the dynamics of deep soil carbon were investigated in up to 30 m deep weathering granite catenas in SW Australia :

1. Are stocks of deep soil carbon labile, or are they effectively inert?
2. What could happen to this carbon following land use change?
3. Are current methods adequate to understand the deep carbon?

Chemical (wet chemistry, carbon dating, metabolomics) and biological (DNA sequencing, microbiological) methods were used to assess the amounts and composition of carbon in kaolinitic profiles occupied or unoccupied by roots.

The key findings will be discussed in light of global climate change and soil carbon stocks.

Keywords：*deep soil, root occupation, soil carbon stock, Southwestern Australia*

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[C1.6] Paleopedology

Buried Paleoanthrosols of the Bronze Age Agricultural Terraces in Kisovodsk Basin (northern Caucasus, Russia)

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The Kislovodsk Basin is a unique monument of ancient agriculture based on the slope terracing. Traces of terrace agriculture in the Kislovodsk basin are numerous, and have for decades attracted the attention of scientists.

Since the first observation of the terraces anthropogenic nature of them was recognized. These terraces can be considered neither as the result of alluvial processes nor as consequences of landslides. Ubiquity of the traces of terracing and their prevalence on every slope and watershed areas exclude alluvial origin of terraces, while regular shape of terrace excludes their landslide nature. And one more reason to consider the terraces as result of ancient agriculture is the presence of buried soil with abundance of pottery, which is proposed to gets to soil with organic manuring.

In 2005-2011 largescale investigations at terraces in the valleys of all the main rivers in the basin were carried out. The investigations included mapping the visible contours of the terraces using GPS, instrumental topographic mapping of the present-day surface, and studying soil properties in soil section in different terraces. Much attention was given to the archaeological materials from the buried anthrosols from the sections, especially to the pottery which comprises over 3000 fragments. Almost all fragments are dated by Koban archaeological culture, existed at the late Bonze Age (9th -6th centuries BC).

The investigations revealed that all the terraces are similar in construction. The buried anthrosols lie directly above the bedrock, and contain a large amount of Koban pottery. The buried soils are similar to Kastanozems, and indicate more arid conditions of their development in comparison with present-day Chernozems.

The buried soils are covered by thick slope deposits, which consist of two layers: lower humus-rich part and an upper part of loam parent material slightly transformed by soil formation with modern soil on the surface. On the lower terraces of slopes the thickness of colluvial layer, covered anthrosols reach 2-3 m ore even more. The soils of similar stratigraphy are widespread in Kislovodsk basin.

The process of building terraces can be reconstructed in the following way. Firstly, the ancient farmers cut away and removed part of the ground, from the upper horizon of the ancient soil to the parent material, so as to create a kind of horizontal stair-step across the slope. Afterwards, they annually brought down the material of upper soil horizons from higher up the slope, whereas natural erosion brought it the material from the uncovered parent soil. In other words, Koban farmers activated the process of controllable “positive” erosion, due to which the terrace grew upwards and became wider.

According to our calculations over 120 km² soil surface were cultivated and terraced during first part of 1st millennium BC. Thus, we can see that the Koban population widely used the landscapes in the Kislovodsk basin for agriculture. In the absence of a natural vegetative cover, the ecosystems in the region became destabilized. The consequences of such agriculture came to light in

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[C1.6] Paleopedology

Late Quaternary Environmental Changes from Aeolian and Fluvial Geoarchives in the Southwestern Kalahari, South Africa: Implications for Past African Climate Dynamics

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Precipitation in southern Africa and specifically in the southwest Kalahari – tropical summer rains in the north and the east, and extratropical winter rains in the southwest – is strongly influenced by a common climate force that also governs the seasonal shift of the Intertropical Convergence Zone (ITCZ). However, the displacement of the southern ITCZ since the Last Glacial Maximum (LGM, ca. 22 to 18 ka) is controversial. We present new field results, 14C- and optically stimulated luminescence (OSL)-data on fluvial and aeolian geoarchives in the catchment area of the lower Molopo River, southwest Kalahari, which indicate different periods of aeolian and fluvial activity in the last 40 ka. Based on our new data, we present a reconstruction of the late Quaternary climatic dynamics and a conceptual model indicating a southward shift of the ITCZ during the LGM, contemporaneously with a northward shift of the westerlies. This model implies that since 24 ka the southwest Kalahari has received summer and winter rains, which resulted in pluvial conditions that annually led to pan flooding throughout most of the year, cessation of lunette dune development due to stagnated deflation, and onset of perennial flow in a part of the lower Molopo River south of the Nossob-Molopo confluence. In addition, glacial climate circulation patterns over the southern African subcontinent can further resolve controversies about palaeoclimate reconstructions, which have important implications for modelling past and future climate scenarios.

Keywords：*Kalahari, climatic change, paleosoils, geoarchives, indicators, ITCZ*

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[C1.6] Paleopedology

Approach for Categorization of Highly Heterogeneous Cultural and Colluvial Sediments on Detailed Spatial Scale: Example of the Early Medieval Viking-Settlement Hedeby

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At complex investigation areas such as former settlements, palaeopedologists and geoarchaeologists often face a problem of identification of stratigraphic units that cannot be described and categorized according to soil classifications. It is particularly complicated when excavations at study sites are not possible.

Landscape history of the famous early medieval Viking-settlement Hedeby that represented the major trading centre of Northern Europe and Southern Scandinavia in the 8th-11th centuries was investigated. The study of such important questions as local geomorphologic changes, soil transformation and erosion and their causes was impeded by the complex stratigraphy of a large number of heterogeneous colluvial layers of different origin and by drilling being the only possibility for observations and sampling due to the protected area status of Hedeby. The aim of this work was to develop an approach for categorization of materials comprising cultural, colluvial and other sediments in the ancient settlement on a detailed spatial scale.

Based on cores from 164 drilling sites, a working classification of all layers and soil horizons present in the area was elaborated. In result of iterative simplifications the classification consisted of 42 layer types aggregated into 6 groups with 11 additional descriptors. Two sites located 3 m away from each other in an accumulative position in the central part of the settlement were selected for detailed analysis. Revealed sequences are characterized by Pleistocene deposits at the basis and a complex alteration of different layers formed in situ and colluvial layers of cultural material dating back to the early medieval age at a depth reaching 3.8 m. In the two cores 17 and 18 layers were distinguished. The following properties were measured: content of > 2 mm fraction, grain size distribution, loss on ignition, magnetic susceptibility and element contents by pXRF. A set of three parameters commonly used as indicators of human activities and relevant for conditions at the study site were selected: magnetic susceptibility (MS), contents of lead (Pb) and phosphorus (P).

Based on the selected parameters, agglomerative cluster analysis divided the data in both sequences into several groups, which were modified into 6 meaningful clusters similar to the groups of the working classification. Cluster 1 contained natural materials free of human activity traces. Clusters 2 and 3 included layers transitional from natural to colluvial layers with traces of human activity. Cluster 4 was very consistent and included the upper part of cultural layer colluvium homogenized by ploughing. Cluster 5 was very heterogeneous; it contained all layers with any indication of human activity (values of the parameters higher than in the natural background). Cluster 6 included colluvial layers with highest degree of anthropogenic influence (colluvium of cultural layer); it had extreme peaks in all three parameters. Nonparametric statistical methods showed significant differences ($p < 0.05$) among all clusters in at least one parameter.

Such aggregation of layers allowed the formation of an overview of the complex stratigraphic sequence and a differentiation of the origins of colluvial materials. The location of the clusters relatively to each other within the cores provided information about possible stratigraphic inversions of materials. At the next research stages, comparison of the obtained categories of layers with those at other points in the catena, interpolation of the results and ultimate “connection” of the layers combined with dating results will enable a detailed reconstruction of extreme erosion processes at Hedeby, too.

Therefore, a categorization of settlement layers allowed a better understanding of the processes, which are responsible for the formation of individual layers and a determination of the degree of anthropogenic transformation of natural soil material. These results also contribute to the general question of classification of cultural materials in settlements on a detailed spatial scale.

Keywords：*geoarchaeology, settlements, Hedeby, cultural material, colluvium*

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[C1.6] Paleopedology

Lateglacial to Holocene Formation of Loess-Paleosol-Colluvial Deposit Sequences in Central Europe: Climate Change and Human Impact

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The loess-paleosol-colluvial deposit (LPCD) sequence of Gambach (Germany) can be regard-ed as an archetypical and unique sequence for deciphering the complete sequence of Lategla-cial-Holocene pedogenesis in dry loess areas with 500 - 600 mm mean annul precipitation in Central Europe. AMS 14C datings of soil organic matter and luminescence dating of colluvial deposits together with soil chemical, soil physical and micromorphological analyses were used for the pedosedimentary reconstruction of the LPCD sequence of Gambach: the remnant of a Lateglacial black soil was covered by Laacher See Tephra during the Allerød period. After the formation of a periglacial layer during the Younger Dryas a Chernozem formed during the early Holocene in this periglacial layer. This Chernozem was eroded and its pedosediments deposited in former periglacial valleys around 6 ka ago. Four succeeding erosional-depositional events could be detected and dated to 4 ka, 3.2 ka, 2.1 ka and 1 ka. Finally loess was eroded in the catchment areas of the former periglacial valleys and the valleys were com-pletely filled with colluvial deposits. Simultaneously decalcification and clay illuviation start-ed since around 6000 years ago leading (i) to a degradation of the Chernozem, (ii) to a com-plete decalcification of the translocated sediments and (iii) to a formation of Luvisols within the colluvial deposits. We suppose that the erosional-depositional events were caused by hu-man activities that could be proofed by the regional settlement history.

A characteristic Lateglacial-Holocene history of soil formation for dry loess landscapes in Central Europe can be reconstructed with the LPCD sequence of Gambach: Calcaric Regosol (Lateglacial) – Deposition of the Laacher See Tephra and formation of a periglacial layer (Al-lerød) - Chernozem formation (Early Holocene) – alternating formation of colluvial deposits (firstly black, lastly loess-coloured) and Luvisols (with beginning of the Atlantic period).

This pedosedimentary sequence reflects also the climate variability from around 15 ka to 6 ka and predominantly human activities since 6 ka. The polygenic history of many surface soils in these areas can be explained now as well.

Keywords：*Paleosols, colluvial deposits, pedogenesis, AMS 14C dating, luminescence dating, micromorphology, , Central Europe*

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[C1.6] Paleopedology

Pedology around a 6700 Year Old Neolithic Ring Ditch System in Germany

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The cultural landscape in Europe is the product of many different human and natural activities and processes. Settlement, clearing and farming over thousands of years are constantly transforming the landscape and the according bio- and geo-components like flora and fauna, relief, hydrology, soils and others. As Geoarchaeology tries to reconstruct certain stages of this cultural landscape development, the existence of geoarchives of the respective time period are a crucial precondition. Soil science often works with colluvium as geoarchives but that presupposes the original soil to be destroyed by erosion. Therefore there is a lack of in situ soils of certain time periods throughout Europe.

During archaeological excavations conducted by the Kreisarchäologie Deggendorf in eastern Bavaria late 2008 a new Neolithic ring ditch system was discovered which dates back to 4700 BC. Beside its enormous archaeological relevance the study site offers unique possibilities for pedological studies. Situated in the loess belt of eastern Bavaria calcic luvisols form the native soils of the region. However, black soils from older floodplains, the so-called Tschernitza, are described some hundred meters beside the excavation area. In addition black sediments which fill the pits of a Neolithic settlement close to the ring ditch system have been detected. The black backfill sediments are correlated with anthropogenic settlement activities. Interestingly, the backfills of the contemporaneous ring ditch

system differ. The 2 m wide and 2.5 m deep ditch functioned as an ideal trap for naturally eroded sediments. The backfills of the ditch indicate different phases of sedimentation and artificial reformation of the ditch. Furthermore, the analysis of thin sections and laboratory data (such as RFA, RDA, pedogenic oxides , magn. suszept., etc.) together with geophysical measurements point to the existence of a fully developed calcic luvisol around 6700 years ago. At the same time within some hundred meters of distance and under the same meso-scale climatic conditions black soils formed and black sediments were produced by the Neolithic settlers. We compare this situation with other sites known in Bavaria and present the meaning of our results for Archaeology.

Keywords：*paaleosol, archaeology, luvisol,*

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[C1.6] Paleopedology

Quantitative Distribution of Phytoliths as a Reliable Diagnostical Criteria of Ancient Arable Lands

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People ploughed the soils in the central part of Russia at list 2th. years. We know about it from the historical documents and archaeological artifacts. But we can not find any traces of ancient arable land because after 200-250 years of uncultivated period all morphological and chemical properties disappear.

Two soils near Moscow were studied: burial and modern. The first soil was under 800-years burial mound and the second about 20m near. It seemed that modern soil was also tillage in the past but nothing in morphology and chemical properties have shown it.

We used phytolith analysis to investigate if typical arable distribution of phytoliths have been preserved in the soil after 800 years of uncultivated period.

The results show that quantitative distribuion of phytoliths is a reliable diagnostic indicator of ancient arable stages of modern soils.

Keywords：*phytoliths, quantitative distribution, ancient arable lands, indicator*

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[C1.6] Paleopedology

A Multi-Proxy Approach for Interpreting the Effects of Climate Change on Intensely Welded Loess-Palaeosols

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Fluctuating climatic conditions in the Quaternary, as recorded in loess-palaeosol sequences, contribute to our understanding of the effects of climate change on soils. However, soil welding and upbuilding due to these environmental shifts add complexity to the interpretation of the soil record. This study focuses on an exceptionally well-preserved, in-situ profile of the Rocourt Soil at Veldwezelt-Hezerwater, the pedostratigraphic marker for the Eemian and early Weichselian in the Belgian loess belt. This soil consists ofa series of rubified illuvial B-horizons, overlain by an E-horizon with grayish-white, bleached bands and finally by an extensive complex of organic-matter containing A-horizons. Loess-palaeosols with properties similar to the Rocourt soil are found on many locations in the European loess-belt, covering a wide time range. Previous studies on the Rocourt pedosequence, based on only a small number of proxies, have yielded contrasting hypotheses regarding the parent material and soil formation in this sequence. Hence, a multi-proxy approach is used to assess the intensity of major sedimentological and pedological processes along depth functions throughout the profile, rather than interpreting each horizon or proxy separately. Measurements included macro- and micromorphology, grain-size, x-ray analysis, mid-infrared spectroscopic analysis, pH, EC, CaCO3, CEC, total elements content, iron and aluminum fractions, carbon content, carbon isotopes and organic matter composition by py-GC/MS. These data were used to asses the sedimentary setting and chemical weathering of the parent material, dissolution of carbonates, cryogenic processes, transport of colloids, iron dynamics, redox conditions, organic matter formation and biological activity. Results indicate that only by combining multiple soil features, consistent information could be obtained on this intensely welded profile.

The petrostratigraphically homogenous parent material developed under a regime of fluctuating rates of primary dust deposition intermixed with periods of (fluvial) reworking of the dust. Strong weathering in the lower stratigraphic unit supports the general consensus that it formed during the Eemian in Saalian loess. Less information is present to confirm the origin of the upper, less developed illuvial units, which may have formed by welding or by pedogenesis in locally redistributed or aeolian material. The overlying A-horizons are clearly less weathered, and evidence for early recalcification indicates that deposition of unweathered, calcareous sediments happened much earlier in the Early-Weichselian than previously assumed.

Furthermore, the data support six major stages of soil formation under fluctuating climatic conditions: first, a strongly weathered argic horizon was formed, most likely during the warm to temperate oceanic climate of the Eemian. This horizon was later disrupted by reticulate ice segregation and stagnogley during the severe and prolonged cold conditions, most likely during the first cold stadial following the Eemian. Weak soil formation, consistent with the relatively short continental St.Germain I interstadial, subsequently formed cambic soil properties and a humiferous horizon in a mixture of local and new sediments. These soils then were disrupted by fragipan formation, with its associated cryogenic structure, banded eluviation and redoxfront, during the succeeding stadial with periglacial conditions. During the St. Germain II, another A horizon formed in new, calcareous material during more stable climatic conditions, allowing organic matter build-up, eluviation of smectite, formation of pedogenetic iron, intensive microbial activity and high decomposition. During the evolution from this warmer climate with forest or forested steppe to eventually periglacial open tundra, an accretionaryhumiferous soil concluded the last episode of soil formation before the onset of pleniglacial conditions.Decomposition and microbial activity decrease, the isotopic signal shifts and wildfires are evidenced in the organic matter. Finally, full pleniglacial conditions shifted the balance to erosive conditions with strong cryoturbation (Nagelbeek horizon) and the deposition of large quantities of calcareous loess.

P2-301

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

Distribution of Soil Textures in Chinese Flue-Cured Tobacco Growing Regions and its Relationship with Tobacco Quality and Style

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The soil and tobacco samples form 78 flue-cured tobacco growing regions in China were collected and analyzed to study the effect of soil texture on the formation of tobacco quality and aroma style. The results showed that more than 60% of the soil texture in full flavor tobacco growing regions were sandy soils and loam soil. The content of chemical components was optimum in sandy loam and loam soils. The flavor style showed best in the sandy loam, the scores of aroma quantitity and quality were all at the highest levels in the sandy loam, while the degree of iritation and off-taste were great in tobacco leaves from loamy clay and caly soils. Degree of flavor style, sweetness and aroma quantility of tobacco were significantly positively correlated with the proportion of fine sand particles, and were negatively correlated with the proportion of clay particales in the soil. Degree of full flavor style and quantity of sweety aroma of tobacco decreased along with the decrease of the content of sand particales with the fitting correlation equations were $y = 0.2131\ln(x) + 2.9361$, $y = 0.3981\ln(x) + 1.9757$, respectively. In conclusion, sandy loam, and loam soil are favorable for the formation of tobacco quality and style, especially the sandy loam. When the proportion of sand particles decreased below 15%, the aroma quality and style would be significanly affected.

Keywords：*soil texture; flue-cured tobacco; sandy loam; sand; clay; tobacco quality and style*

P2-302

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

Compared to the Optimum Moisture Content and Mechanical Strength of Clay and Sand under Compaction

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Soil compaction is one of the indices showing soil physical degradation accompanying with increase in bulk density and decrease in pore spaces and restricts plant growth, microbial activity and nutrient elements. In order to assess compaction effect on two kind of texture (clay and sand), an experiment was conducted in form of factorial with randomized completely design with three repetitions at agriculture college of university of Guilan. The soil texture were studied in three (natural, 10% and 20% compaction level) and two levels (light and heavy texture that involved totally 18 pots. To exert compaction levels on the soils poured into cylindrical PVC pots with 35 cm height, 16 cm diameter and 7033 cm3 volume, first soil bulk density was measured using undisturbed core samples and it was regarded as a representative bulk density for a soil without compaction. Knowing volume and bulk density of each pot, we calculated the amount of required soil for each pot. In order to determine the amount of required soil for compaction levels of 10 and 20%, we raised the soil weight of representative pot as much as 10 and 20% respectively. Afterwards we compacted soil of each pot with a 2 kg hammer. Optimum moisture content where the maximum density occurs falls. Practor tests were used in two types of clay and sand. In the experiment using a hammer compaction method was modified. Practor model ASTMD 698-78 (Standard) were used. The experiment was repeated 5 times and then dry density of soil was calculated. Mechanical resistance of soils using cone penetrometer was measured The mean density of each soil type showed that the mechanical strength of clay soils increased with increasing density - has got twenty percent with an average density of under 94/1155 kPa (15/1 MPa) Highest the resistance of Poll created . Clay soil moisture has the greatest density of 18% (79/1 grams per cubic meter), and sandy soil water content by weight 5/8 percent, has the highest density (82/1 grams per cubic meter), respectively. Sandy soil bulk density at optimum moisture content is higher than that of clay. The critical level of soil penetration resistance tester that affects the compressibility increases with increasing clay content, as well as more compressibility clay soils and sandy soils have fewer compressibility. Taylor and colleagues (2011) surveyed the critical level of resistance offered MPa 2, but for the ultimate penetration resistance of plants to different gauges . reported that the strength of the survey depends on the amount of clay so that the clay is less than the resistivity survey may be more critical . The results showed that the mechanical strength of sandy soil under zero percent , with an average density of 14/232 kPa of least resistance against jamming more is the mechanical strength of ten percent and twenty percent of the density difference sandy soil there were. It looks like sandy soil pores than large pores. Studies show congestion during the demolition of large pores , the pores of the coarse and irregular , resulting in decreased soil bulk density increases, while the number of small pores of the soil increases, the initial regular coarse texture, mechanical strength limiting root growth may be due to the sand in front of the skid resistance of the particles are displaced.

Keywords：*compaction, mechanical strength, optimum moisture*

P2-303

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

Influence of Phosphate Sorption on Dispersion and Flocculation of Kaolinite

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1. Introduction

The excessive application of phosphate fertilizer in crop fields causes high accumulation of phosphate because phosphate is sorbed strongly in some soils. When the soil is conveyed by water and discharged into water environment, it causes water pollution such as eutrophication. Phosphate sorption affects clay dispersion because it changes the surface charge of clay minerals. Therefore, its research is valuable as a fundamental knowledge of soil dispersion concerning erosion, colloid leaching, effective phosphate application and environmental preservation, because soil dispersion induces soil erosion and colloid leaching. Kaolinite is a typical 1:1 layer type aluminosilicate clay mineral which exists in the weathered soil. This study was conducted to evaluate the influence of phosphate sorption on kaolinite dispersion under different pH and electrolyte concentration using stability ratio and zeta potential.

2. Materials and Methods

Iriki kaolinite was purchased from IWAMOTO mineral company. The kaolinite particles with diameter <2 ㎛ obtained by sedimentation was used as the sample. The phosphate sorption experiment was conducted as follows. The sample was saturated with 1 M NaCl at the prescribed pH (pH 3, 4, 5, 7). Then, the sample was equilibrated at 1 or 10 mM NaCl and the prescribed pH. The pH was adjusted by adding HCl or NaOH. After discarding the supernatant, the NaH_2PO_4 solution was added and adjusted at the prescribed pH. After shaking for 24 hours and adjusting pH, the supernatant was decanted to measure the phosphate concentration by the ascorbic acid method. The phosphate sorption was calculated by subtracting the phosphate amount of the solution from the input phosphate amount. Finally, the sample was washed with 50mM K_2SO_4 solution. The discarded solutions were gathered and its Na concentration was measured by the frame emission spectrometry method and its Cl concentration was measured by the ion chromatography method or mercuric(ii) thiocyanate method. The amounts of Na and Cl adsorption were calculated from the amount of desorption. The electrophoretic mobility of clay particles was measured with the microelectrophoresis method using the clay suspension in the same solution conditions of the phosphate sorption experiment. Zeta potential was estimated from the mobility using Smoluchowski's equation. Flocculation rate was measured by the dynamic-light-scattering method in the same solution conditions. Stability ratio was calculated by k(f)/k; k(f) is the rate of fast coagulation and k is the rate of sample coagulation. All experiments were performed at 25±1 ℃.

3. Results

3.1. Phosphate sorption

The maximum phosphate sorption was at pH 3 when the electrolyte concentration was 1 mM. The maximum phosphate sorption was at pH 5 when the electrolyte concentration was 10mM. At pH 3, amount of phosphate sorption was larger at 1mM than at 10mM. At pH 4 and 5, phosphate sorption was larger at 10mM than at 1mM. At pH 7, the difference of phosphate sorption between the different electrolyte concentrations was small.

3.2. Flocculation/Dispersion

Under experimental conditions, zeta potentials were always negative; the range was from -61.8mV to -12.5mV. The magnitude of zeta potential increased with increasing pH and phosphate sorption. At pH 4 to 7, the magnitude of zeta potential decreased with the increase of electrolyte concentration. At pH 3 to 4, the kaolinite flocculated well irrespective of electrolyte concentration and the amount of phosphate sorption. At 1 mM electrolyte concentration and pH 5, and at 10 mM electrolyte concentration and pH 7, the stability ratios increased with phosphate sorption. At 1 mM electrolyte concentration and pH 7, the kaolinite was more dispersive and the influence of phosphate sorption was not clear. The dispersion corresponded with the increase of the magnitude of zeta potential.

4. Discussion and Conclusion

It was confirmed by the measurement of zeta potential and stability ratio that the dispersibility of the kaolinite increased with phosphate sorption at 1 mM electrolyte concentration and pH 5, and at 10 mM electrolyte concentration and pH 7. The dispersibility increased with the increase of pH and the reduction of electrolyte concentration. The DLVO theory can explain these results as the the increase of negative charge with the increase of phosphate sorption and pH generates the electrical repulsive force and the reduction of electrolyte concentration decreases the electrical repulsive force.

Keywords：*Kaolinite, Phosphate sorption, Dispersion, Flocculation, Zeta potential, Stability ratio*

P2-304

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

Energetic Aspect at Agriculture Production on Semidesert Conditions of Azerbaijan

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Recently in connection with growth of a tendency of creation of combustible materials from various vegetable substances, for example from sugar beet, rice and so on, to reveal profitability of these methods we offer to define the energy accumulated in various parts of this vegetation and to draw conclusions: what parts of vegetable substance are most favorable to receiving from them combustible materials.

Energetic aspect of processes in agriculture production has been assuming more interest with energetic crisis in world.

Calorimetric measurements show that the amount of energy accumulated in the organic matter of Azerbaijan semidesert community to stay from wide limits of calories per gram of dry mass. In that conditions only 1 to 3 percent of incoming Sun light energy is accumulated in the mass of plant community.

One aspect of this research has been determination of the amount of energy accumulated in the plant matter of various type of characteristic plant communities of the Shirvan Steppe and different parts of Azerbaijan Republic.

The amount of energy accumulated by the plant was determined by means the special calorimeter with a self-compacting bomb. A calorimetric determination of the energy accumulated in the plant matter of a biocenosis involves placing the plant mass in the bomb, which is then filled with oxygen at pressure 25-30 kg/cm2, placed in a container filled with water, and ignited.

A metastatic thermometer, capable of measuring temperatures to the nearest 0.001 oC, is used to determine the increase of water temperature produced by the heat of combustion of the plant material.
On the basis of the temperature rise and the mass of plant material, one can calculate the heat of combustion in calories corresponding to the energy accumulated in one gram of plant matter.
Questions of rational use of food and energy resources demand the attentive relation to problems of the biosphere, considerable expansion of ecological researches, justification of methods of preservation and improvement of a condition of the soil-plant-atmosphere system.
Researches of various processes in ecosystems from the power point of view regularities in transformations of solar energy on a terrestrial surface allow to reveal research of various processes: in atmo-, hydro- and lithospheres to define moisture circulation

components in various conditions of the environment of growth vegetable biocenoses, to make the utilization models of arriving solar radiation in the soil-plant-atmosphere system and to consider the main sum of power expenses for ensuring normal activity of agricultural production of the whole area or its divisions. Bio-energetics provisions of functioning of this system, revealing regularities of the studied processes in various conditions of the environment have to become theoretical base of such works.

Efficiency of these researches substantially depends from integrated system approach to studying in the environment the soil-plant-atmosphere of such heat transfer of water, thermo-gradient coefficient, power consumption, etc. Despite a significant amount of researches, as a whole they are carried out is separate for various objects and processes that leads to certain miscalculations by drawing up bases of the production technology of agriculture at which development only private characteristics of objects are quite often considered.

The result of these calorimetric measurements show that the amount of energy accumulated in the organic matter of various organs of a particular plant species as well as the energy accumulated in the material of different plant species ranges from wide limits.

By comparing the amount of organic matter in the plant community (per hectare) and the amount of energy accumulated in the one gram of plant matter with the amount of incoming solar energy, we find that in the condition of the Shirvan steppe only 1 to 3 percent of the incoming light energy is accumulate in the plant matter of a biocenosis.

Keywords：*soil-plant-atmosphere, Shirvan Steppe, environment, measurements, energy*

P2-305

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

Effect of Phosphate Sorption on Ferralsol Soil Dispersion: Evaluation with Stability Ratio and Repulsive Potential Energy

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Introduction

Ferralsol soil has much amount of kaolinite and metal oxides. The phosphate (P) sorption on positively charged edge sites of the mineral oxides results in increase of net negative charge. Then, the soil structure is supposed to be influenced by the change. P sorption is supposed be an important factor to evaluate soil loss due to soil dispersion. Consequently, soil dispersion induces soil erosion and colloid leaching. Accordingly loss of nutrients causes water contamination. Because phosphate affects the soil dispersion, the influence must be evaluated well to control soil erosion and leaching. Stability ratio is used commonly to evaluate stabilization of clay mineral colloids. In this study, influence of P sorption on Ferralsol soil dispersion was investigated by measuring zeta potential combining with stability ratio of soil suspension at different salt concentration.

Materials

Ferralsol soil sampled at 10cm depth in central Vietnam was used. Soil texture is light clay; sand (29.39%), silt (29.35%) and clay (41.26%). The minerals present in the clay fraction (<2µm) were quartz (61%), kaolinite (34.4%) and goethite (<4.6%).

Methods

Adsorption experiment. The soil was saturated with 1 and 10 mmolc l-1 NaNO3. The pH was adjusted to pH 4, 5.5, 7 or 8.5. Then, different concentration of NaH2PO4 was added and the pH was adjusted to the prescribed value. The sample was shaken well and the phosphate concentration of the supernatant was measured. Na concentration was changed when the input NaH2PO4 concentration was larger than 1 or 10 mmol l-1.

Zeta potential (ζ) measurement. The soil sample under the same solution conditions as those in adsorption experiment was prepared. It was shaken well and 1 cm3 of the supernatant from 2 cm below the water surface was taken. It was diluted with the same concentration of equilibrium solution. ζ of the soil particles was measured.

Dynamic light Scattering. Soil suspensions were prepared as the same solution condition of adsorption experiment and diluted with the same concentration of equilibrium solution for the measurement. A 1ml soil suspension in cuvette was monitored the early-stage particle coagulation with time resolution of 3s for 10-15 min at 25oC by using Delsa Nano - Beckman Coulter. Coagulation rate constants (k) were obtained from the initial slope of the record of the hydrodynamic radius as a function of time. Stability ratio, W, was calculated by kf/k, where kf is an experimental value determined for coagulation in the fast regime.

Repulsive potential energy. The repulsive potential energy when two soil particles approach to 1 nm distance from each zeta potential plane was calculated based on the diffuse double layer theory and the measured ζ.

Results and Discussion

The stability ratio increased when P sorption increased up to around 10 mmol P kg-1 at all pH. After the peak, it decreased with increasing P sorption at > 10 mmol P kg-1 because of the increase of electrolyte concentration (>10 mmolc l-1 Na). It increased with increasing pH. It also increased with the increase of the repulsive potential energy. The soil flocculated well when the repulsive potential energy was < 0.1 μJ m-2, corresponding with logW <1.15. Soil dispersed well when logW >1.4 at repulsive potential energy >0.17 μJ m-2. The result confirms that the increase of the repulsive potential energy induced the soil dispersion. When phosphate sorbed until around 10 mmol P kg-1, the increase of the negative charge increased the repulsive potential energy and the soil dispersion proceeded. When the electrolyte concentration increased, the repulsive potential energy decreased due to screening effect of the high electrolyte concentration and the stability ratio decreased. ζ also correlated with the stability ratio because this relates to the repulsive potential energy as included in the calculation. The soil was flocculative when the ζ was larger than -20 mV. It was well dispersive when the ζ was smaller than -30 mV.

Conclusion

The dispersion of the Ferralsol soil was well explained by using the repulsive potential energy and W. The soil was more dispersive at higher pH and increase of P sorption up to around 10 mmol P kg-1. Because the soil dispersion causes soil and P loss, the influence of soil pH and P sorption on the soil dispersion should be considered for good soil management.

Keywords：*Ferralsol. phosphate sorption, dispersion, stability ratio, zeta potential, repulsive potential energy*

P2-306

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

Dynamics of Soil Macropores During Shrinkage Investigated by X-Ray Microtomography

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Our knowledge concerning the dynamic of macropores and their geometry during soil shrinkage is rather scanty. This was partly due to the lack of reliable methods for non-destructive observation and measurement of soil macropores in relation to changes of hydraulic stress conditions. This study aimed to investigate the dynamics of macropores of two shrinking soils during drying and to discuss changes with parameters given by the shrinkage curve analysis. 3D macropore parameters (volume, connectivity and orientation of pores > 30 μm) obtained with X-ray microtomography and the shrinkage curve parameters were measured together on undisturbed soil samples of 21 cm3. While the shrinkage of soils led to the significant decrease in void ratio, the volume of macropores and their connectivity increased concurrently. In contrast, macropores did not show any preferential orientation during drying. Changes in macropores occurred during all the shrinkage phases. However, main changes took place during the proportional shrinkage phase, and were caused by the increase of macropores in the range 225-1215 μm with the concomitant large decrease in soil volume. Macropores formed were recognized as cracks and extended pre-existing macropores whereas no macropore extinction was detected. The overall increase in macroporosity was three times higher in the soil presenting the lowest shrinkage capacity, highlighting that pore development was not related to the linear coefficient of extensibility.

Keywords：*soil structure dynamics; cracking; wetting-drying*

P2-307

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

The Soil-Litter Interface as Biogeochemical Hot Spot of Coupled Carbon Turnover and Mcpa Degradation

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The detritusphere (soil close to the soil-litter interface) is characterized by a high availability of litter-derived organic substrates stimulating microbial growth and activity. It is a hotspot of carbon (C) turnover and degradation of pesticides. To improve our understanding of the regulation mechanisms, which are responsible for stimulated degradation of the herbicide MCPA (2-Methyl-4-chlorophenoxyacetic acid) at the soil-litter interface, we applied the recently developed PECCAD (PEsticide degradation Coupled to CArbon turnover in the Detritusphere) model (Pagel et al. 2013) with the data of a detailed microcosm experiment. We prepared ^{14}C-MCPA (50 mg kg^{-1}) amended soil cores and set up three experimental treatments: 1) maize litter (control), 2) MCPA and 3) MCPA + maize litter. The litter was placed on top of the soil cores and the microcosms were incubated at 20 °C for 23 days. We analysed MCPA and different C pools (soil and CO_2) for total concentration as well as isotopic composition (^{13}C, ^{14}C). We measured three molecular markers (tfdA, 16SrRNA genes and the fungal ITS fragment) to estimate the abundance of bacterial MCPA degraders, total bacteria and fungi in soil. The PECCAD model was calibrated using these data by means of a multi-objective Pareto analysis.

In the detritusphere, we observed increased concentrations of dissolved organic matter and accelerated degradation of MCPA. Litter stimulated the microbial community as reflected by increased abundances of tfdA, 16S rRNA and 18S rRNA genes in the detritusphere. The PECCAD model could match the observed C dynamic and the model was able to simulate accelerated MCPA degradation at the soil-litter interface.

Our study demonstrated that knowledge about the micro-scale dynamics of hot spots and hot moments in soil is very important to understand fundamental soil functions, such as decomposition of organic matter and degradation of pesticides. The PECCAD model served as a valuable tool to trace C flows and to improve our understanding of microbial functioning regulated by litter-derived C at the micro-scale.

References

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Keywords：*Biogeochemical interface, Soil organic matter, Priming, mechanistic model, pesticide degradation*

P2-308

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

A New Analytical Method for Prediction of Soil Sorptivity and Cumulative Infiltration Using Particle Size Distribution Data

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In this study a new analytical method was develop to predict soil sorptivity, S, wetting front distance, xf, and average volumetric water content in wetted soil,θ ?, using particle size distribution data, fractal dimension of the pore space, Dp, average pore radius ,maximum ,Rm, and minimum,R0, pore radius. For developing the new method we assume that average pore radius, , is equal summation of probability of an arbitrary pore multiple to pore radius. Also we assume that cumulative infiltration could be calculated using multiple of average volumetric water content of the wetted soil and wetting front distance, xf . Finally cumulative infiltration in different time was estimated as a function of fluid viscosity, surface tension, average pore radius, minimum pore radius Rm and fractal dimension of pore space. 18 soils with wide range of soil physical properties were selected to evaluate the new method. Experiments were conducted using a horizontal cylindrical column with a length of 100 cm. A Marriotte tube was used to supply water, and a zero water head was maintained at the in soil inlet. Cumulative infiltration and wetting front distance were measured in various times. Soil water content profiles were measured using gravimetric method. Estimated and measured wetting front distance, xf, in different time, t0.5, had good agreement. Although the estimated, xf, are somewhat larger than measured xf in sandy clay loam and sandy Loam soils texture classes. The results show that the estimated, xf, and cumulative infiltration, I, spatially at large infiltration stage is less agreement with the measured wetting front distance. The results show that the predicted values of sorptivity are very similar to the given values of measured sorptivity. Root mean square error (RMSE) and normalized root mean square error (NRMSE) between measured and predicted soptivity were 0.1 cm min0.5 and 0.12, respectively. The maximum absolute difference between estimated and actual sorptivity was 0.1 cm min0.5. The NRMSE for prediction xf in and cumulative infiltration, I, were 0.16 and 0.23, respectivly. Sensitivity analysis shows that, S, is sensitive to fluid viscosity. Soil soptivity, decrease exponentially with increasing viscosity. Results show that, S, is sensitive to surface tension. Result showed that new method overestimates S and xf values by 12 and 23% respectively. Results show that the new method is applicable for prediction of another liquid such as oil as the infiltrating liquid.

Keywords：*Horizontal cumulative infiltration, Soil sorptivity, Particle size distribution*

P2-309

[C2.1-2] Biophysical Aspects of Soil Function - Exploring Soil Hidden Frontiers

A Protocol for Selecting Physically Varying Soils for Basic Studies from a Limited Dataset

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Soils are ultimate sinks of intended or unintended residues of anthropogenic wastes – agricultural as well as industrial. Diverse materials are added to soils to increase their suitability for agricultural, industrial and allied purposes or even at times to dispose the wastes. These include fertilizers, manures, crop and animal residues, amendments, biochars, municipal wastes and industrial effluents, among others. Studies involving sustainability of systems intend to analyse the impacts of human activities on subsequent suitability of soils for their intended uses. Field studies on pilot scales can usually be conducted to assess the impacts of any specific phenomenon or input into a soil. These studies can give a very good assessment of the impacts of such interventions, but the assessed impacts are often limited to the particular soil. Being cumbersome and labour and cost intensive, there is a limitation for their feasibility on an extensive scale. Laboratory incubation studies can overcome this limitation to some extent as they allow studies on more number of soils with far more number of levels of interventions. But the basic limitation still remains that the results are only applicable to the soils subjected to the study. However, if the field or laboratory incubation studies are conducted on soils selected to represent the diversity of soil types encountered in the ecology on the basis of quantified soil properties, the results can be subjected to interpolation and extrapolation for wider application. The objective of this presentation is thus to propose and discuss a protocol to select soils from a limited dataset so as to represent the diversity of soils that need to be studied for any particular intervention. A limited dataset that is most likely to be available could consist of data regarding texture, organic carbon, available nutrients (N, P, K & S), pH and EC as these are routinely analysed in soil tests. Among these parameters, texture and organic carbon content may be considered as the identifying parameters of a soil that control the response of soils to the addition of foreign materials. Moreover, the interaction of the particle size and organic carbon content often create functional categories resulting from aggregation.

As a first step, the dataset is ranked in the increasing order of particle size as indicated by mean weight diameter of the soil separates. The ranked data is then grouped into convenient groups (n) with fixed class intervals. The soils of each group are then ranked again on the basis of organic carbon content. The soils of each group are then further categorized into n equal sub-groups in the order of their ranking in the list. To identify any multiple number (say n*t) of soils for further studies, t soils from xth class can be selected randomly from among the soils in the [n-(x-1)] sub-group of that group.

To illustrate this, a dataset of 226 soils from a limited dataset in eastern India is used. The mean weight diameters of the textural separates in 7 classes averaged 0.05, 0.15, 0.25, 0.36, 0.44, 0.55 and 0.64 mm with corresponding organic carbon content values of 0.61, 0.70, 0.62, 0.51, 0.60, 0.41 and 0.43 per cent respectively. The mean weight diameters and the organic carbon contents averaged over various classes were negatively correlated (r= - 0.83) showing that organic carbon contents of course textured soils were lower than that of fine textured soils. The mean weight diameters averaged over various classes were also negatively correlated with the electrical conductivity of the soils (r= - 0.85) and soil available potassium (r=-0.80) averaged over each class. Thus the coarsest soils with least organic carbon content are at one end of the functional characterization whereas the finest soils with maximum organic carbon content are at the other extreme end.

Keywords： *soil selection, soil dataset, physically varying soils, incubation studies, soils as sinks*

P2-310

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Stabilization and Storage of Carbon Using Organic Amendments

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Applying organic amendments including biosolids and composts to agricultural land could increase carbon (C) storage in soils and contribute significantly to the reduction of greenhouse gas emissions. Recently, there have been increasing interests in the conversion of these organic residues into biochars in order to reduce the rate of decomposition, thereby enhancing carbon (C) sequestration in soils. However energy is required to initiate the pyrolysis process during biochar production which can also lead to the release of greenhouse gasses. Alternative methods can be used to stabilize C in composts and other organic residues without impacting their quality. The objectives of this study include: (i) to compare the rate of decomposition among various organic amendments; (ii) to examine the effect of clay materials on the stabilization of C in organic amendments; and (iii) to examine the potential value of biosolids in C sequestration in soils.

The decomposition of a number of organic amendments (composts and biochars) was examined by monitoring the release of carbon-dioxide using respiration experiments. The results indicated that the rate of decomposition as measured by half life (t1/2) varied between the organic amendments. Addition of clay materials to compost decreased the rate of decomposition, thereby increasing the stabilization of C. The half life value for poultry manure compost increased from 139 days to 620, 806 and 474 days with the addition of goethite, gibbsite and allophane, respectively. The increase in the stabilization of C with the addition of clay materials may be attributed to the immobilization of C, thereby preventing it from microbial decomposition. Stabilization of C in compost using clay materials did not impact negatively the value of composts in improving soil quality as measured by potentially mineralizable nitrogen and microbial biomass carbon in soil.

Two types of experiments were conducted to examine the effect of biosolid application on C sequestration. In the first laboratory incubation experiment, the rate of decomposition of a range of biosolid samples was compared. In the second field experiment, the effect of biosolids on the growth of two bioenergy crops, Brassica juncea (Indian mustard) and Helianthus annuus (sunflower) on a landfill site was examined in relation to biomass production and C sequestration. The rate of decomposition of biosolids decreased with increasing iron (Fe) and aluminum (Al) contents of biosolids. Biosolid application increased the dry matter yield of both plant species (by 2?2.5 fold), thereby increasing the biomass C input to soils. The rate of net C sequestration resulting from biosolid application was higher for mustard than sunflower. Biosolid application is likely to result in a higher level of C sequestration when compared to other management strategies including fertilizer application and conservation tillage, which is attributed to increased microbial biomass, and Fe and Al oxide-induced immobilization of C.

Keywords：*Organic amendments, Heavy metals, Immobilization, Decomposition, Mineralizable nitrogen*

P2-311

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Physical Fractions of Soil Organic Matter as Affected by Cover Crops and No-Till System

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The soil organic matter (SOM) can be greatly increased by growing cover crops under a no-till system (NTS). The magnitude of SOM increase after using a NTS is dependent on soil type, species and biomass input of cover crops, and regional climate. Short-term changes in total SOM due to the soil management practices are often small and difficult to assess. Some physical fractions of SOM are more sensitive to soil management and can be good indicators of soil management changes over the short time period. This is because physical fractions of SOM are more responsive compared to the chemical structure and function of SOM. Therefore, physical fractions (free light fraction, intra-aggregate light fraction and heavy fraction) of soil organic matter (SOM) are good indicators of soil quality for sustainable land use. The objective of this study was to evaluate the effect of cover crops on total organic carbon (TOC) and physical fractions of soil organic matter in soil under a no-tillage system (NTS) and a conventional tillage system (CTS, one plowing and two disking).

A field experiment was conducted in Santo Antonio de Goias, GO, Brazil (16° 27' S , 49º 17' We, and 823 m elevation). The regional climate is tropical savanna, classified as Aw by the Koppen classification system. There are two seasons: the dry season from May to September and the rainy season from October to April. Annual mean rainfall and temperature are 1,500 mm and 22.7°C, respectively. A NTS had been used at the experimental site for six years (2001 - 2007). Crop rotations were corn (Zea mays) for2001, 2003 and 2005 and soybean (Glycine max) for2002, 2004 and 2006 during the rainy season, and the site was fallow during the dry season. Soil at the site is classified as a kaolinitic, thermic Typic Haplorthox. The study was conducted over a three-year period (2007-2009). Crop rotations included a cover crop-rice-cover crop-rice rotation. Cover crops and upland rice were planted in November 2007 andNovember 2008, respectively and planted again in March 29 and November 2009, respectively. The cover crops used for this experiment were 1) fallow (spontaneous vegetation, predominantly Bidens pilosa, Commelina benghalensis, Conyza bonariensis and Cenchrus echinatus), 2) Panicum maximum Jacq., 3) Brachiaria ruziziensis R. Germ. And C.M. Evrard, 4) Brachiaria brizantha (Hochst. Ex A. Rich.) Stapf. - cultivar Marandu, 5) millet, Pennisetum glaucum (L.) R. Br. - cultivar BN-2. Two additional control treatments were included as 6) fallow plus CTS (CTS, one plowing and two disking), and 7) ? Brachiaria brizantha plus CTS. The experimental design was a randomized block design with seven treatments and three replications. The size of each plot was 6 x 10 m with 1 m buffer between plots. Soil samples were collected from depths of 0-0.05, 0.05-0.10 and 0.10-0.20 m after rice harvesting in April 2010. The samples were air-dried, and sieved to pass a 2 mm screen. The

SOM was physically fractionated in free light fraction (FLF), intra-aggregates light fraction (IALF) and heavy fraction (HF). The levels of C in whole soil were also evaluated, as well as C in the light fractions (FLF + IALF) and in the HF.
Results indicated that concentrations of C in the FLF and IALF in surface soils (0-0.05 m) were much higher (10.8 and 1.95 g kg-1, respectively) than in the 0.05-0.1 m soil depth (7.68 and 1.54 g kg-1, respectively) and in the 0.1-0.2 m soil depth (4.98 and 1.24 g kg-1, respectively). The NTS resulted in higher levels of FLF (12.2 g kg-1) and IALF (2.19 g kg-1) than with CTS (1.37-7.30 g kg-1). Millet had the highest C (19.5 g kg-1) and N (1.1 g kg-1) concentrations in soil. There was an accumulation of TOC and total N in the surface soil with cover crops, and concentrations of TOC were higher in the HF (79.0%) than in the light fractions (21.0%). Although SOM changed little during the two years of this experiment, the various C fractions were significantly affected by the tillage treatments. We conclude that SOM physical fractionation allowed seeing significant differences caused by the soil management in the organic matter dynamics in a short period of time.

Keywords：*Brachiaria brizantha, Brachiaria ruziziensis, Panicum maximum, Millet, Soil management.*

P2-312

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Charcoal Distribution and Stability in a Sandy Soil

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Charcoal presence, distribution and stability in three particle-size fractions (2000-200 μm, 200-60 μm, <60 μm) of a sandy soil from South-Eastern Australia was investigated using diffuse reflectance infrared Fourier Transform spectroscopy, scanning electron microscopy and radiocarbon analysis. Charcoal was uniformly distributed between particle-size fractions in the topsoil (0-30 cm depth), accounting for ~17% of the total soil organic carbon of the bulk soil. No difference in stability was found between fractions in the topsoil. At a depth of 30-60 cm, the amount of charcoal as a portion of total soil organic carbon increased by similar amounts in the two finer fractions, and was not significantly different between these two finer fractions. In contrast, there was no conclusive change in the amount of charcoal as a portion of soil organic carbon in the coarsest fraction at a depth of 30-60 cm compared with the topsoil. However, the stability of the charcoal differed between fractions at 30-60 cm depth. Whilst the two coarser fractions contained charcoal of a similar age and stability, the finest fraction contained less stable, younger charcoal. At a depth of 60-100 cm, only the mid-sized fraction had clearly identifiable charcoal, which yielded a radiocarbon age of ~6500 yrs Before Present. Below 100 cm, no charcoal was detectable in the soil. We believe that the differing stability of the charcoal in the fractions is connected to the size and reactivity of the charcoal, with the finest fraction being most mobile and most reactive in the soil. This results in an uneven distribution of charcoal content and charcoal ages between different particle-size fractions down the soil profile, for which we propose a conceptual model. The presence of charcoal in the subsoil is, therefore, attributed to a gradual translocation of charcoal down the soil profile.

Keywords：*Charcoal, mobility, stability, radiocarbon*

P2-313

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Residue and Soil Carbon Sequestration in Relation to Crop Yield as Affected by Irrigation, Tillage, Cropping System and Nitrogen Fertilization

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Information on management practices is needed to increase surface residue and soil C sequestration to obtain farm C credit. The effects of irrigation, tillage, cropping system, and N fertilization were evaluated on the amount of crop biomass (stems and leaves) returned to the soil, surface residue C, and soil organic C (SOC) at the 0-85 cm depth in a sandy loam soil from 2005 to 2011 in western North Dakota, USA. Treatments were two irrigation practices (irrigated vs. non-irrigated) as the main plot and six cropping systems (Conservation Reserve Program [CRP], conventional till malt barley with N fertilizer [CTBN], conventional till malt barley without N fertilizer [CTBO], no-till malt barley-pea with N fertilizer [NTB-P], no-till malt barley with N fertilizer [NTBN], and no-till malt barley without N fertilizer [NTBO] as the split plot arranged in a randomized complete block with three replications. Crop biomass varied with treatments and years and was greater in the irrigated CTBN, NTB-P, and NTBN than other treatments. Soil surface residue amount and C content were greater in CRP and NTBN than other cropping systems, regardless of irrigation. The SOC at 0-5 cm was greater in irrigated CRP than other treatments, except non-irrigated CRP, NTBN, and NTBO. At 0-85 cm, SOC was greater in non-irrigated NTBN than other treatments, except irrigated CRP and non-irrigated CRP, CTBN, CTBO, and NTBO. At 0-50 cm, SOC declined by 500 kg C ha-1 yr-1 in the irrigated treatment and 40 kg C ha-1 yr-1 in the non-irrigated treatment from 2005 to 2011. Similarly, at 0-20 cm, SOC declined by 20 to 630 kg C ha-1 yr-1 in all cropping systems, except in CRP and NTB-P where SOC increased from 220 to 1080 kg C ha-1 yr-1. No-till increased SOC by 8.5 % at 0-5 cm but decreased by 9.2% at 5-10 cm compared to conventional till. Perennial grasses increased SOC at 0-85 cm by 7% compared to annual crops. The SOC at multiple depths was related to annualized crop grain yield ($R2 = 0.26$ to 0.45, $P \leq 0.05$, $n = 10$). Irrigation led to a decline in SOC compared to non-irrigation and tillage redistributed SOC in the surface soil layers. While perennial grasses increased SOC probably by increasing root biomass compared to annual crops, regardless of irrigation, NTB-P increased SOC from 2005 to 2011 compared to decreases in other annual cropping systems. As a result, no-till barley-pea with N fertilization can be used to increase C sequestration in the surface layer and annual crop grain yields compared to other cropping systems, regardless of irrigation, in the northern Great Plains, USA.

Keywords：*Carbon sequestration, crop residue, irrigation, tillage, cropping system, nitrogen fertilization*

P2-314

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Effects of Discontinuing Long-Term Manure Use on Soil Carbon and Nitrogen Sequestrations in a Paddy Field in Niigata, Japan

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Introduction

The pedscape stores a substantial amount of soil carbon, estimated at 1200-1600 Gt, which exceeds the amount of soil carbon storage by vegetation biomass. Thus, changes in soil carbon sequestration affect global climate change. Improvements in agronomic practices for carbon sequestration in agricultural soils are very important for the mitigation of climate change. It is well known that soil carbon sequestration in agricultural lands is affected by soil management practices including the application of organic matter and plowing.

One of the primary methods for adding carbon to paddy field soils is the application of manure. However, increasing soil carbon storage in a paddy field by the application of manure provides benefits for about 15-25 years. After this time, however, the plow layer loses its ability to absorb additional carbon dioxide. Furthermore, soil carbon sequestration in paddy fields via manure usage for long term will decrease if the application of manure ceases because the microbial activity related to organic destruction increases.

To assess these hypotheses, we discontinued the use of manure in a paddy field that had received manure applications for 25 years and studied the changes in soil chemical properties over a 3-year period, such as soil carbon and nitrogen sequestrations and rice crop yield.

Materials and Methods

The paddy field used in the current study where subjected to applications of manure made from rice straw for over 25 years was located in Nagaoka, Niigata, Japan. The classification of the field is Epi-gray Gley Lowland Soil, and increasing the soil carbon storage in the region is known to hit the ceiling. We set up 2 field experiments in the paddy field in 2011. In one field, manure applications were continued for rice crop cultivation (i.e., Manure Experiment). In the other field, manure applications were discontinued; this field was subjected to fertilizer treatments only (i.e., Manure-Stop Experiment). The application rate was 48 kg N, 75 kg P_2O_5, and 71 kg K_2O ha^{-1} $year^{-1}$ for both the fields. In the Manure Experiment, 10 t ha^{-1} $year^{-1}$ manure made from rice straw was applied in the spring. Other field management practices (e.g., water management) were the same for both the fields. We determined the chemical properties of the plow layer (0-14 cm depth), such as the soil carbon sequestration and rice crop yield for both the fields during each year of the experiment.

Results and Discussion

In the Manure-Stop Experiment, a 0.75 t C ha^{-1} decrease in soil carbon sequestration was noted when compared to the Manure Experiment after a 2year period. The rate of decrease in soil carbon sequestration (0.38 t C ha^{-1} $year^{-1}$) was almost the same as the rate of increase in soil carbon sequestration for the initial 5 years of manure application (0.44 t C ha^{-1} $year^{-1}$). Similarly, a 0.11 t N

ha^{-1} decrease in soil nitrogen sequestration was observed in the Manure-Stop Experiment when compared to the Manure Experiment, and the rate of decrease in soil nitrogen sequestration (0.052 t N ha^{-1} $year^{-1}$) was almost the same as the rate of increase in soil nitrogen sequestration for the initial 5 years of manure application (0.049 t C ha^{-1} $year^{-1}$).

These results suggest that soil carbon and nitrogen sequestrations quickly decrease in paddy fields that had previously experienced an increase in soil carbon storage (thus, hitting the ceiling) through long-term applications of manure, after the applications were discontinued..

The other soil chemical properties of the Manure-Stop Experiment, available nitrogen, available P_2O_5, cation-exchange capacity, exchangeable-K_2O, free iron oxide, and available SiO_2, after 2 years were almost same as those in the Manure Experiment. Furthermore, rice crop growth and yield were similar for both experiments.

Conclusion

To mitigate climate change, it is important for carbon dioxide to be fixed in cultivated land soils such as paddy fields. However, it has become clear that soil carbon and nitrogen sequestrations in a paddy field subjected to manure applications for 15-25 years quickly decreases when the use of manure discontinued. Other field management practices, including water management, must be optimized in combination with the application of manure to further increase soil carbon storage.

Keywords：*Paddy field, Soil carbon sequestration, Soil nitrogen sequestration, Manure made from rice straw*

P2-315

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Characterization of the Chemical Composition of Soil Humic Acids Using Fourier Transform Ion Cyclotron Resonance Mass Spectrometry

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Introduction

Soil organic matters partlly transformed to dark color materials called humic substances. Persistence of humic substances may be determined by the construction units and their combinations/arrangements and increased with increasing degree of structural modification (humification) toward darker colored (Kumada, 1987). However, the molecular composition and/or structure associated to the degree of humification or persistence are not elucidated. In the present study, 10 soil humic acids (HAs) with various degrees of humification were characterized using negative-mode electrospray ionization coupled with Fourier transform ion cyclotron resonance mass spectrometry (FTICR-MS), to obtain information about general and specific molecular formula-based structural components in soil HAs and their relation to the stability of HAs in soil.

Materials and methods

Both Dando and Inogashira HAs were prepared according to the IHSS method, and the other eight HAs were prepared according to the NAGOYA method (Kuwatsuka et al., 1992), in which HAs were extracted with 0.1 M NaOH at the mixing ratio of 300 mL g per soil C by continuous shaking at 25℃ under N_2 atmosphere. The HAs were treated with 0.3 M HF and 0.1 M HCl (1:1), dialyzed, and freeze-dried. The degree of humification of the HAs was evaluated from the absorbance at 600 nm per mg C mL^{-1} (A_{600}/C) and the ratio of absorbance at 400 nm to that at 600 nm in a logarithmic scale [$\log(A_{400}/A_{600})$]. Larger A_{600}/C and/or smaller $\log(A_{400}/A_{600})$ values indicate a higher degree of humification. Aromatic C content was estimated by ^{13}C CPMAS NMR spectroscopy.

FTICR-MS was performed according to Sleighter and Hatcher (2008). The HA samples in a protonated form were dissolved in water/methanol (1:1) containing 0.1% ammonium hydroxide (pH 8) and injected into an ESI ion source of a 12 Tesla FTICR-MS. Samples were introduced by a syringe pump at an infusion rate of 120 μL h^{-1} and analyzed in negative ion mode with an m/z range of 200–2,000. The peaks were identified at an S/N>4. Molecular formulas were assigned to the peaks utilizing the Molecular Formula Calculator using $C_{0\text{-}100}$, $H_{0\text{-}200}$, $N_{0\text{-}7}$, $O_{0\text{-}50}$, $S_{0\text{-}3}$, and $P_{0\text{-}3}$ atoms. Those assigned were categorized based on their alignment in the van Krevelen diagram, double bond equivalents (DBE), and Kendrick mass defect (KMD) analysis, and analyzed with respect to the degree of humification and aromaticity. Potential condensed aromatic acid components assigned on the basis of the molecular formulas using the KMD analysis were discussed with referring to previous FTICR-MS and other related studies.

Results and discussion

Numerous peaks were observed in the m/z range of 200–700 and molecular formulas were assigned to 817–2457 peaks in each HA sample. The molecular formulas having H/C and O/C ratios similar to those of lipid and protein (including other aliphatics) with low double bond equivalents (DBE) of 0–7 were generally observed over the m/z range of 200–700.

Although there were a number of molecular formulas having H/C and O/C values similar to those of lignin over the wide m/z range in the HAs with a low degree of humification, most of lignin-like molecular formulas in the larger m/z range (450–650) or irrespective of m/z were lacking in the HAs with middle and high degrees of humifications, respectively. These observations suggested the longer residence time of lignin-phenol oligomers than longer residual lignin chains.

The number of the molecular formulas having H/C and O/C values similar to those of condensed aromatics increased with increasing degree of humification [i.e., with increasing both A_{600}/C and %aromatic C content and decreasing log (A_{400}/A_{600})]. The m/z and DBE values of condensed aromatics-like molecular formulas in the HAs with a lower degree of humification were, <500 and 10–25, respectively, whilst the ranges expanded to 600 and 30–33, respectively, in the highly-humified black HAs. KMD analysis using carboxyl groups as the characteristic functional group found that 31, 73, and 39 molecular formulas had chain-type, net-type, and biphenyl-type condensed aromatic acids as possible structures, respectively. Summed peak magnitudes of the condensed aromatics-like molecular formulas, in particular those with higher (>17) DBE values expected to have >4 rings, increased with increasing degree of humification, suggesting their contribution to the recalcitrance of the HAs in soil.

Keywords：*humic acids (HAs), FTICR-MS, condensed aromatics, degree of humification.*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

The Effect of Grazing Intensity on Soil C Response to Slurry and Urea Addition

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Slurry and urea are part of normal nutrient management on livestock farms utilizing grazed grass and silage. We hypothesized that history of grazing intensity would result in a different C response to slurry and urea application. We sampled three Irish grassland soils each with a long management history: (a) extensive grazing by horses; (b) medium intensity grazing by sheep and cattle, and grass silage conservation; and (c) intensive dairy grazing. There were three slurry treatments (S_0, no slurry; S_m, slurry mixed with soil; S_f, slurry added on the soil surface) and three urea treatments (N_0, no urea; N_1, urea added once; and N_3, urea added three times) designed to supply 36 g C m^{-2} and 2 g N m^{-2} during an 85 day incubation trial. Soil pH, total C, DOC, respiration and two C-related enzymes (β-glucosidase and CM-cellulase) were measured. All measured soil properties showed a significant difference among the three soils, indicating a strong influence of management history. For each soil, a greater change in total C and DOC with incubation time was observed with slurry compared to urea. The DOC:TC ratio increased with the slurry treatments and decreased with the urea treatments. There was a significant correlation between pH and DOC and TC. β-glucosidase and CM-cellulase activity showed a strong relationship with soil management history rather than with slurry or urea treatment. Soil respiration showed significant differences by management history, and increased significantly with slurry applied on the soil surface or with the multiple urea treatment. It was concluded that management history was important to C dynamics. Slurry addition was beneficial to the dissolved organic carbon fraction while urea might be regarded as detrimental. No obvious changes to the soil properties measured were identified with interactions of management history, slurry and urea addition treatments, confirming the important role of management history for C dynamics.

Keywords：*grazing, management history, slurry, urea*

P2-317

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Effect of Fertilizer Elements (CA, MG, and K) on Soil Organic Carbon Mineralization

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More than two to three times as much organic carbon is held in the soils as soil organic carbon (SOC) worldwide compared to the amount held in terrestrial biomass. SOC can therefore be regarded as a potentially important carbon (C) sink, mitigating global warming by sequestering C removed from the atmosphere by plants. Conversely, soils can be a source of CO_2 through biological oxidation of SOC. Because any net increase in soil CO_2 emissions, perhaps in response to environmental changes, can influence global climate, identification of the factors that influence soil respiration is critical in predicting ecosystems response to global change. Very limited information is available on the effect of fertilizer on biological oxidation of SOC to CO_2 termed SOC mineralization. The present study was undertaken to determine the effect of fertilizer elements (Mg, Ca, and K) on SOC mineralization in a short-term laboratory experiment. The soil sample (0-20cm) used for the study was sandy loam and had pH in water 5.5, organic carbon 20.2 g kg^{-1}, available P 15 mg kg^{-1}, total nitrogen 2.5 g kg^{-1}, and cation exchange capacity 7.50 cmol kg^{-1}. One hundred grams of the soil sample were weighed into incubation jars. The treatment comprised three fertilizer elements (Mg, Ca, and K) and four levels of application (0, 5.0, 10.0, 15.0 g kg^{-1}). Ten milliliters of each of the fertilizer elements in aqueous solution (prepared from the nitrates of the metals) containing the appropriate level of the fertilizer element were added to the soil sample in the jar. Each of the soils in the jar was treated with one fertilizer element of one concentration. The soils were watered to 80% field capacity and maintained at that moisture level throughout the experiment. The treatments were replicated three times. A plastic beaker containing 10 ml of 1.0 M was placed in each incubation jars. There were also three jars, without soil sample, each containing 10 ml of 1.0 M NaOH All the jars were properly labeled, tightly corked and placed on a laboratory table in a completely randomized design. At the end of every 7 days, the amount of CO_2-C liberated was determined by back-titrating the excess alkali against standard 1.0 M HCl solution. After each titration, each beaker was replenished with 10 ml of 1.0 M NaOH solution and returned into the jar. The experiment lasted for 28 days. All the rates of the fertilizer elements studied gave higher mean periodic CO_2-C than the control (no fertilizer). The mean Carbon dioxide-C liberated increased with increase in rate of fertilizer application for the three fertilizer elements studied. The rate of SOC mineralization was highest in the Mg^{2+} treated soils with a mean value of 235.75 mg carbon dioxide-Carbon kg^{+}soil day^{-1} followed jointly by Ca^{2+} and K^{+} each with a value of 228.75 mg Carbon dioxide-Carbon kg^{-1}soil day^{-1} and lastly by the control with a mean value of 153.0 mg Carbon dioxide-Carbon kg^{-1}soil day^{-1}. The first order kinetic model adequately described SOC mineralization in the control and fertilizer treated soils as evidenced by high correlation coefficient values that ranged from 0.847 to 0.9991. It was concluded that application of fertilizer (Mg, Ca and K) results to increase in SOC mineralization and hence liberation of carbon dioxide into the atmosphere.

Keywords : *fertilizer, calcium, magnesium, potassium soil, organic carbon, mineralization*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Distribution and Storage of SOC in Coastal Soil at Different Reclamation Ages

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Soil organic carbon (SOC) is a key indicator for assessing soil quality and plays an important role in increasing crop productivity. Estimating the change of its distribution and storage are important for evaluating global warming and improving SOC sequestration. In this study, SOC distribution at different reclamation ages ((a) 2004-2007, (b) 1995-2004, (c) 1955-1995, (d) 1024-1955 and (e) > 1024) and its storage in Dongtai city, Jiangsu province were evaluated. The results showed that the average SOC content at three soil depths in the study area is between 3.98-8.49 g kg^{-1} and followed the trend 0-10 cm >10-20 cm >20-40 cm. The coefficients of variation indicate a moderate variation in SOC content at each soil depth. The soil bulk density followed the opposite trend and was not very variable throughout the study area. The SOC content and density were affected by reclamation ages and followed the order >1024>1024-1955>1955-1995>1995-2004>2004-2007 reclamation ages. The SOC content under 1024-1955 and > 1024 reclamation ages were significantly higher than other reclamation ages. For each reclamation ages, the SOC content decreased with the increase of soil depth. And the difference of SOC content among reclamation ages became smaller with soil depth increasing. The SOC storage in the study area at 0-40 cm soil layer was 8.03×105 kg with a SOC density 3.07 kg m^{-2} .

Keywords：*soil organic carbon content , soil organic carbon density , storage and distribution, reclamation ages, coastal soil*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

C-Tool: Simple Soil Organic Carbon Model

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Soil organic matter (SOM) is one of the most fundamental contributors to soil quality. The main component of SOM is carbon (C) and SOM contains about three times more C than the atmosphere. Therefore, any small change in the amount of C in soil may affect carbon dioxide (CO2) concentrations in the atmosphere. The C-TOOL model has been developed to enable simulations of SOM turnover in well-drained mineral soils under agriculture and land management for estimating effects of management measures at medium to long time scales for the entire soil profile. A three-pool linked SOC model is applied for both the topsoil and subsoil using temperature dependent first order kinetics for describing decomposition. The simulation of C isotopes14C is facilitated in C-TOOL. Compared with many other SOC models, C-TOOL applies a less complicated structure, which facilitates easier calibration, and it requires only few inputs (i.e., average monthly air temperature, soil clay content, and C inputs to the soil from plants and other sources). The model was parameterized using SOC and radiocarbon data from nineteen selected long-term field treatments in United Kingdom, Sweden and Denmark. The results showed that the initial C content needed to be optimized for each treatment; however the same set of values for the other parameters can be used on all sites. The results from C-TOOL simulations showed a decline in soil organic carbon content in most soils under agricultural management noted in several studies in Europe, and also an increase in soil organic carbon in the treatments with high amount of C input and grassland. The model simulates SOC changes in both topsoil and subsoil. However, less data were available for evaluation of subsoil C from the long-term experiments applied. Future work should focus on further improving the estimation of C inputs, in particular root C input at different soil depth, as well as evaluating effects on subsoil C.

Keywords：*Soil organic carbon, modelling, C-TOOL, agriculture, management, grassland*

P2-320

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Inflence of Agricultural Land on Organic Carbon Distribution in Soil Aggregates Fractions in Ile-Ife, Southwestern Nigeria

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There is currently limited knowledge of which mechanisms are most important for C storage under different soils and land-use systems, yet such knowledge is crucial for devising systems with efficient C sequestration. This study is therefore aimed at evaluating the influence of land use type on soil organic carbon (SOC) distribution, SOC protection potentials of soil aggregate fractions and the relationships between SOC and the soil aggregate stability. In a study conducted at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria, soil samples from 0-15 cm and 15 ? 30 cm depths were collected under seven different land use types and dry sieved into aggregate size fractions of 1-2, 0.5-1, 0.25-0.5, 0.125-0.25, 0.05-0.125, and <0.05 mm. The organic matter and total N composition of each of the size fractions were analysed while the water stability of the macro-aggregate fractions (1-2, 0.5-1 and 0.25-0.5) were determined by wet sieving. The aggregate stability of the size fractions decreased with increase in aggregate size. The WSA was significantly ($P< 0.05$) positively correlated with SOC for each aggregate size, but less so at the lower depth indicating that the soils' water stability were mainly mediated by organic C. Soil tillage and cultivation reduced the soils' SOC. The consistently lower C:N ratio obtained in the fine particle size fractions may indicate lower decomposition rates, thus suggesting a measure of protection of SOC by the fine sized soil particles.

Keywords：*Soil aggregate fractions, soil carbon sequestration, water stable aggregates*

P2-321

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Architecture, Chemistry, and Mineralogy of Soil Aggregates and their Contribution to Soil Carbon Sequestration

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Chemical protection of soil organic carbon (SOC), due to adsorption of SOC onto mineral surfaces through different bonding mechanisms and chemical recalcitrance, protects SOC from decomposition. On the other hand differences in mineralogy, physical locations of organic carbon, and SOC and mineral distribution could result in differences in SOC protection and therefore, a differential response to global climate change. Overall objective of our research is to understand process-level physico-chemical mechanisms that control soil aggregate development and stabilization. Our research focusses on gathering information on how interactions between physical location, OC chemistry, and mineralogy of soil aggregate contributing to SOC sequestration. We are currently focusing on soil aggregates collected from two long-term field sites in temperate and tropical climates. They were under differing management practices (such as tillage, crop rotation, manure addition, and/or fertilization) led to different levels of aggregation, soil C, and microbial communities. We use new generation analytical techniques such as synchrotron based-STXM-NEXAFS, -XANES, and ?XRD, and 13C NMR as well as traditional wet chemical analysis such as iron/aluminum fractionation techniques to understand physical, chemical, and mineralogical mechanisms of C sequestration. Results will be presented with the emphasis that how interactions between aggregate architecture, mineralogy, and chemistry impact SOC protection in these studied soils. In summary, 13C NMR analysis showed differences in macromolecular C chemistry in high manure added plots. Amorphous Fe/Al and total organic C were correlated in some aggregate size fractions in temperate soils. X-ray spectromicroscopy indicated physical protection of organic C and N in soil aggregates by Fe minerals. This is an opportunity to further our understanding of soil aggregate structure, mineralogy, and carbon sequestration in soils, and the soils' vulnerability to climate change. Understanding the relative importance of chemical and mineralogical contribution for C stabilization is needed to develop process-based soil carbon models.

Keywords: *soil organic carbon, carbon sequestration, aggregates, NEXAFS-STXM, 13C NMR, management practices*

P2-322

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

The Intrinsic Energy of Soil Aggregates Affected by Soil Organic Matter

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Much is made of the link between soil organic matter and the formation of stable aggregates. Previous research has demonstrated that that the presence of organic matter can increase the stability of soil aggregates requiring more energy input for this disruption and dispersion. To study the link between soil aggregates and energy will involve the use of reconstituted clay soil collected from the field. Half the air-dried soil sampled was passed through a 2 mm sieve and stored, while the other half of the soil was then puddled to destroy most of the inherent soil macro- and microaggregates. The sieved and puddled soil was then incubated in pots housed in sealed containers for a period of up to 3 months. In addition to the controls three levels (1, 2, & 3% organic matter) of two types of organic matter (alfalfa; C:N 10:1, and ; barley straw C:N 50:1) where incubated in the soil. The change in soil organic carbon was assessed at days 14 and 28 of each month for the three months. Two vials of NaOH were placed in each of the sealed containers to capture the CO2 generated during the incubation which were sampled at 7,14,21 and 28 days of each month that the experiment was conducted over. Soil was sampled at the end of each of the three months and the change in aggregation was assessed using a combination of end-over-end shaking and wet sieving for 5 time periods for each sample. This enabled the dynamics of aggregate breakdown to be assessed by scaling the exponential curves fitted for each sample. From this samples were selected and the kinetics of breakdown assessed using ultrasonic agitation so that the energy consumed could be measured. We will show the dynamics of soil aggregate formation and will able to infer energy of aggregate formation. From the study, we will discuss how this information can provide strategies that produce more stable aggregates, and more protected soil carbon.

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

The Impact of Land Uses And Soil Management Practices on Soil Carbon in New South Wales, Australia

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This project aimed to identify land uses and soil management practices that have significant associations with soil organic carbon (SOC) stocks in south-eastern Australia. Redundancy analysis (RDA) was undertaken to explore the association between land uses, soil management, soil properties, environmental variables and the variation in stocks of SOC fractions [i.e. particulate organic carbon (POC), humic organic carbon (HUM) and resistant organic carbon (ROC)] across 780 sites in the state of New South Wales (NSW), Australia. Results indicated that soil properties, land uses, soil management and environmental variables together could explain 46.8% of total variation in stocks of the SOC fractions. Specifically, land uses and management practices together explained 7.2% of the total variation in SOC fractions, while the greater proportion of explainable variation was associated with soil properties and environmental variables. A forward selection RDA was also undertaken considering soil properties and environmental variables as covariates to assess the statistical significance of land uses and management practices on stocks of POC, HUM and ROC. We found that pasture had significant positive associations on stocks of SOC fractions. Using a novel multivariate technique, the current work identified the land uses and soil management that may have significant impacts on carbon stocks in soil after accounting for influences of soil properties and environmental variables.

Keywords：*Soil organic carbon, Particulate organic carbon, Humic organic carbon, Resistant organic carbon*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Change of Organic Carbon Content in Black Soil Under Long-Term Application of Chemical Fertilizers and Recycled Organic Manure

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Soil organic matter (SOM) is an important indicator for soil fertility, and agricultural practices may strongly affect SOM content and quality. A 28-year field experiment was established to examine the effect of chemical fertilizers and recycled organic manure on the contents of SOM in black soil. The field experiments included eight treatments: 1) control with no chemical fertilizer, CK, 2) recycled organic manure, ROM, 3) chemical fertilizer nitrogen (N) alone, 4) N + ROM, 5) chemical fertilizer nitrogen and phosphorous, NP, 6) NP + ROM, 7) chemical fertilizer nitrogen, phosphorous and potassium, NPK, and 8) NPK + ROM. Compares with the SOM content in 1985, the SOM did not change significantly, and decreased by 11.3%, 3.2% and 4.8% in CK, N and NP sites, respectively, but increased by 3.6% in NPK site, indicating that the SOM will not change significantly under stable rotation, tillage and fertilization managements, but will decrease with growing time, proper chemical fertilization with N, P, and K can facilitate the decrease in SOM. In the sites with recycled organic manure, the SOM increased by 2.6%, 3.7% and 7.4% in N + ROM, NP + ROM and NPK + ROM, respectively, and decreased by 4.8% in only ROM site, indicating the chemical fertilizer plus recycled organic manure can balance the SOM content. Other approaches are needed to increase the soil fertility, such as increasing organic carbon inputs, to improve the soil fertility. Compared with the data in 1985, in all eight treatments soil organic carbon in the humic acid fraction decreased by 5.0-13% and in fulvic acid decreased by 1.4-14%; however, with chemical fertilizers and ROM applied together, the rates of decrease were reduced. Overall, ROM is effective for increasing the content of SOM and thus, its different humic carbon fractions in black soil would help to maintain or increase soil fertility.

Keywords：*black soil, Chemical fertilizer, Recycled organic manure, Soil organic matter, Humic matter*

P2-325

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Long-Term Effects of Tillage, Crop Rotation and Fertilizer on Soil Organic Matter Quality Assessed by NMR Spectroscopy

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Crop and land management practices affect both the quality and quantity of soil organic matter (SOM), hence are driving forces for soil organic carbon (SOC) sequestration. The objective of this study was to assess the long-term effects of fertilization, crop rotation, and tillage practices on quality and quantity of SOC. We worked in an area of southern Norway where a soil fertility and crop rotation experiment was started in 1953 and another experiment on tillage practices in 1983. First experiment was 6-year crop rotations with cereals only and 2-year cereal and 4-year grass rotations with base fertilization and strong fertilization and the second experiment was autumn ploughed (conventional-till) and direct drilled plots (no-till). Soil samples at 0-10 and 10-30 cm depths were collected in autumn 2009. The SOC stock was calculated from SOC concentration and bulk density for each depth. The quality of SOC was determined by ^{13C} - CPMAS NMR spectroscopy for the 0-10 cm depth. No-till systems showed a significantly higher SOC stock than the conventional-till systems at both 0-10 cm and 10-30 cm depths during the 26 years of experimental period. However, the SOC stock did not differ significantly at any depth of fertilization and rotation experiment even after 56 years of experimental period. Notably SOM quality differed with tillage types, fertilizations and crop rotations. No-till systems showed abundance of O-Alkyl C while conventional-till systems showed abundance of Alkyl C, which suggests more advanced stage of SOM decomposition. Cereal only rotation and cereal-grass rotation apparently had similar abundance of O-Alkyl and Alkyl C but cereal-grass rotation receiving manure application showed more intense signal of O-Alkyl C than cereal only rotation.

Keywords：*Crop rotation, Fertilization, Soil organic carbon (SOC), Soil organic matter (SOM) quality, Tillage,*

P2-326

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Quantification of Aggregated Carbon by Using Mid and near Infrared Spectroscopic Techniques

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Soil organic matter is closely related to the formation and stabilisation of soil aggregates. To understand these relationships and mechanisms it is necessary to physically separate soil by fractionation procedures. However, these fractionation procedures are costly and time-consuming to perform. Over the past twenty years, near infrared (NIR) and mid infrared (MIR) techniques has showed rapid acquisition of soil data. Therefore, this study focuses on testing the efficacy of NIR and MIR spectra taken from whole soil to predict carbon in aggregate fractions and therefore avoiding traditional fractionation procedures. Forty five soil samples were collected from three major bioregions of New South Wales, Australia. Soil samples were wet sieved into aggregate-size fractions <63 μm, 63-250 μm and >250 μm. Aggregate fractions were dried at 40 0C. Fractions were weighed and calculated mass recoveries. Whole soil and aggregate fractions were ground in to 53μm and total carbon content was measured by Elementar CNS analyser. Carbon mass recoveries were calculated to evaluate the success of the fractionation procedure. Recoveries between 85% and 115% were obtained. Whole soils were scanned by Brucker Tensor37 spectrophotometer with spectral range from nm 2500- 25000 nm (MIR region) and 800-2500 nm^{-1} (NIR region). The relative mean square error (RMSE) and the R2 values were obtained from the training and test samples by using both Cubist and Partial Least Square (PLS) models. The correlation coefficient between measured and predicted aggregated carbon values varied between 0.86 to 0.90 with RMSE range from 0.009-0.019 of MIR spectra and 0.55-0.91 with RMSE range from 0.021-0.031 of NIR spectra. The results confirmed NIR and MIR spectroscopy techniques are appropriate tools to quantify carbon content of aggregate fractions thus avoiding traditional fractionation procedures and rapidly and efficiently yielding initial conditions for carbon turnover models

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Effect of Water Management during Early Growth Stage on Nitrogen Dynamics of Paddy Field

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Water and nitrogen (N) are two of the most important inputs in rice production. Many studies recommend continuous flooding for rice production. However, there have been an increasing number of studies that have found that other water saving management practices such as alternate wet-dry irrigation, shallow water depth, saturated soil culture and so on, enhanced the growth and yield of rice. On the other hand, water saving management produces the partially aerobic condition of soil. Under aerobic conditions, the NH4-N is oxidized to NO3-N and NO3-N moves to anaerobic parts, resulting denitrified. Therefore, fate of N in paddy field might be affected by water management. Soil ammonium N in all the paddy soils largely disappeared at the maximum tiller number stage. This fact is suggested that fertilizer, especially basal N recovery by rice plant or loss through nitrification-denitrification is affected by water management before maximum tiller number stage. Fate of fertilizer N, growth and yield of rice under water saving conditions is still unknown and found limited references. Therefore, this study was conducted to examine the impacts of different irrigation practices on N dynamics of rice during early and middle growth stage.

Materials and Methods

Field experiment was conducted at Takasaka, experimental farm of Yamagata University, Tsuruoka, Japan. The experiment consisted of 3 treatments with 3 replications mentioned in 2011 and 2012 as conventional irrigation system (Flooding), Shallow Water Depth (SWD) and Unsaturated. The doses of chemical fertilizers were 40:40:40=N:P2O5:K2O kgha-1 respectively applied as basal fertilizer. Ten kg N ha-1 as top-dressing N at panicle initiation stage was applied in both years. In each plot the area for 15N application was set up without basal fertilizer (-N plot). The wooden box (0.6m x 0.3m) was placed in ?N plot. Forty kg N ha-1 labelled with 3 atom % (15NH4)2SO4 were applied to wooden box. In Flooding, 0.05 to 0.06 m ponding water depth was maintained throughout the growing period. For SWD, 0.01-0.02 m ponding water depth was maintained from 20 DAT until middle growth stage. For Unsaturated, plots were kept saturated from 20 DAT up to vegetative stage. After vegetative stage, ponding water depth of 0.01-0.02 m was maintained until middle growth stage. Plant samples were taken from randomly selected 12 hills from each plot at 29, 36, 48, 59 and 80 DAT in 2011 and 36, 48, 57 and 74 DAT in 2012, respectively. Soil samples for determining amounts of exchangeable NH4-N were taken by plastic core in each plot at 20, 29 and 48 DAT in 2011 and 24, 36 and 48 DAT in 2012, respectively. Soil was extracted by 1M KCl solution and amount of NH4-N was estimated by distillation method. N content in plant was determined by Kjeldahl method. 15N plant samples were taken at maximum tillering and heading stage and analyzed by the mass spectrometer. Xylem exudation rate was measured in the year 2011, (42 and 80 DAT) and 2012, (39 and 79 DAT) respectively using the method of San-Oh et al. (2004).

Results

Ex. NH4-N was almost same among the treatments at DAT 20, 29 and 48 in 2011 while 24, 36 and 48 in 2012, respectively. SWD had consistently had the significantly higher amount of xylem exudation than Flooding and Unsaturated at heading stage. No

significant difference in above-ground biomass among treatments was observed in both years at maximum tillering stage. On the other hand, above-ground biomass in SWD was significantly higher than Flooding and Unsaturated at heading stage. At maximum tillering stage, N uptake was significantly lower in Flooding than SWD. The lower N uptake in Unsaturated and Flooding than SWD was recognized at heading stage and had statistically significant in SWD than Unsaturated and Flooding. At maximum tillering stage, basal recovery efficiency (RE) was higher in SWD than Unsaturated and Flooding, but not significant difference. At heading stage, across years, SWD consistently had the highest recovery efficiency and significantly higher than Flooding and Unsaturated. Across years, the top dressing recovery efficiency was higher in SWD than Unsaturated and Flooding.

Conclusion

The SWD and Unsaturated water management can maintain the fate of N fertilizer, the N use efficiency, and the growth of rice were not reduced compared to the Flooding water management.

Keywords：*Water-saving irrigation, shallow water depth, unsaturated, recovery efficiency*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Isotopic Characterization of Biomass Carbon Incorporation into Soil Aggregates

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Introduction：Soil aggregates is suitable places, where SOC could be preserved and humified. In this study, we hypothesize that SOC-aggregate interactions involve a two-way selective action. Protection of humic substances in aggregates varies with aggregate size and in turn causes the difference in constitution and structure of humic substances in different aggregate fractions. On the other hand, the differences in chemical properties of humic substance constituents determine the formation or restructuring and stability of each aggregate fraction. Such a two-way selective process is certainly subject to agricultural managements, such as fertilizer application, residual return, and tillage. Study on the dynamics of formation of humic acid (HA) and fulvic acid (FA) in water-stable aggregates from wheat residues might help clarify this selective mechanism and provide theoretical basis for enhancing carbon sequestration through recycled use of agricultural biomass resources.

Methods ：A Typic Hapludoll（Mollisol）was taken from the top soil layer (0-20 cm) in Gongzhuling City, Jilin Province, northeast China (43º31′ N, 124º49′ E),which has a loam texture (39.08% sand, 29.87% silt, and 31.05% clay) with SOC 10.91 g kg−1.14C-labelled wheat residues used in the incubation with a 14C specific activity of 3.70×103 kBq gC-1. The soil was incubated in the dark at 25oC and sampled for aggregates on the 60th, 180th and 360th days with triplicates. Water-stable aggregate was extracted on a set of sieves consisting of 2mm, 0.25mm and0.0 53mm sieves. Humic substances were extracted with 0.1 M mixture of NaOH. 14C activity (DPM) in 1 M NaOH solution (including 14CO2 trapped in NaOH, HA14C, and FA14C) was determined by liquid scintillation counting (Tri-carb2800) .

Results：The results demonstrate that addition of wheat residues to soil significantly enhanced SOC concentrations in soil aggregates at 25oC and under 70% of field capacity. The largest increase occurred with the 2-0.25mm aggregate fraction. The concentrations of newly formed HA14C and FA14C in >0.25mm macroaggregates were 57-90% and 60-84% more than those in <0.25mm microaggregates, respectively. Sequestrated SOC was found to change in chemistry. HA14C/FA14C ratio decreased in macroaggregates with incubation days, indicating that part of HA14C might degrade into FA14C due to less protection of macrostructure (with large pores) for SOC. This transformation of humic substances is consistent with Waksman's lignin theory. On the contrary, the HA14C/FA14C ratio in the silt/clay fraction (0.053mm) increased with incubation days, suggesting a slow SOC degradation due to strong surface adsorption or pore protection by microstructure. This result is consistent with Kononova's polyphenol theory. Overall, this study suggests that organic matter in macroaggregates are more easily transformed from large to small molecules than in microagregates and that macroaggregates play very important role in controlling the transformation of organic carbon.

Acknowledgements：This research was performed based on the China 973 Program (2011CB100503), National Natural Science Foundation of China (40971141), and National Science Foundation of the United States (CBET-1220731).

Keywords：*14C , Isotopic characterization, Soil Aggregates, Fulvic acid; Humic acid*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Geographical Distribution of Organic Carbon and its Relation with Soil Physical, Chemical Properties and Climate Condition of Hamedan Province, Iran

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The collection of measures to identify soil of an area can be included outlines of the soil properties; the scheme of classification based on standard systems, determination of soils borders on the map and explains their statues. Variability of soil properties in precision agriculture is the importance of possessing in order to achieve higher performance with better management, a thorough knowledge of the physicochemical characteristics of soil and nutrients critical level is necessary field. Due to lack of sufficient knowledge of the nutrient distribution in soils under cultivation, even with having the critical level of elements, accurate fertilizer recommendations would not be possible and in these condition, fertilizer advise will cause the lack of balance nutrients.For the project, Arable land layers were selected and with the aid of GPS devices, sampling was conducted at 2 km 2 km sampling grid in the lands of Hamedan province, in west of Iran, soil samples were taken from depth of 0 ? 30 cm and 30-year average rain, humidity and temperature throughout the province were investigated. then by ARC GIS and ARC VIW soft ware's grid sampling points set out, and values of soil texture, organic carbon, TNV, potassium and phosphorus were measured in the laboratory.Semivariograms for each variable were calculated and a suitable model based on minimum residual sum of square and maximum of R2 was fitted to semivariogram models. Also interpolation was conducted by 2 methods kriging and idw in order to estimate not taking samples points. Sand, silt, clay, TNV and potassium variables fallow Exponential model, organic carbon fallows spherical model and phosphorous fallows linear model and then maps were derived. According to the derived map, organic carbon didn't have particular order in the region. Condition of organic carbon in Hamedan soil is favorable. The results show that the excessive use of chemical fertilizers, lack of organic fertilizers application, the prevailing conditions in the area of calcareous soils with high pH which cause that soil productivity reduction, regardless of soil fertility status and risk factors that apply to the use of chemical fertilizers are unbalanced.

Keywords：*organic carbon, kriging, idw, half Modify*

P2-330

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Yasso07 and Rothc In Predicting the Changes in Soil Carbon in Abandoned Arable Land in Russia

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The collapse of socialism in former Soviet Union in early 1990's led to abandonment of large area of arable land. It is estimated that in Russia, Ukraine and Belarus approximately 50 million hectares of croplands were abandoned. Land-use change from cropland to grassland has been shown to increase carbon (C) in soils.

In this study we compared the results of two dynamic soil C models (Yasso07 and RothC) and carbon response function with soil C measurements in long term experiment in Pushchino in Moscow region. The experiment was established in 1980 to study the effect of land-use change from cropland to grassland on soil properties. Experiment was divided in four treatments according to fertilizing or mowing. The soil C content was determined in 1980, 1999 and 2004.

The soil C increased by about 1.5-1.8 fold during the study period, but the differences in soil C stock between treatments were not statistically significant. Both dynamic soil C models and carbon response functions predicted the overall change in soil C relatively well. Dynamic soil C models performed slightly better than carbon response function. Modeling efficiency of Yasso07, RothC and carbon response function were 0.60, 0.73 and 0.51, respectively. The models predicted the initial increase of 140-150 g C m-2 yr-1 during the first five years after conversion of cropland to grassland. After 20 years of abandonment the sequestration rate is about 40-50 g C m-2 yr-1. Abandoned soils therefore still act as a considerable C sink.

Keywords: *land use change, soil organic carbon, modeling, abandoned arable land*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Soil Chemical and Physical Properties with Rice Straw Management during Fallow Period

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Proper method and timing of incorporating farm biomass such as rice straw into the soil is vital to ensure soil organic matter (SOM) build-up. Two field experiments were conducted in two sites with different levels of soil organic matter (SOM) to determine the appropriate means of managing the biomass left after harvest of rice crops during fallow period. The effect of mowing rice stubbles and incorporation of rice straws left after harvest during the fallow period were determined. The effects of different land preparation method and fertilizer management were also assessed, based on the physical and chemical properties of the soil. In general, mowing of rice stubbles and methods of land preparation have no effect on carbonnitrogen (C:N) ratio of soil organic matter, bulk density, depth of mud, and on certain soil chemical properties. About 70% of the rice straw incorporated is composed of stubbles left after harvest and 30% from threshed rice straw. Increased C:N ratio 2 months before transplanting up to harvest time implies that the incorporated straw has not been thoroughly decomposed. Mineralizable or available nitrogen (N) tend to be lower with higher SOM level. This is due to the recalcitrant nature of SOM when conditions allow them to accumulate, such as under reduced condition in poorly drained soils. Additional inorganic N must be supplied even in soils with high SOM to offset immobilized N. The amount of straw to be incorporated and its respective N content are critical in SOM accumulation. Higher amount of straw incorporated resulted to higher SOM accumulation. Incorporation of 4-5 t ha-1 straw, which is equivalent to one season straw biomass production per hectare, was not enough to significantly change the level of SOM, as well as the physical and chemical properties of the soil. Nevertheless, continuous recycling and incorporation of rice straw in soil during fallow period may lead to the improvement of soil properties over the long-term.

Keywords：*carbon-nitrogen ratio, fallow period, immobilized nitrogen, mineralizable N, mowing, nitrogen, soil*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

The Fate of Soybean Photosynthetic Carbon Varies in Mollisols Differing in Organic Carbon

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Knowledge of the carbon (C) partitioning of plant photosynthetic C in soil C pools can elucidate the mechanisms of soil C sequestration as affected by plant-microbe interactions. However, the quantification of the photosynthesized C flow belowground and its contribution to soil C sequestration is limited.

Soybean [Glycine max (L.) Merr.] was grown in three Mollisols with low- (10.4 mg/g), medium- (29.0 mg/g) and high (50.5 mg/g) organic C contents, respectively. Plants were labelled with 13CO2 at the full-pod stage. Airtight glass chambers were used for the labelling procedure. The 13C recovery in plant, soil and microorganisms were quantified over time for up to 288 hours.

There was no significant difference ($P > 0.05$) on the total amount of 13C fixation by plants between the three soils. However, soil type significantly influenced the 13C dynamics in soil. The 13C recovery in soil organic matter (SOM) increased over time from 2.7 to 8.8% in the high-Corg soil, while it had non-significant change with an average of 2.8% in the medium-Corg soil, and decreased from 4.2% to 0.2% in the low-Corg soil. In the low-Corg soil, the proportion of 13C in soil microbes decreased markedly over time showing a fast turnover, and had a significant ($P \leq 0.01$) correlation with 13C in the SOM pool. However, no such relationship was found in the soil with high-Corg and clay.

These results indicate that soybean root exudates made a greater contribution to soil C sequestration in high- than low SOM soils. Most of the root-borne C was degraded by microbes in the low SOM soil. The greater contribution of photosynthesized C to the SOM pool in the high SOM soil was likely attributed to the SOM- and mineral-induced physical adsorption to preserve root-borne C degraded by microbes. Thus, decent contents of SOM and clay are essential to preserve the root-derived C in the SOM pool.

In order to confirm the mechanisms for this process, the spatial and chemical structures of SOM contributing to the soils' sorptive properties, as well as the nature of microbial species functioning in the turnover of the root-derived C need to be characterized.

Acknowledgements

The project is funded by the National Natural Science Foundation of China (41271261), Hundred Talents and Key Project by Chinese Academy of Sciences (KZZD-EW-TZ-16).

Keywords: *Mollisols; organic C; 13C labelling; Photosynthetic C;*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Effect of Heating on Biodegradation of Organic Horizons Developed on Permafrost Affected Soils in the Siberian Taiga Forest

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Organic horizons in the Siberian taiga forest have a significant role for heat insulation due to its thickness, resulting in preservation of the permafrost table. Besides this heat insulation, organic horizons contribute to substantial carbon pool in the taiga region, releasing dissolved organic carbon into active layers as persistent organic carbon through its sorption onto minerals. However large scale forest fires have often attached the Siberian taiga forest, probably decreasing the heat insulation and/or nutrient supply potential of the organic horizons. Ground temperature during forest fire is a key variable for changes in properties of organic horizons. Solutes release potential and biodegradability of organic horizons was evaluated in this study along with heating temperature gradient. To estimate the effect of forest fire on the biodegradation properties of organic horizons, we prepared organic horizon samples heated between 65ºC and 550ºC under a relatively oxygen limited atmospheric condition.

A sampling site locating in the Evenkia province in the central Siberia is occupied by Larch forest. The permafrost-affected soils developed in the Siberian Basaltic Province are classified as Oxyaquic Cryosols or Gelic Cambisols according to the WRB classification system (FAO, 1998). Beneath the soils, there is continuous permafrost with 200-300m thickness. The hydromorphic soil moisture due to preventing water drainage by permafrost table accompanied by low soil temperature promotes organic horizon thickening over 10cm. Samples were taken from organic horizons covering so-called hummock topography developed on the continuous permafrost. Air-dried samples were pulverized and mixed well by a blender. The powdered samples in a crucible with a lid were heated in a muffle furnace at 105, 250, 350, 450, and 550ºC for 15minites. Ash, solid C and N were determined after the heating. Biogenic elemental solutes released from the heated samples by saturating with pure water for 24 hours were determined by ICP-AES (ICPE-9000, Shimadzu Kyoto Japan), Ion-chromatography (Methorom, Hanau Switzerland), and TOC-L with total nitrogen module unit (Shimadzu, Kyoto Japan). Biodegradation was evaluated from mineralization rates being calculated using temporal changes in CO2 concentration during an incubation experiment and total organic carbon content in heated solid samples.

Solutes release from heated organic horizon samples by water saturation was different between samples depending on the heating temperature. Samples heated at 180ºC released the highest amount of solutes mainly dominated by dissolved organic C. Basic cations and major anions including phosphate, nitrate and chloride were also largely released from the sample heated at 180ºC. Higher the heating temperature was, solutes concentration was lower. Solution pH was higher with increasing the heating temperature. The ratios of carbon to nitrogen in solid samples were decreased with increasing the heating temperature.

Biodegradation was evaluated from a carbon mineralization process being calculated from exponential regression of CO2 release during the incubation experiment. The maximum mineralization (%) was approximately 4% of total C in samples heated at lower temperature below 180ºC. That was lower in the samples heated at the higher temperature and was below 1% in the samples heated over 350ºC. The mineralization rate was not largely different between samples, indicating that the biodegradation process in all heated samples mainly depends on the amounts of easily decomposable carbon source, such as DOC. There are significant correlations between the maximum mineralization rate and DOC or inorganic N. Solutes mainly consisting of nutrients and energy source for microorganisms can be a significant controlling factor for the biodegradation process of organic horizons. The difference in solutes composition and the biodegradation indicator were mainly depending on heating temperature of organic horizons. Heating temperature during a forest fire is an important parameter controlling the further degradation of organic matter in organic horizons and the fate of carbon dynamics in the boreal permafrost affected forest region.

Keywords：*taiga, forest fire, permafrost, organic horizon, biodegradation*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Impact of Land-Use on Soil Organic Carbon Composition and Quality of Black Soil in Northeast China: Characterization with Solid-State ^{13}C NMR Studies

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Land use can alter the chemical structure of carbon (C) in soil. To investigate detailed C changes derived from land uses was important for sustainable development of soil resources. In this study, all soil was sampled from three different lands in northeast China: uncultivated wetland, continue cultivated and abandon cultivated land. Series of solid-state ^{13}C NMR spectroscopy were used to characterize qualitatively and quantitatively the composition of soil organic C under the three lands. Although similar carbon function groups were present in all samples analyzed, an influence of land use change was evident. From uncultivated wetland to continue cultivated land, C loss was attributed to primary vegetation burning and subsequent cultivation. While from continue cultivated to abandon cultivated land, a recovery of C was probably for fallow and secondary vegetation succession. In terms of SOC composition, a minor decrease in aromatic and O-alkyl C and a parallel increase in carbonyl/carboxyl C arose in land-use translation of uncultivated wetland to continue cultivated land, but from continue cultivated to abandon cultivated land, the subsequent change induce a significant increase in aromatic C and a contrast decrease in alkyl, O-alkyl and carbonyl/ carboxyl C region. Our results indicated that long-term cultivation decreased C storage via alteration chemical structure to expedite retention of SOC, and abandon cultivation with vegetation restoration increased SOC content by delay C retention and litters decomposition.

Keywords：*Land use; SOC quality; SOC composition; Solid-state ^{13}C NMR spectroscopy*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Estimation of Carbon Stock in Acacia Mangium Stand in Sabah, Malaysia

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This study was aimed to estimate above and belowground carbon stock in Acacia mangium stands of different silvicultural system (planted and regeneration) at the Bengkoka Forest Plantation, Pitas, Sabah, Malaysia. This study quantified the above ground biomass (AGB) and below ground biomass(AGB), and soil organic carbon content (SOC) at depth of 30cm. A comparison is made between the two different silvicultural systems Acacia mangium. A random systematic sampling method was used for conducting the forest inventory. Two circular plots of 0.25 ha were established in each of the Acacia mangium. Diameter breast high (DBH) of every tree were taken by using diameter tape. Shrub layer and organic layer were taken at five randomly selected positions in each plot. Five litter fall traps (1m x 1m) were set up at the same position as the shrub and organic layer. Three holes (25 cm x 25 cm x 30 cm) were dug to get the roots for quantifying the roots biomass and carbon content. The soil bulk density was determined by using undisturbed soil samples that were collected by using 51 mm diameter ring (100 cc.). The result shows that the total amount of carbon stock was 73.56 t ha-1 and 82.40 t ha-1 for planted and regeneration stands respectively. This study found that the major contributor to total carbon stock for both planted and regeneration Acacia mangium stand was the aboveground 46.99 t ha-1 and 53.83 t ha-1 followed by below ground 26.57 t ha-1 and 28.57 t ha-1 respectively.

Keywords：*Acacia mangium, Above ground, carbon stock, soil organic carbon, organic layer*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Contribution of Microbial Biomass to the Formation of Soil Organic Matter

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Soil organic matter (SOM) plays an important role in soils, both for soil fertility and for the soil carbon cycle. The molecular imprint of the direct precursors of soil organic matter will determine the mineralisation, transformation and stabilisation of SOM. Recently, it has been shown that microbial biomass residues contribute significantly to the formation of SOM [1, 2]. Although living microorganisms only constitute about 1-2% of the carbon in soil, their contribution to SOM formation is much higher because of their rapid turnover. A high contribution of microbial residues to SOM can explain why microbial biomolecules are relatively stable in soil and even accumulate during SOM development, but also other chemical and physical properties of SOM such as the elemental composition and the water repellency. We studied the fate of microbial biomass residues in soils by incubating ^{13}C-labelled microorganisms in soil for up to 240 days. The microorganisms were selected to represent different types of microorganisms, each with its characteristic cell wall composition and included Escherichia coli (Gram-negative bacterium), Bacillus subtilis (Gram-positive bacterium) and Laccaria bicolor (ectomycorrhizal fungus). During incubation, we traced mineralisation, incorporation into biomass as detected by analysis of biomarkers (fatty acids, amino acids, proteins), and transformation to SOM of the labelled carbon. We also visualised microbial residues in soil samples by scanning electron microscopy. We found that the carbon from all types of biomass residues was partly mineralised, partly incorporated into microbial biomass, and partly transformed into non-living SOM. The partitioning between these three processes, however, was slightly different for the different biomass types. Over all treatments, 50-65% of the microbial biomass C remained in the soil during incubation. However, only a small part remained in the microbial biomass, the majority was transformed to SOM. In particular, proteins seemed to be rather stable in our experiments. Total amino acid contents did not decline during degradation, and quite a number of B. subtilis-derived proteins were conserved throughout the experiment. However, the biomass residue-derived carbon was also incorporated into other proteins which could be assigned to a wide variety of soil microorganisms, indicating that many different soil microorganisms thrive on the residues of other organisms. Scanning electron micrographs showed a low number of intact cells, but mainly fragments of about 200-500 nm size. Similar fragments were found in artificial groundwater microcosms where the only possible origin was microbial biomass residues, in particular cell wall fragments. These results indicate that microbial biomass residues, in particular cell wall fragments and proteins, are stabilised in soil and contribute significantly to SOM formation. The extent of this contribution is difficult to estimate as it depends on the residue material, on the degrading organisms and on the environmental conditions.

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Keywords：*soil organic matter, microbial biomass residues, carbon turnover*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Effects of the Different Microbial Communities on Humus Characteristics in a Black Soil Amended with Wheat Straw

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The formation and transformation of soil humus are significant to soil fertility, environmental protection and carbon sequestration. The microorganisms are ubiquitous in agricultural soil, which can function as a driving force and regulator of the formation, transformation, degradation and mineralization of humus. No doubt microbial activities are important to regulate the global C storage and cycle, especially the composition and characteristics of soil humus. Further, the microbial communities may also influence SOM (soil organic matter) chemistry since distinct microbial taxa may differ in their rates of C metabolism and the pools of C metabolized.

Black soil amended with wheat straw which is inoculated with soil-derived bacteria (B, Brevibacterium sp and Bacillus megaterium), actinomycetes (A, Streptosporangium sp and Streptomyces sp), fungi (F, Trichoderma viride、Penicillium and Aspergillus niger) and mixed strains (M) cultured 180 d in aerobic conditions. The objective of this article is to study the effects of different microbial communities on the formed process and composition of humic fractions in a Black soil amended with wheat straw. Application of wheat straw markedly could enhance the C contents of WSS (water soluble substance), FA (fulvic acid), HA (humic acid), Hu (humin) and prompt the molecular structures of FA or HA to a simplified direction.

Compared to CK, the inoculations of strains result in the reduction of TOC and WSS. The incubations are not only helpful to transform from FA to HA fraction and decompose Hu fraction of Black soil, in this process, the decomposed capacity of fungi is the most.

The strains tested can effectively simplify the FA molecules first because of the addition of wheat straw, and then they experience a series of aromatization and polycondensation later. Overall, all the FA molecules from inoculated treatments tend to be easier. HA extracted from the inoculated treatments undergo an oxidation process originally, but then a decomposed process. On the whole, the effects of bacteria and actinomyces are helpful to enhance their degrees of oxidation and condensation of HA, however the fungi and mixed strains play a key role in the degradation and decomposition of HA. At the end, the overall level of HA molecular structure from B, A, F and M treatments became more complicated, of which the role of bacteria is the most remarkably.

The change rule of CHA/CFA ratio means the polymerisation process mainly occurred in HA rather than FA. With the culture, the strains examined can transfer N, H contents from FA and HA to WSS. Due to the microbial activities, N-containing compounds of WSS and HA probably are increased, but which is utilized in FA. When the oxidation and polycondensation of WSS gets weakened, much more oxidized functional group and aromatic C–H detected in FA and HA.

This research was performed based on the financial support by National Basic Research Program of China (973 Program) (2011CB100503), National Natural Science Foundation of China (41171188).

Keywords：*microbial communities , humus characteristics, Black soil, wheat straw*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Variability in Carbon Dioxide Emission from Soil Grown to Wheat Crop in Kathmandu, Nepal

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Changes in farming practices could be an effective way to reduce carbon (CO2-C) emissions from agricultural lands thereby sequestering more carbon in the soil. A field experiment was conducted on an acidic silt loam upland soil of Kathmandu, Nepal during the dry season of 2011/2012. The study evaluated soil CO2-C emission from a wheat field as influenced by farming practices such as tillage, mulch, and nitrogen (N) application. The factorial experiment laid-out on a split-split plot design consisted of three replications of 12 treatment combinations, i.e., two types of tillage (zero and conventional) on a main-plot, two levels of mulch (zero and 4 Mg ha-1 of rice straw) on a sub-plot and three levels of N application (zero, 100 and 150 kg ha-1) on a sub-sub plot. The crop growing season in this region is relatively longer primarily due to the effects of low temperature and high elevation (1300 m above msl); therefore, wheat (var. WK-1204) planted on December 6 of 2011 matured in six months (harvest date June 2 of 2012). Wheat was planted @120 kg ha-1 on plots of 4m x 3m size. Major nutrients, viz., phosphorus and potassium were applied @50 kg ha-1 each, and nitrogen was applied as a treatment. The test crop received irrigation at the crown root initiation stage, maximum tillering stage; and heading stage.

A closed-chamber (25cm high and 20cm radius) technique was employed to collect CO2 gas samples inserting the iron channels 3 cm below the soil surface, and used CO2 monitor to estimate its concentrations (conc.) in the sample. Gas samples were collected from the chamber for initial 6 minutes at 10 different dates, keeping a constant time interval of 16 days until crop harvest. This interval is generally accepted for a single growing season measurement where rainfall and other factors, such as residue and soil disturbances, are minimal. The CO2-C conc. values obtained for each date were converted into the flux of C emission. Trend lines were then constructed for each factor's C fluxes separately within the growing season. The most efficient treatment in terms of C emission reduction was evaluated by separating C flux values for each date using least square difference (LSD) significant at 0.05 probability level.

Results showed that within the season variability in the CO2-C emission (mg m-2 hr-1) was high in all treatments, as indicated by mean values ranging between 123 and 264 on tillage plots, 89 and 306 on mulch plots, and 58 and 389 on N plots. Although not always significant ($p = 0.05$), zero tillage, no mulch, and lower rates of N application treatments were invariably superior in terms of reducing C emission relative to conventional tillage, mulched, and higher rates of N application treatments. Lower C emission may also imply that part of the applied carbon is sequestered in the soil and immobilized as microbial tissues. A closer observation of the trend lines revealed CO2-C emission spikes during the early growing stage and towards the maturation stage under tillage and mulch treatments. This was likely associated with the increased soil wetness due to irrigation and, or rainfall events preceding the CO2 gas sampling. The rates of N application from zero to 150 kg ha-1 in this study consistently maintained higher C emissions ($p = 0.01$) through all data collection dates until crop harvest, differing from the highest CO2-C emission seen in the early stage of treatment application observed by several incubation and field studies. In this short-term study, results were encouraging in terms of keeping the C emission lower, such as zero tillage, no mulch and lower N rate treatments; but some results still appeared inconsistent and complex. Therefore, extensive field experimentation of carbon decomposition is warranted to develop a better understanding of carbon dynamics in soil and in the environment.

Keywords: *carbon emission, climate change, Nepal soil, nitrogen application, residue, tillage*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Landscape Position Effect on Soil Organic Carbon of Three Evergreen Broad-Leaved Forests in Taiwan

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The objective of this article is to evaluate the influence of landscape positions on soil organic carbon (SOC) content at stand scale across three sites. This study focused on three sites at low elevations which are dominated by broad-leaved evergreen forests that have never been extensively logged or plowed. They are Fushan Forest Dynamics Plot (FS, 25-ha, 600-733 m asl), Lienhuachih Forest Dynamics Plot (LHC, 25-ha, 667-845 m asl), and Nanjenshan Transect Plot (NJS, 1-ha, 295-480 m asl) located in the northern, central and southern Taiwan, respectively. Electronic total-station theodolites were used for precise topographic measurements when these sites were set up, and all 3 sites were further divided into quadrats of 10 ×10 m (NJS) or 20 ×20 m (FS and LHC).

Tree species within each quadrat were surveyed and recorded, and soil properties such as pH, available N, Bray-1 P, base cations and micronutrient elements (DTPA-extractable Fe, Mn, Cu and Zn) in each quadrat of all sites have been analyzed. SOC content was determined by modified Walkley-Black method. We focused on the top 15 cm of soils because the topsoil is strongly influenced by climate, vegetation and organic matter, topography, soil constituents and surface processes. Soils were classified into Inceptisols (FS, LHC and NJS) and Ultisols (FS and NJS) at different landscape positions. Most soil with a pH lower than 5 indicated that intense weathering under the warm and humid climate condition of Taiwan. SOC contents were positively correlated with available N, base cations and micronutrient elements and negatively correlated with soil pH at all 3 sites.

The SOC contents of FS ranged from 34.0 to 160 g/kg in 0-5 cm soil layer and from 2.4 to 78.5 g/kg in 5-15 cm soil layer. There was not any significant difference among landscape positions, and the mean value of SOC content (0-5 cm) was summit (98.4 g/kg) ~ backslope (96.0 g/kg) ~ valley (87.5 g/kg) > flat region (82.8 g/kg) ~ river side (82.0 g/kg). The SOC contents of LHC were 6-150 g/kg in 0-5 cm soil layer and 11-70 g/kg in 5-15 cm soil layer. SOC contents were significantly higher in quadrats on the ridge (87 g/kg) than those of the slopes (65 g/kg) and gully (54 g/kg). The SOC contents of NJS were lowest among three plots, ranging 10.9-36.0 g/kg in 0-5 cm and 7.85-28.7 g/kg in 5-15 cm soil layer, and they differed significantly among landscape positions: summit (29.6 g/kg) > upper backslope (26.7 g/kg) > lower backslope (22.5 g/kg) > footslope (14.9 g/kg).

At stand scale, SOC content on high slope position was higher than that on lower slope position. Previous work in the FS Plot and NJS Plot indicated that the litterfall quality of dominant tree species at summit was less favorable for decomposition. Besides, intensive leaching at the flat summit positions leading to fine-textured soils which can hold more water; high soil moisture regime also decreased the litter decomposition rate. Soil and vegetation characteristics mentioned above may result in higher SOC content on summit position than those on lower slope positions. On the other hand, SOC may loss due to erosion at the backslope and

lower slope position such as footslope or valley region. The topography of LHC Plot is characterized by hills with valleys, steep slopes and ridges, with an average slope of 35.3°. It implied that soil layers as well as soil organic matter could be moved by water downward toward the streams in the LHC Plot.

In conclusion, despite of different site-specific factors (e.g. topographic parameters, vegetation, soil-specific factors) among three sites, SOC contents were relatively high on upper slope positions (summit or ridge) and decreased downward slope, indicating that landscape position is an important factor in determining the SOC content in the three broad-leaved evergreen forests at low elevations in Taiwan.

Keywords：*Landscape position; Low elevation; Soil organic carbon (SOC); Broad-leaved forest*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Composition and Properties of Density Fractions of Upper Horizons at Forest and Tundra Soils

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In recent studies methods of physical fractioning, using sodium polytungstate as heavy liquid, are used actively to investigate features of carbon pools (Grunewald et. al., 2006; Wiesmaeier et.al. 2012). It was showed that with the use of sodium polytungstate we can range organic matter according to its activity in biocycles and soil carbon lifetime. Also, it is possible to estimate regularities of fixation and stabilization of humic substances in soil. Soils of untouched northern landscapes are still one of the less investigated objects. That is why the aim of our work was to research features of densimetric fractions, separated from natural (without human impact) soils of taiga and tundra, followed by analysis of their chemical features and carbon content.

We selected reference soil pits from Subpolar Urals. Here the results of fractioning of upper genetic layers of four types of soils of the Subpolar Urals (Yugyd va national park): Entic Podzol (Turbic, Skeletic) (pit. 69-11), Stagnic Entic Podzol (Turbic, Skeletic) (pit. 1-10), Albic Podzol (Skeletic) (pit. 9-09) и Leptic Cambisol (Dystric) (pit. 54-10). The morphological characterization and physicochemical properties of the soils of the studied areas were described in detail earlier (Dymov et. al., 2013).

Densimetric fractionation was performed according to the methodological recommendations of (Grunewald et.al., 2006; Cerli et.al., 2012). The free OM fraction was separated using a sodium polytungstate with a density of 1.60 ± 0.03 g/cm3. The occluded OM was extracted with a polytungstate solution of the same density but after an ultrasonic treatment (150 J/cm3). The fractions bound to the mineral component were separated into the HF1 (density of 1.6–2.2 g/cm3) and HF2 (density >2.2 g/cm3) fractions. After the addition of polytungstate solution, the suspensions were shaken for 10 min and centrifuged at 10000 rpm for 20 min. Later on, the supernatant and the precipitate were separated. The obtained fractions were filtered off from the polytungstate through glass fiber filters (Macherey Nagel GF5, porosity of 0.4 μm; Macherey Nagel, Germany) using a Millipore system. The precipitate on the filter was washed with a small quantity of water, quantitatively transferred into porcelain cups, dried on a sand bath at about 60°C, and weighed. The particle size distribution of soil and densimetric fractions were analyzed by the laser diffractometer Analizette 22 (Fritch).

Content and properties of the densimetric fractions depend on conditions of soil formation and qualitative composition of the litterfall, involved in the biochemical cycle. Fractions with density > 1.60 g/cm3 dominate in the upper mineral layers of the investigated soils. The main soil carbon pool is concentrated in the fractions of free and occluded substances. Stagnic Entic Podzol have the largest content of fractions of free and occluded substances among all the investigated soils. Possibly, exactly these fractions determine an increase of the total carbon in the upper mineral layers of the soils, forming in semihygromorphic and similar tundra and taiga landscapes. It can be assumed that with warming climate organic substances of these fractions will be the main reason for increased CO2 emission. Content of fractions 1.6-2.2 g/cm3 is also important diagnostic feature. The content of this fraction increase in the illuvial layers of the investigated soils. Here we found the major contribution of silty and clay fractions comparing with soil and heavier densimetric fractions. The larges ferrum content was revealed on the surface of the fraction HF1. Generally, in the investigated soils hydrophobic properties of soil are determined by free and occluded organic matter. Soil carbon content determines an increase of hydrophobicity of the surface. These results are consistent with data obtained using 13-C NMR and hydrophobic interaction chromatography for humic substances extracted from soils of mountainous tundra and forest zone.

This study was supported by RFBR project № 13-04-00570a, project of Russian Federation President for young candidate of science MK-1027.2013.4 and program presidium RAS № 12-P-4-1018.

Keywords: *soil organic matter, densimetric fractionation, humic substances, hudrofobic properties*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Dynamics of Polysaccharides, Microbial Biomass and Humic Substances in Different Sources of Organic Matter

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Soil organic matter (SOM) is an important indicator of soil quality as it determines many soil characteristics such as nutrient mineralization, structural stability and water holding capacity. An understanding of different bio-chemical processes undergoing inside the conventional sources of organic matter, which are used for farm management regarding improvement of soil structure which rely on organic carbon input. Farm yard manure (FYM), poultry litter (PL) and municipal solid waste compost (MSWC) were characterized in an incubation experiment for six months in a completely randomized design (CRD). Organic matter fractionation, total organic carbon (TOC), total polysaccharide content (TPC) and microbial biomass carbon (MBC) were determined. Results showed that PL has significantly highest values in all of the parameters except humic acid as compared to other manures. Results as per days concerned showed that TOC, MBC, humic acid decreased with time, fulvic acid maintained its content throughout the period and TPC was significantly increasing with time. Interaction of manures and days showed that PL at 180 days had significant highest contents of TOC and TPC. MBC content and humic acid was significantly highest at 0 and 30 days, respectively. Fulvic acid was highest at 30, 120, 150 and 180 days by PL. Correlation analysis showed that TPC was positively and significantly correlated with fulvic acid (0.732), TOC was negatively correlated with humic acid (- 0.295) and positively correlated with MBC (0.668). It concludes that the PL is better among other manures under study regarding parameters which affect soil structure.

Keywords：*Humic acid, Microbial biomass carbon, Organic matter fractionation, Polysaccharides, Manures, Soil s*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Nutrient Dynamics and Carbon Sequestration in a Tropical Ultisol as Affected by Nitrogen Sources

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Organic manures and inorganic fertilizers are an important resource in sustainable and profitable crop production in the tropics. In addition, soil organic matter (SOM) has been implicated as an important sink for atmospheric carbon dioxide (CO2). Understanding the dynamics of plant nutrients and soil organic carbon (SOC) sequestration is important for addressing such issues as the fragility of tropical soils, their sustainability for production, global biogeochemical cycles and CO2 emission into the atmosphere. Field experiments were conducted at the Teaching and Research farm of Abia State University, Umudike, Nigeria, during the 2009 and 2010 cropping seasons to determine the effects of organic and inorganic nitrogen (N) sources on nutrient dynamics and carbon sequestration in a tropical ultisol in the rainforest agro-ecological zone of Nigeria. The experiment was a randomized complete block (RCB) design, with three replications. The N sources, each applied at the rate of 120 kg ha-1, were urea (UR), sawdust (SD), poultry dropping (PD), cow dung (CD), brewers' spent grains (BS), pig manure (PM) and a combination of all the organic N sources (CB). Over two cropping seasons, soil chemical properties sampled at 0 ? 10, 10 ? 20 and 20 ? 40 cm depths showed that addition of N sources increased soil pH, SOC and total N content and storage, available P, exchangeable cations, acidity and ECEC over the control (CT) with no N input. In the 0 ? 10 cm depth SOC content was of the order BS > CD > CT > PM > CB > PD > SD > UR. On the contrary, the UR treatment had distinctly highest N content and lowest C:N ratio, while the SD treatment had the highest C:N ratio. The PD, CD and BS treatments gave significantly highest increase in soil pH and ECEC over the other organic N sources. For most of the chemical properties, there were no significant differences between the UR and BS treatments. The BS treatment had the highest SOC content and storage (for the entire soil profile of the 0 ? 40 cm depth), while the UR treatment had the highest N content and storage. The SD treatment had the lowest SOC and N content and storage when compared with the other N sources. The combination of organic manures (CB treatment) did not improve the soil properties, SOC and N content and storage above the other organic N sources. In the 0 ? 10 cm depth, SOC storage (stock) related positively and significantly ($p < 0.05$) with soil pH, exchangeable acidity, ECEC and available P ($r = 0.866$, 0.722, 0.734 and 0.840) respectively. This relationship was also established for the 10 ? 20 and 20 ? 40 cm depths. Total N storage did not show any significant correlation with soil properties. Generally, application of N sources enhanced soil properties and carbon sequestration in the soil in the study area.

Keywords：*Nutrient dynamics, carbon sequestration, ultisol, nitrogen sources*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Distribution and Chemistry of Organo-Mineral Associations in an Andisol: Air-Drying and Sonication Effects

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Multiple types of organo-mineral associations co-exist in soil. Due to the variations in the types of minerals and organic matter as well as the mixing ratio of the two, soil particles show a wide range of densities. Sequential density separation method has been successful in distinguishing soil organo-mineral particles of different degrees of microbial alteration, turnover rate of C, mineral associations. A major methodological difference among the density separation studies is the choice of soil aggregate dispersion (mechanical shaking vs. ultrasound sonication). Aggregation can also be induced by air-drying, a common pretreatment of soil sample. The drying and sonication effects on the recovery of organo-mineral association may be quite severe for volcanic-ash soils (Andisols) that contain large amounts of orgnaic matter as well as reactive inorganic materials such as short-range-order (SRO) minerals and exchangeable aluminum.

We thus examined these two effects on the concentration and distribution of C, N and extractable phases of Fe and Al (by pyrophosphate and acid oxalate) across six density fractions (from <1.6 to >2.5 g/cm^3) using a surface-horizon of an allophanic Andisol. We also assessed these effects on the natural abundance of C-13 and N-15 as well as solid-state 13C-NMR spectra for the fractions from field-moist and sonicated samples.

Compared to field-moist sample, air-drying had little effects on the elemental concentration or distribution across the fractions. In contrast, sonication treatment at each density cutoff during fractionation led to significant changes. First, sonication liberated the low-density material (occluded light fraction) which had characteristically higher C:N ratio, higher delta C-13 and N-15, aromaticity as well as aliphaticity, compared to the light fraction without sonication.

Second, sonication led to the increase in the distribution of C, N, and metals in 2.0-2.3 g/cm^3 fraction, which was largely compensated by the reduction 1.8-2.0 g/cm^3 and 2.3-2.5 g/cm^3 particles. The sonication-induced redistribution of organic matter and the extractable metals were 15-20% of the total of respective elements. Regarless of the treatments, most of the materials were present in 2.0-2.3 g/cm^3 fraction – accounting for 49-70% of total C and N, and 51-74% of the extractable Al and Fe.

The sonication treatment did not change the general patterns of C-13 and N-15 enrichment and lowering of C:N ratio from low- to higher-density fractions. These results suggest that the organic matter in higher-density particles (thus greater mineral abundance) is more microbially-recycled. Thus, even after different degrees of aggregate disruption, sequential density separation approach appeared to be effective to assess the change in microbial alteration of organic matter and concurrent progression of organo-mineral associations.

Keywords：*soil organic matter, aggregate, organo-metal complex, 13C-NMR, 15N natural abundance*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Organic Carbon and Nitrogen Distribution in Water-Stable Aggregates of Cultivated and Non-Cultivated Soils of Southeastern Nigeria

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Cultivating bush-fallowed land using conventional tillage affects soil aggregates including their C and N content and distribution. Knowledge of the sensitivity of these soil quality indicators to land use change is crucial for the overall management of soil against degradation. A study was carried out on four different soils from four different locations. Soils were sampled at 0-30 cm depth in triplicates from cultivated and non-cultivated land uses at each location. The research objective was to compare differences in soil organic carbon (SOC) and total soil nitrogen (TSN) contents in five water-stable aggregate (WSA) classes at each site, which result from cultivating fallowed land. The soils were acidic and low in exchangeable cations. Land use reduced the Ca2+ content of the cultivated soils. The soils aggregate C contents were moderately low although greater than the aggregate TSN. Location influenced the SOC and TSN content in 0.50-1.00, 0.25-0.50 and < 0.25 mm WSA classes. The SOC and TSN in > 2.00 mm and 1.00-2.00 mm WSA are more stable than the other classes. The > 2.00 mm and 1.00-2.00 mm WSA of cultivated soils contained the greatest and lowest SOC content, respectively, while aggregate SOC decreased with decrease in WSA classes of non-cultivated soils. Aggregate TSN in both land uses increased with decrease in WSA classes. Aggregate SOC and TSN contents were equivalent in both land uses. Therefore, first season cultivation of a four-five year fallowed agricultural land does not reduce the aggregate associated SOC and TSN contents. Land fallowing is a possible means of enhancing C and N stabilization in WSA against adverse processes associated with cultivation.

Keywords：*Carbon, nitrogen, water-stable aggregate, land use, cultivation.*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Carbon Quantification in Forest Soils Using Low Resolution Laser-Induced Breakdown Spectroscopy

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The C cycle in the Brazilian forests is very important for issues related to climate changes. Assessing and understanding C dynamics in Amazonian soils can help scientists to improve models and anticipate scenarios. Development of new methods for soil C measurements in situ is crucial in this region due to the financial costs and times needed for collecting and sending soil samples from the forest to the research laboratory. Laser-induced breakdown spectroscopy (LIBS) is a type of atomic emission spectroscopy which uses a highly energetic laser pulse for the plasma production. In this technique sample preparation is typically minimized or unnecessary. Furthermore, LIBS is able to perform a simultaneous semi-quantitative and multi-element analysis in few seconds, thus allowing the monitoring and comprehensive analysis of soil in situ. In this study, the feasibility of a portable and low resolution LIBS system for the in situ quantitative analysis of soil C was investigated in two typical forest Brazilian soils, a Spodosol (Amazon Forest) and an Oxisol (Atlantic Forest). The intensities of LIBS C lines were analyzed in fifty-three soil samples. In particular, two C lines were evaluated, at 193.03 nm and 247.86 nm. The line at 247.86 nm showed a very strong interference with iron and titanium lines, which made impossible any quantitative analysis. The line at 193.03 nm showed interference by atomic and ionic aluminum emission lines, but the analytical conditions were better than those at 247 nm. To solve this problem a correction method was proposed and tested for the C line at 193.03 nm. A strong correlation was found between the C data measured by LIBS and those measured by the reference technique (CHN elemental analysis). The Pearson's coefficient value of R = 0.91 supported the efficiency of the used correction.

Keywords：*Carbon, Brazilian forest, LIBS*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Dissolved Organic Matter Load from Agricultural Soils

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Introduction

Increased dissolved organic carbon (DOC) concentrations in surface waters have been reported across Europe and North America. In lakes and rivers, allochtonic dissolved organic matter (DOM) load from agricultural soils changes water color and affects light penetration as well as primary production. Moreover, DOM is the largest source of C and energy for the secondary producers in the aquatic ecosystems and its degradation can increase oxygen consumption in the receiving waters thus contributing to oxygen depletion of the bottoms. The quantity and quality of allochtonic DOM loads entering the surface waters is affected by soil properties, precipitation, ecological processes and human activities such as land use. The data on the DOM load from agricultural soil is quite limited but some studies have reported increased DOC concentrations when there is high proportion of agricultural land in the catchment.

To maintain good soil structure and favourable biological activity of agricultural soil, farmers are subsidized for agricultural practices that mitigate the loss of organic matter or even increase organic C content in soil. On the other hand, increasing the soil organic C in agricultural soils may affect the export of nutrient rich DOM from soil to surface water.
In this study, the loss of DOC in surface runoff and tile drainage water is measured at two sites with different agricultural practices: (1) clay soil under ploughing or no-till and (2) sandy soil under organic or conventional cultivation. In no-till, while being an effective measure to reduce erosion, organic C tends to enrich in the surface soil. Organically cultivated fields, in turn, receive regular inputs of organic fertilizers which may gradually alter soil organic C pool. In this study, also the biodegradability of DOM load from ploughed and no-till soil is further investigated with an incubation study.

Material and methods

The experimental sites are fields located at Jokioinen (Southern Finland) with soil clay content of over 60% and a mean slope of 2.6% and at Toholampi (Central Ostrobothnia) with sandy soil and a mean slope of 0.5%. On clay soil, the management practices (with 2 plots/replicates of each) are conventional ploughing and no-till with spring cereal cultivation. On sandy soil the management practices (with 2 plots/replicates of each) are fertilization with organic manure (grass and cereals in the crop rotation) and fertilization with mineral fertilizers (only cereals in the crop rotation). For all management practices, quantity of both surface runoff and drainage flow are measured separately and DOC and nutrients are analyzed from the flow-weighted water samples.

The DOM pool that is biologically degradable will be estimated by incubating the samples with bacterial community in nutrient repleted conditions. This will be done in a 2 month incubation experiment with Baltic Sea bacteria by measuring DOC and nutrient concentrations, oxygen consumption and bacterial growth.

Results

During the first-year measurements, we could not distinguish clear management-induced differences in the total DOC load from the different agricultural fields. However, for all managements the DOC load correlated positively with the total discharge and there was also differences between the flow routes (surface runoff or drainage) between the treatments. The proportions of surface runoff were higher for no-till compared to ploughing (37- 44% vs 15-24%) and slightly higher for organic compared to conventional (13-17% vs 7-8%) The management practices increasing the surface runoff at the expense of tile drainage discharge increased also the proportion of surface runoff DOC load. First observations made in late spring indicated that the quality of DOC load may differ according to the flow route and preliminary results of the incubation study revealed high oxygen consumption in surface runoff.

Keywords：*DOM, lability, agricultural soil, discharge*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Soil Organic Carbon Content Under Different Plantation Crops of Different Ages in a Tropical Oxic Paleustalf

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Sequestration of atmospheric CO2 in the soil, as stable soil organic matter, provides a long lasting solution to decrease the CO2 in the atmosphere. A study was conducted to assess the organic carbon pool under young and old tree plantations at Uhonmora, Edo State, Nigeria which has wide variety of land uses and land cover. for proper cultural and soil fertility management of the plantations. The plantation species included Anacadium occidentales, Theobroma cacao and Coffea robusta. Soil samples were collected from each plantation using random sampling technique. The samples were analyzed using standard procedures for sand, silt, clay, pH (H2O), EC, total N, organic carbon (OC). Result showed that SOC pool was the maximum in the old cashew plots (45 years) and decreased in the following order SOC in young cocoa (1 year) > young coffee (6 years) > old cocoa (46 years) > young cashew (2 years) > old coffee (20 years). Results also indicated that differences in SOC pool under different plantation were statistically significant ($p \leq 0.05$). The A. Occidentals had 6.36g/kg soil organic carbon after 45 years in this region and had higher mitigation potential as it was found to store more than double SOC pool when compared to other plantations. The soils also vary in the N contents. The young cashew plot was low in N content but adequate for other plots. Using the SOC as indicator, the soil organic matter content needs to be improved upon for sustainable productivity. Soil texture in all the plantations was loamy sand except in the old coffee plot. Soil organic carbon content variation across the plantations with age of establishment will necessitates the need to produce a suitable habitat for microorganisms which are involved in litter degradation process. However, there was strong correlation between soil organic carbon and nitrogen ($r=0.9616$; $p \leq 0.05$) across the plantations. The regression analysis to predict soil organic carbon in any of the plantation showed that soil organic carbon content will continue to increase in the cashew plantation while that of coffee and cocoa will continue to decrease.

Keywords：*Soil organic carbon, plantation crops, soil fertility management, tropical oxic paleustalf*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Variation of Soil Organic Carbon Density Under Different Altitudinal Zones and Aspects in Eastern Himalayas

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Globally, high-altitude ecosystems are one of the main reservoirs of carbon and are potentially vulnerable to global warming and climate change impacts. To examine their roles in the global carbon cycle and potential feedback to global environmental change, it is important to understand the patterns and controls of SOC in montane ecosystems. In this paper, we investigated the variation of SOC density and their vertical distribution under different altitudinal zones (i.e. 1769-2500 m (Zone 1), 2501-3000 m (Zone 2), 3001-3500 m (Zone 3), 3501-4000 m (Zone 4) and > 4000 m (Zone 5)) and aspects (i.e. northern (316-45°), eastern (46-135°), southern (136-225°) and western (226-315°)) in montane ecosystems in the Eastern Himalayas. A total of 186 soil profile pits were described and sampled by natural horizons. An equal area spline profile function was applied to interpolate the horizon-based SOC contents onto the specified depths (i.e. 0-20, 20-40, 40-60, 60-80 and 80-100 cm). Our results revealed a significant influence of altitude and aspect on spatial variation of SOC density. Mean SOC densities invariably increased with altitude but only Zone 4 and 5 were significantly different from other zones at all depths. Mean SOC densities for the upper meter depth were 16.3 kg m^{-2} (Zone 1), 18.3 kg m^{-2} (Zone 2), 27.0 kg m^{-2}(Zone 3), 38.4 kg m^{-2} (Zone 4) and 32.0 kg m^{-2} (Zone 5). Furthermore, the mean SOC densities on the northern aspect were also significantly higher than other aspects. The mean SOC densities for the upper meter under different aspects were 20.9 kg m^{-2} (eastern), 27.1 kg m^{-2} (northern), 20.4 kg m^{-2} (western) and 16.4 kg m^{-2} (southern). As expected, the vertical distribution of SOC densities with depth exhibited a decreasing trend under all altitudinal zones and aspects. Under both altitudinal zones and aspects, the first two depth intervals (i.e. 0-20 and 20-40 cm) had significantly higher mean SOC densities compared to the last three depths. This may be due to limited SOC inputs and lower biopedoturbation in the deeper soil layers. Furthermore, the decrease in soil depth in high altitude soils (e.g. Zone 5) precludes them from having more SOC stocks despite their high SOC contents. This study is expected to contribute to filling the gaps in data and detailed knowledge about SOC in montane ecosystems.

Keywords：*Soil organic carbon, SOC density, altitudinal zone, aspect, Himalayas*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Effect of Land Use/ Land Cover Patterns on Particulate and Mineral-Associated Soil Organic Carbon Fractions in Himalayan Ecosystems

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The aboveground vegetation cover, which is the main source of soil organic carbon (SOC) input into the soil, is largely controlled by land use and land cover (LULC) types. LULC also determines the amount and type of SOC input from the above and belowground biomass, which inevitably affect soil carbon sequestration. Past studies have focused on investigating the impact of generalized LULC types on total SOC but not so much on different SOC fractions, which by far are more critical to sustainable agricultural production and environmental protection. In this study, we investigated the effect of higher-level LULC categories (i.e. Fir, mixed conifer, temperate broadleaf, blue pine, shrubs, grassland, paddy field, dryland and orchard) on particulate organic carbon (POC) and mineral-associated organic carbon (Humus) at specific depths in montane ecosystems of Bhutan, Eastern Himalayas. In addition, the spatial variability of SOC fractions under different climatic zones (i.e. warm, cool and cold temperate, subalpine and alpine) was also investigated. But first the conditioned Latin Hypercube Sampling procedure was used to determine 62 sampling sites covering all LULC types and climatic zones of the study area. Secondly at each sampling site, a soil profile was described and sampled by horizons. Thirdly, this was followed by fractionation of SOC in which soil samples (< 2mm) were dispersed and then fractionated using 53 μm sieve into > 53 μm fraction of POC + recalcitrant organic carbon (ROC) associated with POC (ROCPOC) + sand and <53 μm fraction of Humus + recalcitrant organic carbon (ROC) associated with Humus (ROCHUM). The horizon-based SOC fractions were interpolated onto specified depths using an equal area spline function. Our preliminary results indicate significant differences of POC + ROCPOC and Humus + ROCHUM between different LULC types and climatic zones at all depths. Thus, this study is anticipated to contribute to the huge gaps in detailed knowledge and database of SOC accounting in relation to landscape biogeochemical processes to better understand the impacts of land use and land cover change in the Himalayan region and its secondary effect on global warming.

Keywords：*Soil organic carbon, particulate organic carbon, humus, land use, land cover, Himalayas*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Impacts of SOC Change on Net Greenhouse Balance in Australian Wheat Cropping Systems

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Agricultural land use for crop production has led to significant decline in soil organic carbon (SOC). Reversing the trend of SOC decline by storing more carbon in the soil in form of soil organic matter (SOM) has been considered as one way of carbon sequestration. However, SOC increase has to rely on increased carbon input from high level of biomass production, which requires matching nitrogen input to meed crop N demand. Furthermore, high SOM content in soil also enables more carbon dioxide (CO2) release though SOC decomposition and more soluble carbon and nitrogen (N) released for nitrifiers and denitrifiers through mineralisation, which resulting in the increase CO2 and nitrous oxide (N2O) emissions from the system. In this study, we use the farming systems model APSIM to explore the SOC potentials under different N application rates and to estimate the N required for achieving the equilibrium SOC contents. We also investigate the optimal nitrogen application rates under various SOC levels and how these N rates, together with SOC level, impact on simulated N2O and CO2 emissions from soil in the Australian rain-fed wheat cropping systems. The results enable us to analyse the trade-offs between SOC increase and the required/subsequent changes in N fertiliser application in terms of greenhouse gas emissions from agricultural soil. These results also form the baseline data to estimate the global warming potential of fertiliser intensive farming systems.

Keywords：*APSIM, carbon sequestration, N2O emission, simulation*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

The Potential for Carbon Sequestration in Australian Agricultural Soils is Technically and Economically Limited

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Do Australian agricultural soils play a role in climate change process and mitigation by sequestering carbon? The net carbon exchange of agro-ecosystems depends on the balance between carbon gain (input of crop residues) and carbon loss (decomposition of soil organic matter). There has been an ongoing debate globally as to whether agricultural practices can increase soil carbon stock. Australian soils are much older when compared to many soils in the northern hemisphere. Nutrient deficiency, salt accumulation and undesirable climate conditions probably restrict the potential of soil carbon sequestration in Australia. However, a quantitative review on the effects of agricultural practices on soil carbon change in Australian cropping systems is lacking. In this meta-analysis, we investigated the effect of agricultural practices viz. zero or reduced tillage, residue incorporation, rotation history and nitrogen fertilizer application on soil carbon change in Australian cropping systems. The potential patterns of variation in the effects of agricultural practices were also assessed by including categorical variables in the meta-analysis models. These variables include soil depth, cropping duration, soil clay content, and geographic location. The objective of this study was to systematically synthesize and quantify the effects of agricultural practices on soil carbon change in Australia. The potential, if any, of agricultural management practices on the mitigation of greenhouse gas emissions from Australian cropping systems will be discussed.

Keywords：*Soil carbon sequestration, nitrogen, meta-analysis, mitigation of greenhouse gas emissions*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Variation of the Soil Organic Carbon Sub Pools in Eucalyptus Grandis Plantation Forests of Sri Lanka along a Chronosequence of Age

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Plantation forests have been identified as a huge sink of carbon which support in mitigating global climate change induced particularly by increasing rates of carbon dioxide emissions. Especially those plantations with fast growing species show direct influence on carbon sequestration by assimilating carbon in to plant biomass and directing them to forest soil. Many evidences suggest that soil organic carbon (SOC) content depends upon the stand age of the forest. However knowledge on the changes in the SOC content after afforestation and the dynamics of SOC sub pools along a chronosequence is very limited especially for tropical forest plantations such as Eucalyptus. This incomplete understanding of patterns of carbon allocation restricts the modelling of carbon sequestration by plantation forests. Therefore this study examined the changes in SOC sub pools associated with age of the plantation forests. We measured labile carbon fractions such as microbial biomass carbon (MBC), oxidizable carbon (OC), water soluble carbon (WSC), stabile carbon (SC) and total organic carbon (TOC) in two soil depths (0-15 cm and 15 -30 cm l) in Eucalyptus grandis plantation forests of different ages (5, 11, 20, 28 years), belonging to same agro ecological zone in Badulla, Sri Lanka. As all these sites were former Patana grasslands analysis was also carried out in an adjacent Patana grassland. Further soils of adjacent natural forest and a tea plantation were also analysed for the comparison of results.

Age of the plantation forest significantly affected ($P < 0.05$) MBC, OC, WSC, SC and TOC levels in soil. MBC, SC and TOC showed progressive increase with age while OC and WSC showed decrease in the 0-15 cm layer. Carbon sub pools showed the same pattern in the 15-30 cm layer except MBC, which decreased with age of the plantation forest. The increment of MBC content of the top layer of the 28 year old plantation was 2.02 kg/ha, than the 5 year old plantation. At the same time SC and TOC in that particular layer had increased in 8 % and 21 % respectively than the 5 year old. Compared with the Patana grassland TOC had shown 190 % increment designating the soil aggregation and structural stability which increase with age.

Interestingly the 28 year old site had more TOC (15.70 kg/ha) than the natural forest (5.86 kg/ha) and the tea estate (5.32 kg/ha) in the top layer. Although natural forest had highest amount of TOC (15.86 kg/ha) in the lower layer, oldest plantation forest also had a considerable amount of TOC (11.79 kg/ha) in that particular layer. Though OC and WSC decreased with age, they showed increment of 13 % and 174 % than the Patana grass land in the upper layer. Variation in density of understory vegetation which decreased with age, possibly could be the reason for above decrease, for these easily decomposable fractions are linked to the supply of organic residues. Additionally soil layer had affect significantly on WSC, SC and TOC content ($P < 0.05$). Furthermore there were interaction effect of plantation age and soil layer for all the carbon sub pools studied ($P = 0.000$ in all the cases).

Our study suggests that there is an increase in stabile carbon sub pools and MBC as forest plantations ages, revealing that their carbon sequestrating ability increase with age. Further afforestation with Eucalyptus is a virtuous land use change which supports in improving carbon sequestration, and mitigating climate change.

Keywords：*Microbial Biomass, Total organic carbon, Water soluble carbon, Oxidizable carbon, Stabile carbon, Eucalyptus grandis, Chronosequence*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

The Content and Reserves of Carbon in Frozen Soils of Boreal Forests of Yakutia

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It is well known that boreal forests of northeastern Eurasia play very important roles in global carbon turnover. Hence, the functional role of the organic matter in boreal forests of different territories is of great interest. This study investigated the content and reserves of the organic matter in mineral profile of frozen soils in boreal forests of Yakutia. Here we examined soils of three types of forests growing in the middle taiga zone: typical frozen pale soils of cowberry larch forests, frozen pale solodic soils of cowberry larch forests with mixture of pine and birch, and frozen taiga podzolized soils of lichen-bearberry pine forests located 40 km north of Yakutsk in the territory of Spasskaya Pad scientific forest station of the Institute for Biological Problems of Cryolithozone (IBPC SB RAS).

Most studies have been performed on typical sites of corresponding forest ecosystem. Based on the data collected by route surveys using satellite images we have earlier created large-scale soil map of the territory (Desyatkin et. al., 2006). The soil mapping covered the area of 5.53 km2 of the forest station. The reserves of organic carbon in soil layer were estimated using the formula: $Cs = C \times p \times h$, where Cs is the reserve of soil organic carbon (tones/ha), C – the content of carbon in soil layer (%), p – soil density (g/cm3), h – thickness of the soil layer (cm). The reserves of organic carbon estimated for certain soil types were multiplied by the area occupied by these soils.

The predominant soil type in larch forests is frozen pale solodic soils occupying 4.06 km2 or 73.2% of the studied territory. This soil type is characterized by extremely high content of organic carbon only within thin raw-humic horizon (13.7%) and by its low abundance (0.3%) in mineral horizons of the soil. The reserve of organic carbon within 1m thick soil layer equals to 95.5 tones/ha, which when multiplied by occupied area makes up total reserve of 39179 tones.

Typical frozen pale soils occasionally occur in lower parts of local depressions and occupy 0.84 km2 or 15.2% of the studied territory. Favorable watering conditions and loamy soil grading favor the accumulation of significant amount of carbon (0.6-0.8%) in mineral horizons as compared to solodic sabulous subtypes. The reserve of organic carbon within 1m thick layer of this soil type makes up 126.7 tones/ha, and its total reserve per occupying area is 10643 tones.

Frozen taiga podzolic sandy soils, developed on dry elevated under pine trees, occupy barely 0.5 km2 or 9.1% of the territory. Carbon reserve in this soil type is relatively poor and makes up 71.2 tones/ha, with total reserve per occupying territory of 3560 tones.

Fractionation studies of organic matter composition of frozen soils allowed us to estimate amounts of humic and fulvic acids. We also observed distinctive differences in reserves of humic acids carbon within 1 m thick soil layer. In frozen pale solodic soil the contribution of humic acids to total reserve of organic carbon is 19.0% or 18.3 tones/ha, while in typical pale soil and frozen taiga soil this percentage makes up 17.3% (22.4 tones/ha) and 9.9% (7.1 tones/ha) respectively. In general, fractional and group composition of soil organic matter is close and common for soils of these bioclimatic conditions. Differences in organic carbon accumulation levels in studied soils are related to watering conditions and grading of soils and pedogenic rocks. These data can be used for assessment of forest growth properties of soils as well as for attainment of carbon balance in boreal forests.

Keywords：*Yakutia, boreal forest, soils, carbon, humic and fulvic acids*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Modern Approaches to the Isolation and Characterisation of Soil Humin

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It is estimated that there are approximately 2344Gt of organic carbon (OC) in the top 3m of the world's soils, which is more than four times the living pool of OC on the earth's surface. Soil organic matter (SOM) can be separated into unaltered organic materials that include fresh and recent debris and transformed products, or humus that bears no morphological resemblance to the structures from which derived. The transformed products can be divided into amorphous, brown coloured humic substances (HSs), and into compounds belonging to recognisable classes such as saccharides, peptides, nucleic acids, altered lignin, etc. The humified products are commonly divided into fulvic acids (FAs), humic acids (HAs) and humin on the basis of their solubility (or lack thereof in the case of humin) in acidic and basic media.

Humin is the least understood of these fractions yet it is known to comprise 50% or more of the OC in mineral soils and more than 70% of that in lithified sediments. Thus it can be assumed that humin is the most abundant operationally definable class of organic substances in the environment, and the major contributor to the sequestration of OC. Despite the obvious importance of humin it has not been studied to the same extent as HAs, mainly because of its low solubility in the extractants commonly used to extract humic substances. At the same time, it has been assumed by many workers to be similar in composition and structure to the less soluble HAs. This is a view that we will challenge.

The emergence of new isolation and fractionation procedures, and above all else the availability of advanced analytical instrumentation has enabled us to focus in more detail on the compositions of the fractions of humified organic matter in the isolates from soil. Recent research suggests that the compositions of the SOM fractions that can be designated as humin are chemically different from humic and fulvic acids such that humins are not in fact HSs. Thus it is time to critically evaluate our concepts of the nature of humic components, and of humin in particular.

Significant advances have been made in studying the composition of humin by exhaustively extracting the base-soluble SOM, and then treating the residual soil or soil clays with HF or HCl/HF mixtures. The residual organic matter when subjected to dialysis and recovered by freeze drying was shown by NMR to be composed largely of aliphatic hydrocarbon materials.

The approach used has been to exhaustively extract the soil in a basic medium (0.1 M NaOH), followed by further exhaustive extraction in 0.1 M NaOH + 6 M urea. The residue is repeatedly extracted in dimethyl sulphoxide (DMSO) + 6% concentrated H2SO4 and the humin precipitated by the addition of H2O. The residual clay material is subjected to the HCl/HF treatment and the remaining associated organic matter that was not recovered in the DMSO-acid system is recovered following dialysis and freeze drying.

The use of two-dimensional (2D) NMR has allowed observations of molecules that are masked in the traditional 1D NMR experiments because of overlapping of signals, and our NMR data have helped resolve awareness of the molecular structures that become part of the long term C sink in soils. The recalcitrant organic C in the humin is mainly composed of aliphatic hydrocarbon materials that are resistant to, or are protected from degradation by microbial activity. Peptides and carbohydrates are also shown to be important contributors and are selectively preserved in the organic C sink. Lignin residues form only a small part of the humin. Detailed studies showed that the DMSO-acid treatment did not chemically alter the compositions of the isolates.

The highly ordered aliphatic hydrocarbon components in humin, (sometimes referred to as ‘crystalline’ methylene structures) resist swelling in DMSO, and represent the most rigid materials in humin. These highly aliphatic ‘polymethylene’ structures have strong association with the mineral colloids, and have a high resistance to microbial transformations. These aliphatic materials can have a significant role in the binding of hydrophobic contaminants. Most importantly, due to their inherent chemical and biological stability, they can play a major role in carbon sequestration and greenhouse gas mitigation.

Keywords：*Humin,Soil organic matter, characterisation, refractory C, carbon sequestration*

P2-355

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Analysis of Soil Organic Carbon and its Fractions in Biodiverse Environmental Plantings Using Mid-Infrared Spectroscopy

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In Australia, establishment of biodiverse environmental plantings (BEP) on farm lands is promoted for benefits such as shelter for livestock and crops, reduced soil erosion and soil salinity, wildlife corridors and biodiversity, and carbon sequestration in the biomass. Soil carbon sequestration may also be a potential benefit of the BEPs, but the effects of land-use change (i.e. from agricultural use) on soil carbon density is not certain (variously increases and decreases are reported), nor is the permanence of change. This research estimated and compared the changes in soil organic carbon (SOC) as total organic carbon (TOC) and biologically significant SOC fractions [particulate organic carbon (POC, 2000-50 μm), humus carbon (HUM, < 50 μm) and resistant organic carbon (ROC, < 2000 μm)] under BEPs and adjoining agricultural lands over time. Mid-infrared spectroscopic (MIRS) techniques were used to analyse and predict soil carbon (totals and fractions) in tandem with conventional analyses.

The BEPs comprising native eucalypt and acacia species were established 1991-2010 on land previously used for agriculture the Southern Tablelands of NSW. Soil samples from 0-5, 5-10, 10-20 and 20-30 cm depth increments were collected from 21 paired sites (BEPs and adjacent agricultural references) aged between 1 and 19 years. SOC was determined in all soils (n = 830) using the Heanes method, and also using Leco C analysis on a subset of soils (n = 96). Mid-infrared spectra were collected from finely ground soils (n = 830) ranging 7800 to 450 cm^{-1} @ 8 cm^{-1} resolution by co-adding the spectra for one minute. The SOC fractions were determined in BEP soils (n = 12, composites from 6 sites) by physical fractionation (> and < 50 μm) involving wet-sieving and C^{13} nuclear magnetic resonance spectroscopy. Mid-infrared spectra (6000-450 cm^{-1}) and partial least squares regression calibrations for TOC and SOC fractions were developed using measured data from current study and soils from Soil Carbon Research Program, Department of Agriculture, Fisheries and Forestry, Australia. Leave-one-out cross validations of these calibrations showed accurate predictions for TOC (R^2 = 0.97), POC (R^2 = 0.94), HUM (R^2 = 0.96), and ROC (R^2 = 0.90), which were used to predict TOC and SOC fractions for all soils (n = 830).

The relationship between samples analysed through Leco and Heanes C showed a strong correlation (R^2 = 0.90, P < 0.001). Heanes C calibration (R^2 = 0.95) from 75% of the 830 samples (n = 628) validated on a randomly selected set (n = 205) showed excellent predictions (R^2 = 0.95, SEP = 0.03). Principle component analysis of soil spectra could not differentiate soils from BEPs and agriculture; however differences in sites arising from soil mineral bands were noted. Although significant differences were not detected, average concentrations of TOC and SOC fractions were slightly higher in BEPs than agricultural soils at all depths (e.g., TOC - 42.3 and 39.2 g kg^{-1}, POC - 14.5 and 12.8 g kg^{-1}, HUM - 14.5 and 14.7 g kg^{-1}, and ROC - 10.81 and 9.39 g kg^{-1} under 0-5 cm depth in BEP and agricultural soil respectively. The BEPs aged 1-5 years showed SOC concentration (28 g kg^{-1}) similar to adjacent agricultural land (27.0 g kg^{-1}). By 11-15 years of age the SOC had increased in BEPs to 40.8 g kg^{-1}, however sites 16-19 years of age showed a decrease in SOC to 36.0 g kg^{-1}. These results suggest that SOC concentration gradually increases during the first 15 years following the establishment of BEPs, after which it appears to decline corresponding to decline in above ground biomass in the older trees, where tree mortality is apparent and the C:N ratio increases.

Keywords： *Biodiverse environmental plantings, Mid-infrared spectroscopy , Soil organic carbon, Heanes C, Total organic carbon, Particulate organic carbon, Humus carbon, Resistant organic carbon*

P2-356

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Water Budget and Short-Term Carbon Dynamics after Introducing Maize into a Paddy Rice Crop Rotation

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Due to aggravating water shortages and rising energy costs for irrigation, some rice farmers in south Asia switch to non-flooded crops -- such as maize in the dry season. This change from predominantly flooded to non-flooded fields has yet unknown consequences for the overall water budget as well as the carbon cycle. The objective of our study was two-fold, namely (i) to quantify the effect of the maize crop on leaching losses of water and dissolved organic carbon (DOC) and (ii) to assess a possible carry-over effect by the preceding maize crop on carbon allocation (assimilation, root exudation and rhizorespiration) by rice plants. To answer these questions we conducted a field experiment at the International Rice Research Institute (Philippines). The field design encompassed two cropping systems: double flooded rice (R-WET) and maize-flooded rice (M-MIX). For each cropping system we installed three freely-drained lysimeters and three PVC-rings. In each lysimeter two pairs of suction cups were installed in 13 cm and 60 cm below soil surface for sampling of soil water and monitoring the water budget; the sampling of bulk soil, rice shoots and roots as well as rhizosphere was performed in the PVC-rings. In each of these sub-trials, sampling was performed after a 13CO2 pulse labeling of rice plants in the wet season 2012. A similar pulse labeling experiment in the greenhouse served as additional control.

In 2012 we observed a continuous leaching of dissolved organic carbon (DOC) both in the M-MIX and R-WET cropping systems especially in the dry and fallow seasons. The shift from double cropping system of paddy rice to a rotation system of maize and paddy rice increased the water losses in the dry and wet season (including the fallow season) by 124 and 727 %, respectively. The higher water losses caused higher leaching losses of DOC, which amounted to 2.7 g DOC/m2 in the M-MIX and to 0.7 g DOC/m2 in the R-WET system within the time stated.

To understand whether also the plant C allocation itself was sensitive to the change in land management, we performed a pulse labeling with 13C (99 atom-%). In the field, the labeled 13C was immediately assimilated by the rice shoots (δshoots 13Cday1: 83.4 to 87.5 ‰ R-WET and M-MIX respectively) while only a small part was transferred to the rice roots (δroots 13Cday3: -15.5 ‰ to -17.7 ‰ R-WET and M-MIX respectively). The 13C signature of rhizosphere soil increased by up to 4 per mille (R-WET: -23.1‰ up to -19.1‰, M-MIX: -24.2‰ up to -19.3‰) in both crop managements. The 13C signature of bulk soil remained unaffected. We also could not trace the 13C signal in DOC of the field site under continuous rice cropping (R-WET: δ13CDOC = -27.2 ‰), while the δ13CDOC in 13 cm depth of M-MIX increased from -26.6 ‰ up to -20.0 ‰, but not in 60 cm depth.

In a supplementary greenhouse experiment, a continuous DO13C release until day 21 was observed, likely due to the suppression of DOC mineralization by sterilization of the rice roots and nutrient solutions. In contrast, we did trace the 13C signal in the dissolved inorganic carbon (DIC) fraction in both the field and greenhouse trials, and intriguingly, this signal was kept there for long (130 days in the field compared with 21 days in the greenhouse), likely reflecting the storage of 13CO2 from root respiration and oxidation of exudates within the HCO3- pool of soil water. Yet, these effects were not affected by maize as previous culture.

In summary, our data showed that cropping maize increased overall water losses after reflooding, i.e., C usually stored in soil solution was lost into the subsoil and groundwater, therewith significantly affecting the C budget of the two land-use systems. Rice roots released considerable amounts of C which was stored also in the form of HCO3- in the soil, independently as from the dry-season crop. The increase in δ13CDOC in 13 cm depth of M-MIX potentially indicated a stronger release and/or a slower degradation of carbon by the rice roots when grown in a crop rotation with maize.

Keywords: *Water budget, Rice-Maize, Carbon leaching, Isotopic labeling, Carbon allocation*

P2-357

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Interactions of Al(iii)/fe(iii) with Dissolved Soil Organic Molecules in an Acidic Environment

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Dissolved organic molecules (DOM) is passed through 0.45 μm filters from soil that the most mobile Soil organic matter (SOM) or humus fraction. It is able to bind a variety of compounds ranging from small charged compounds such as metals that modify the surface properties of the soil minerals and regulate indirectly the mobility and bioavailability of organic and inorganic contaminants. On the other hand, intimate associations of polyvalent metals (Fe, Al) with DOM may protect these organic molecules against biodegradation, influencing indirectly the biogeochemical carbon cycle in soils. In this study, DOMs derived from two peat soils of Changhua (CHA) and Yangminshan (YS) from Taiwan as influenced by specific multivalent cations, such as Al(III) and Fe(III) were examined in acidic environment (pH 3~6). Results show that formations of insoluble metal-DOM complexes with a higher metal/C ratio and acidic conditions may affect surface charges and increase particle size. CHA-DOM has highest amount of precipitate with Fe(III) at pH 3 but highest amount of precipitate with Al(III) at pH 4.5. However, YS-DOM has highest amount of precipitate with Fe(III)/Al(III) at pH 6. CHA-DOM has higher affinity than YS-DOM with Fe(III) and Al(III) resulting from limited binding sites in YS-DOM. FTIR shows that carboxyl and phenolic groups exist which indicate Fe(III)/Al(III) interact with DOM oxygen-containing groups. TEM and SEM images show two DOM structures were different that YS-DOM had many groups but CHA-DOM had many strips. However, two DOM-Fe complexes had lower domain size than two DOM-Al complexes. We predict Fe(III) ion could bind to DOM surface that produce Fe-core structures but Al(III) ion could produce polymers with DOM both them could alter DOM mobility and composition. Fe-XANES indicate that original YS-DOM was different with YS-DOM-Fe(III), CHA-DOM and CHA-DOM-Fe(III) that tend between Fe(II) and Fe(III). LCF also show that two DOM-Fe(III) complexes were resemble with organic acid-Fe complexes.

Keywords：*dissolved soil organic molecules, Fe(III), Al(III), complex, precipitate*

P2-358

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Stable Carbon Isotope Composition of Soil and Plant Under Pig Slurry Applications in Silty Loam Soil, SE Spain

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Pig slurry application on soil a common practice in Spain in last decades. However, there is limited information, pig slurry impact on soil and plant carbon dynamics. The use of the natural δ13C abundance technique to study the dynamics of soil organic matter turnover is limited to situations in which a previous, long-term vegetative cover or large amount of organic residues such as pig slurry, has been replaced by vegetation and pig slurry having a significantly different 13C isotope composition. The objective of this study was to investigate the long-term effects of pig slurry on the distribution stable carbon isotope ratio in a silty loam soil with cereal cultivation in the Southeast of the Spain, in order to elucidate the inherent mechanism by which SOC was recycled in the silty loam soil ecosystem.

Three different doses of PS: 170 kg N ha-1 yr-1, 340 kg N ha-1 yr-1 and, 510 kg N ha-1 yr-1, were applied and compared with a control in a non-irrigated Mediterranean environment. Pig slurry (PS) was adjusted to 170 kg N ha-1 yr-1 according to the legal rate of N-requirement accepted for Murcia region. There are distinct δ13C values of organic C: (i) soils were considerably enriched in δ13C values with D1 application; (ii) δ13C values were higher in second years application in the soil and plant; (iii) δ13C values of organic C was became lower with depth. Our stable isotope data have shown that the source of C in PS and plants is derived from organic matter. There is a high correlation between carbon isotopic values of organic carbon and pig slurry. This means that stable isotope composition os soil and plant are affected by pig slurry application; it is recommended that further silty loam soil studies should implement various management practices such as the type of cultivation, the rate of addition of manure and crop residues. Knowledge of these factors will promote our understanding of the dynamics of the SOC pools, their turnover rates, residue stabilization and the potential role of these systems to sequester C in the soil and promote long-term nutrient storage.

Keywords : δ 13C, Soil, Plant, Pig Slurry

P2-359

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Assessment of the Distribution of Organic Carbon in Soil Aggregates in Arenosols, Ferralsols and Gleysols Soils Under Different Cropping Systems

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The distribution of soil aggregates and the storage of organic carbon (C) are important parameters to evaluate of physical and chemical properties of soil. This study was carried out to aim at (i) assessing the ratios of different soil aggregates in the studied soils, (ii) investigating the distribution of organic C and the fractions of soil easily degradable organic C present in different soil aggregates and (iii) elucidating the role of soil aggregates in protecting soil organic C against microbial degradation. The study was done by separating soil aggregates (macro-aggregate, aggregate, micro-aggregate and silt-clay) through wet sieving fractionation procedure, analyzing the total contents of organic carbon presenting in different levels of soil aggregate and assessing the fractions of easily degradable organic C based on measuring the evolution of CO2-C through C mineralization. The total amounts of organic C present in different levels of soil aggregate were evaluated to reveal the role of soil aggregates in protecting organic C from soil microbial degradation. Soils were sampled from soil groups of Arenosols, Ferralsols and Gleysols located in Southern Vietnam and were under different cropping systems. Arenosols, Ferralsols soils were cultivated with black peper, whereas Gleysols soil was under rotation system of vegetables. The results showed that soils Arenosols and Ferralsols contain high proportion of aggregate (53 µm – 0.3 mm) and silt-clay (<53 µm) fractions. In Gleysols, the fraction of different soil aggregates were similar, whereas silt-clay fraction was high in proportion. Amongst the soils, Gleysols contained much more macro-aggregate and silt-clay fraction than those in the other soils. Analyzing organic C present in soil aggregates indicated that organic C mostly concentrated in silt-clay fraction of soils Arenosols and Ferralsols. However, the easily degradable organic C in this fraction was very low. In Gleysols soil, the distribution of organic C and its easily degradable fractions were similar in different levels of soil aggregate. In all three soils, the total content of organic C in silt-clay fractions was in the highest proportion. This revealed that the silt-clay fraction plays an important role in storage of soil organic C and protecting organic C from microbial mineralization processes.

Keywords：*soil aggregate, easily degradable organic C, Arenosols, Ferralsols, Gleysols*

P2-360

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Carbon Storage in the Urban Soils of Three Hungarian Cities

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The soil carbon stock has a very significant role in the global carbon cycle. In many ecosystems the carbon content of soils is higher, than what is stored in plants and this is typical for urban soils too. In order to investigate the carbon content of the soils we have collected samples from the upper layer of sampling sites in the city of Sopron, of Szombathely and Székesfehérvár. These cities can be characterised with a variety of geological conditions. The major part of Sopron city is in the Sopron-basin (calcareous alluvial), another part is located in the Sopron Mountains (consisting of polymetamorphic mica-schist and gneiss rock) and the rest of its territory is covered by neogene deposits. The east part of Székesfehérvár formed on granite bedrock while the greater part of city settled on loess. Most part of Szombathely city is located on gravel, clay river sediments. That is why there are significant differences in the land use. Samples were collected from soil spots from 0-10 and 10-20 cms depth as well as from soil profiles, where samples were taken from each of the profile layers.

First we selected the appropriate method for the measurement of the soil carbon content, as there are several possible methods for this. Carbon content cannot be determined in calcareous soils using the C/N/S apparatus, thus we used wet-burning methods with potassium-permanganate.

The highest average carbon content has been determined in the upper layer (in depth of 0-10 cm) in the urban soils of Sopron (4.6 % C) and lowest average carbon were in the lower layer on the area of Székesfehérvár (2.1 % C). Differences between carbon results can be explained by the effects of the vegetation and land use. Land use is also significantly determined by some ecological conditions.

Keywords：*Carbon storage, land use, GIS*

P2-361

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

The Effect of organic Fertilizers on Quality and Quantity of Soil Organic Carbon

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The effect of organic fertilizers on soil organic carbon was observed during the years 2010 and 2011 in the mountain range, in the Czech Republic. Experimental treatments were carried out in natural conditions of permanent grassland, soil type Cambisol. The experiment included two organic fertilizer types: slurry and compost with range of stocking rates 0.9, 1.4 and 2.0 LU/ha and control without fertilizer. Soil organic matter properties were determined as follows: water soluble carbon (Cws, mg/kg), hot water soluble carbon (Chws, mg/kg), oxidizable carbon content (Cox, %), humic acids content (HA, g/kg), fulvic acids content (FA, g/kg). Measured Cws values for slurry treatments varied from 183 to 350 mg/kg and for compost treatments varied from 176 to 332 mg/kg. Measured Chws values for slurry treatments varied from 462 to 759 mg/kg and for compost treatments varied from 474 to 876 mg/kg. The application of slurry and compost increased the amount of Cws, Chws and Cox. Furthermore, the greater stocking rate was, the greater amount of Chws was found. Greater amount of Chws and Cox were measured on compost treatments in comparison to slurry.

Acknowledgments - This study was financially supported by project INGO II LG13019.

Keywords：*Hot water soluble carbon, water soluble carbon, slurry, compost*

P2-362

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Exploring Relationships Between Environmental Parameters, Microbial Communities and Molecular Composition of Soluble Organic Matter in Soils at the Regional Scale

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Dissolved organic matter (DOM) is a key component for many biogeochemical processes in soil ecosystems, such as fresh organic matter incorporation and redistribution in soil horizons, or soil organic matter biodegradation and mineralisation. DOM is a complex mixture of organic molecules controlled by bio-physico-chemical processes, and its molecular characterisation is a primary objective for soil science and environmental biogeochemistry. Fourier transform-ion cyclotron resonance-mass spectrometry (FT-ICR-MS) is an instrument of choice for the molecular characterisation of natural organic matter, mainly because the ultra-high resolution of the mass spectra obtained permits the identification of thousands of organic compounds.

We conducted an integrated study at the scale of the Burgundy region (France) to determine the effects of soil characteristics on water-soluble organic matter (WSOM) quality. This work was conducted on 120 topsoil samples from the French Soil Quality Monitoring Network (RMQS). The Burgundy region is characterised by the diversity of its geology and land cover. The bedrock is composed of (i) magmatic and metamorphous rocks, (ii) calcareous sedimentary rocks and (iii) recent terrestrial sediments. The land cover is a mosaic of forest, cropland, and permanent grassland, in balanced proportions. The resulting combinations of land cover and geology lead to a great pedological diversity. Thus the Burgundy region appears to be a suitable study area to investigate the effects of environmental parameters on the molecular fingerprint of WSOM.

The WSOM fraction was extracted from the 120 soil samples, quantified and then characterised by UV spectrometry ($SUVA_{254}$), carbon isotopic signature ($\delta^{13}C$) and FT-ICR-MS. To investigate the relationships between WSOM molecular composition and microbial community, the structure of the bacterial communities was described by performing Bacterial-Automated Ribosomal Intergenic Spacer Analysis (B-ARISA).

Our results show that land cover and geology strongly influence WSOM molecular composition at the regional scale. The $\delta^{13}C$ values of WSOM revealed a clear distinction between grassland soils (-27.1 ± 0.1‰) and forest soils (-24.2 ± 0.2‰). In cropland soils, $\delta^{13}C$ values vary greatly (-25.8 ± 0.2‰), suggesting the influence of past land cover on WSOM composition. The $SUVA_{254}$ index of WSOM is correlated with the inverse of the total soil organic carbon concentration, underlining the higher aromaticity of organic molecules extracted from soils with low carbon concentration and low clay content, such as cropland soils and highly weathered soils. The WSOM originating from organic rich soils, such as forest soils and soils with a high clay content, is composed of low molecular weight organic compounds that are less aromatic, showing the enrichment in the hydrophilic organic fraction in these soil categories. FT-ICR-MS measurements allowed the identification of six thousand to ten thousand different masses in each

sample, with assigned molecular formulas giving an error lower than 0.2 ppm. The masses of these molecules range from 150 Da to 800 Da, corresponding to $C_{1-100}H_{1-\infty}O_{1-80}N_{0-2}S_{0-1}$ molecules. The formulas generated were validated by setting sensible chemical constraints (nitrogen rule, positive double bond equivalent, O/C ratio ≤ 1, H/C ratio ≤ 2.5) and by graphical analysis of the data in Van Krevelen diagrams (H/C vs O/C). The entire data set was then investigated by multivariate statistical methods (hierarchical clustering, principal component analysis and partial least squares) that revealed the respective influence of soil characteristics (land cover, geology, pH, texture, and $SUVA_{254}$) and their hierarchy on WSOM molecular composition. A clearly distinct WSOM molecular composition was found for forest soils. The differentiation of these samples into four subgroups corresponding to soils developed on calcareous rocks, residual formation with high concentration of exchangeable calcium, residual formation with low concentration of exchangeable calcium, and siliceous rocks revealed that geology was the second structuring factor for forest soils. The WSOM samples from grassland and cropland soils are more similar, and the classification of these samples is primarily influenced by the geology and the associated soil parameters (pH, texture) and secondly by the variable abundance of N and S heteroatoms in organic compounds. The groups of molecular formulas correlated with these structuring soil parameters (land cover, geology, pH, texture, $SUVA_{254}$ and bacterial community structure) and their chemical meanings were described and can now be presented. These results thus provide an ultra-fine description of the molecular composition of WSOM in soils, directly related to the characteristics of each type of soil.

Keywords：*Dissolved Organic Matter, Hierarchy of controlling parameters, Molecular characterisation, $\delta^{13}C$, Fourier Transform Mass Spectrometry*

P2-363

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Characterizing Soil Organic Matter: What Can Synchrotron-Based Approaches Reveal?

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Soil organic matter plays a critical role in sustainable crop production and serves as both a source and sink of carbon. The soil carbon pool is the largest terrestrial pool of C and thus net gains or losses of C from this pool have the potential to significantly influence atmospheric C levels. Despite the importance of SOM, the role of soil as either a carbon source or sink as our climate changes remains uncertain due, in part, to our incomplete knowledge of factors affecting the persistence of soil organic matter, and understanding of soil organic matter structure. As such, there is a need to describe differences in the molecular nature of soil organic matter that result from changes in environmental conditions. We used synchrotron-based C and N K-edge x-ray absorption near-edge structure (XANES) spectroscopy coupled with more traditional techniques to explore C and N chemistry among soils from different regions, landscape positions, and management regimes. Although some differences in chemical functionalities have been detected, soils from highly divergent locations frequently are remarkably similar. We explore the argument that the molecular structure of SOM is largely dependent on the degree of decomposition, and discuss implications for soil organic matter dynamics in a changing climate.

Keywords：*soil organic matter, N-XANES, C-XANES, decomposition*

P2-364

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

A Comparison of Extraction Procedures of Water-Extractable Organic Matter in Soils

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Dissolved organic matter (DOM) is the most active and mobile form of soil organic matter (SOM) and understanding its dynamics is crucial in order to better constrain the role of soils in the global C cycle. Studies of DOM concentrations and fluxes in soils are often conducted in laboratory experiments by characterising water-extractable organic matter (WEOM). However, many different extraction protocols have been used to extract WEOM from soil, making the inter-study comparison more complicated. Here we compared three WEOM extraction procedures: (i) pressurised hot-water extractable organic carbon (PH-WEOC), (ii) water extractable organic carbon (WEOC) and (iii) leaching extractable organic carbon (LEOC). The comparison of extraction procedures was conducted on the A horizons of five soil samples, selected by paying particular attention to texture, organic carbon content and parent material of soils. The extracted solutions were characterised for efficiency of organic carbon extraction, aromaticity ($SUVA_{254}$), potential biodegradability and 3D-fluorescence of WEOM.

PH-WEOC extraction saves a considerable amount of time and increases extracted OM yield. Therefore, smaller sample amounts are required for extraction and larger sample sets can be studied using this method.

Potential biodegradability was assessed during a 48-day incubation of WEOM with measurements of CO_2 concentration in the flask headspace. Dissolved organic carbon (DOC) mineralisation is adequately described when considering two pools of organic C with different decomposition rate constants: (i) a labile pool, readily decomposable and (ii) a more stable pool, relatively resistant to mineralisation. In our experiment, the labile pool accounted for 15.5 to 41.2 % of total DOC with a mean residence time comprised between 1 and 5 days. The stable pool, which accounted for 58.8 to 84.5 % of total DOC, had a mean residence time ranging from 23 to 137 days. A slightly greater proportion of stable DOC was extracted using the PH-WEOC method but no significant differences between methods were detected for the mineralisation rate constants of stable and labile pools.

Fluorescence Excitation-Emission Matrices (FEEMs) were submitted to a PARAFAC analysis in order to obtain the fluorescent components present in solution and their relative contribution to total fluorescence using the Alternating Least Square algorithm (ALS)

of the 'N-way toolbox for MATLAB'. In this study, a three-component model explaining 98.86% of the FEEMs variance and giving a CORCONDIA score of 81.67% was selected as the appropriate PARAFAC model. Component 1 and 2 were composed of two non-separated peaks with two excitation spectral peaks and a single emission spectral peak. The first peak of component 1 had a wavelength domain of about 330/410–460, while the second had a wavelength domain of about 260/390–480 and were respectively attributed to type C and type A humic-like compounds. Component 2 had a wavelength domain characteristic of terrestrial humic-like compounds and showed longer wavelength domains for excitation and emission than component 1 (Figure 2).

The red shift in this region may result from a higher content in aromatic and high molecular weight humic materials as a consequence of more advanced maturation of organic molecules. Component 3 had a wavelength domain of about 275/330–360 and is attributed to peak T, tryptophan-like fluorophore. The effect of soil type was major for all the fluorescence components. In contrast, the effect of extraction procedure was less discriminant and the two most similar methods were PH-WEOC and WEOC, while LEOC was characterised by higher proportions of humic-like fluorophores.

To summarize, the DOC pools differed in potential biodegradability among the five soils but only slightly among the three extraction procedures for a given soil. The PH-WEOC method is thus relevant to assess the potential biodegradability of DOM in soils. Spectroscopic investigations revealed clear differences in DOM fluorescence properties for the solutions extracted from the five soil samples, but the extraction method used in this study did not greatly modify DOM fluorescence properties. The three extraction methods produce solutions composed of the same fluorophores, present in similar proportions. Therefore, in addition to presenting advantages in terms of time and reproducibility, the PH-WEOC method does not alter the information about DOM quality obtained in fluorescence studies and can thus be considered a relevant approach to explore WEOM properties in soil samples.

Keywords：*Water soluble organic carbon, 3D-Fluorescence, Biodegradation experiment*

P2-365

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Soil Organic Carbon Fractionation in Protected Natural Reserves under a Mediterranean Climate

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Soil organic carbon fractionation is useful for distinguishing specific C pools responsive to management, identifying the physical control of soil organic matter (SOM) and characterizing the relationship between SOM and particle size distribution.

Soil samples were collected from six different natural reserves in Jordan: Ajloun, Dibbeen, Shaumari, Dhana,Yarmook, and Mujeb. These reserves are located in different climatic zones in Jordan; each receives different amount of rainfall. They have contrasting topography and landscape formation. Ajloun and Dibbeen are located in the highlands of Jordan and receive the highest rainfall (400-600 mm), while Shaumari receives the least rainfall (90 mm) and it is located in the eastern Jordan desert. Dhana and Mujeb reserves are located in south Jordan and are very mountainous areas characterized by high variation in elevation (100-1500 m) and (450-900 m), respectively. Five soil samples were collected from each reserve to represent the topography and vegetation cover variation in the reserve. Density fractionation and particle size analysis were used to assess the variation in different fractions of SOC and to identify the major factors that contribute to this variation in the collected samples. The Free Light Fraction (FLF), the Intra Aggregate Fraction (IAF), and Heavy Fraction (HF) were measured. The FLF and IAF fractions of SOC were separated and measured using 1.6 g mL-1 sodium iodide solution by centrifugation and sonication. The HF was measured using wet sieving for the particle size analysis (200, 53, 2 μm). Data were statistically analyzed using Excel pivoting table.

The results showed that The mass of light fraction increased with the increase in vegetation cover and with the increase in rainfall area as in Ajloun,Debbin. It was also high in Shaumari because it is a flat fenced area which led to increased vegetative cover. The FLF was significantly lower in reserves with steep slopes like Dhana and Mujeb. The proportion of each of the different SOC fractions as a percent of the total SOC was extremely variable. The amount of the FLF varied from around 1% to over 70% of SOC. The IAF varied from less than 1% to about 30% of the total SOC. This reflects how much are the different fractions related to the climatic, topographic, and land cover conditions.

Keywords：*Soil organic carbon, Fractionation, Natural Reserves, Meditrranean climate*

P2-366

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Changes in Soil Carbon and Root Distribution With Depth in a Chronosequence of Perennial Pastures in South-Western Australia

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Replacement of native vegetation with annual vegetation and pastures has been shown to increase the risk of land degradation in south-western Australia, where soils in this region are generally characterized by a high degree of weathering, low fertility, and low organic matter content. Since land degradation including soil erosion, soil acidification and soil compaction is a major constraint to sustainable agriculture, priority actions have been needed to manage the soils effectively. For this purpose, perennial grass pastures have been introduced into farming systems to identify an acceptable balance between agricultural productions with environmental effects for sustainable agriculture systems. Along with the benefits for out-of-season green feed and increased production, perennial grass pastures are predicted to aid soil environmentally functioned (e.g. increase water use, reduce deep drainage to ground and reduce risk of soil erosion). In addition to this, due to the deeper developed root systems of perennial grass pastures, which have a potential to contribute more organic material returned to the soil, there has been increasing interest in the possible role of perennial grass pastures for mitigating climate change through soil carbon sequestration.

Hence it is critical to identify the long term impact of perennial grass pasture on soil carbon storage. Investigation of how the duration of the perennial grass pasture affects soil carbon storage as well as how soil carbon accumulation rates differ throughout the soil profile with respect to root development are essential. Nevertheless, sampling issues including depth of sampling and frequency of sampling have been raised in various studies when assessing soil carbon storage in agricultural land. To address these issues and to overcome experimental limitations of increasing variability of soil carbon storage, a chronosequence of perennial grass pastures was surveyed to investigate soil carbon storage in conjunction with root development.

The aim of this study was to clarify the potential role of perennial grass pastures in soil carbon storage by evaluating how the duration of pasture establishment influences soil carbon storage in respect to root distribution with soil depth.

Total soil carbon and root mass were assessed in a chronosequence of perennial grass pastures established for 1, 5, 7 and 9 years. Although a range of perennial grasses has been established in these pastures, sampling in this study was restricted to tall wheat grass. Soil samples were collected from 4 randomly selected plots in each pasture. In each plot, soils from at least 7 randomly located cores under tall wheat grass from 3 soil depths (0-10, 10-20 and 20-30 cm) were collected and bulked. Root samples were collected from soil samples at 3 soil depths (0-10, 10-20 and 20-30 cm).

There was a trend that total soil carbon increases with perennial pasture age. The total soil carbon in the oldest pasture (9 years

since the establishment) was 18.2 t/ha (0-30 cm) which was significantly higher than total soil carbon in the other pastures ($P < 0.001$). Two-sided correlation analysis showed that total soil carbon was strongly correlated with root mass ($P < 0.001$) which indicated that root development strongly effected soil carbon storage in these perennial grass pastures.
Total soil carbon was localised in the surface soil depth (0-10 cm) ($P < 0.001$) and corresponded with the distribution of root mass ($P < 0.001$). Although the value of root mass and its corresponding total soil carbon were higher in the surface soil depth (0-10 cm) than the deeper soil depth (10-30 cm), the regression analysis showed that both soil depths had similar significant increase in total soil carbon with root mass.

These findings indicated that perennial grass pastures have a potential to increase soil carbon storage associated with root development. In addition to other predictable carbon sources such as shoot residues and animal manure, large root mass in the surface soil (0-10 cm) was likely to be the major factor contributing to total soil carbon. Moreover, our results suggested that root mass, consequently total soil carbon increase with the perennial grass pasture age at all varying soil depths.

Keywords：*soil carbon, root distribution, chronosequence, perennial pasture*

P2-367

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Determination of Soil Carbon at the Microaggregate Scale Using a Combination of Hyperspectral and X-Ray Fluorescence Imaging Techniques

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Future EU policy on agriculture will utilize soil carbon (C) to offset carbon dioxide emission by C sequestration. However, a consistent picture of existing agricultural soil C stock (Lugato et al., 2013), soil carbon storage potential (Stewart et al., 2007) and an understanding of how secure C is once sequestered (Stamati et al., 2013; Six et al., 2002) is lacking and will need to be resolved before soil C management policy can be developed. Part of the problem is that conventional soil sampling and C analysis of macro samples, collected at standard 10 cm depths or similar characteristic soil horizon intervals, miss much of the inherent soil variability. In terms of soil imaging, there is a knowledge gap at the soil profile scale (Lorenz and Lal, 2005), thus failing to adequately link what is known about soil C at the sub-micron to larger scales. The objective of this research was to develop methods that will facilitate understanding of the role of small-scale spatial organization of soil organic carbon with respect to the long-term security of the abiotic carbon store. A tool will be developed to determine soil C at the microaggregate scale to map C distribution in the soil profile. The technology being used is laboratory based hyperspectral imaging, which combines imaging and spectroscopy to extract intrinsic chemical information from a sample. Hyperspectral imaging rapidly collects thousands of spectra, making it possible to detect spectral properties for each pixel in an image. Typically, developing a calibrated model to predict C involves selecting a proportion of the sample with a region of interest tool to acquire the 'average spectra'. The spectrum of the selected pixels is then related to macro-scale properties of the sample. Once a prediction model has been developed for a population of samples, it can be used to map the concentrations of the property of interest on a pixel-by pixel basis. Due to the heterogeneous composition of soil, referencing spectral data with C values determined for macro samples may not be optimal. Here, a second technology, X-ray fluorescence (XRF) core scanning, is being investigated to determine if soil C can be predicted from XRF spectra to provide reference soil C values at a similar pixel scale to that in hyperspectral imaging. Following model calibration with C values determined at different scales (10 cm, 1 cm and 200 μm soil depth intervals), the accuracy of predicted C in soil profiles will be assessed for a range of Irish grassland soils (Cambisols, Podzols and Gleysols).

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Keywords: *soil carbon, hyperspectral imaging*

P2-368

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Organic Carbon Content and Quality among Soil Particle Size Fractions Down the Profiles under Native Woodland, Native Pastures and Cultivation in Northern New South Wales Australia

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The extent and degree to which soil organic carbon is bound to soil mineral particles (clay and silt) has implications for long-term soil organic carbon (SOC) stability and storage. We isolated soil organic matter into two fractions namely particulate organic matter (POM) and mineral-associated organic matter (MOM) and determined the quantities of carbon and nitrogen associated with the two fractions in soil profiles (0-80 cm) of native woodland, native pastures and cultivation. The quantity and quality of SOC differed between the two fractions. Strong and significant land use by soil depth interactions were found for particulate organic carbon (POC) and mineral-associated organic carbon (MOC) concentrations. Native woodland soils were associated with consistently wider C:N ratios in the POM fraction throughout the soil profile compared with native pastures and cultivation which differed between each other in the 50 cm. The result indicated differences in the quality of organic matter inputs (litter) entering the POM fraction with native woodland soils associated with less easily decomposed inputs due to their inherent chemical composition. Consequently, native woodland showed the least decline in POC with soil depth compared with the other two land uses. The proportion of MOC to the total SOC increased with soil depth indicating that subsurface C was more protected than surface C probably due to mineral association with clayey subsoils. Compared with native pastures and cultivation which were largely similar, native woodland soils contained significantly larger amounts of MOC in all soil depths suggesting that C was more physically protected from microbial attack. As a result, C may be more slowly decomposed hence more stabilized which is key to long term C sequestration.

Keywords：*Soil carbon sequestration, land use, particulate organic carbon, mineral-associated organic carbon,*

P2-369

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

The Distribution of Carbon Stock in Selected Mangrove Ecosystem of Wetlands Papua, Eastern Indonesia

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Mangroves has significant roles in the ecosystem, among them are well known for high Carbon (C) storage. The objective were to measure the amount of C-Stocks including its distribution, and also to monitor C-pools of the mangrove forest in the south of Papua. The collected data will be used namely: to directly assess the current C stocks in above and underground pools; and to initialize the simulation model for C and N dynamics of the various pools of organic matter. There were 3 locations for C stocks sampling in West Papua and Papua Provinces, i.e. : Teminabuan, Bintuni and Timika. Result of the analyzed data of the soil and vegetation species was used to study the distribution and quantity of C content of the representative locations. This study pointed out that mangroves in Bintuni is the most significant ecosystems in storing large number of carbon. The Mangrove Ecosystems of Bintuni site was dominated by Rhizophora mucronata (BA = 12.62 m2/ha) followed by Bruguiera gymnorrhyza (BA = 11.24 m2/ha), and Rhizophora apiculata (BA = 4.46 m2/ha). Other species had a very low basal area, which ranged from 2.26 to 0.06 m2/ha. Teminabuan site was dominated by B. gymnorrhiza (11.40 m2/ha), followed by R.mucronata (6.60 m2/ha) and Avicennia marina (4.40 m2/ha). While Timika site was dominated by R.apiculata (24.68 m2/ha), followed by B. gymnorrhiza (7.20 m2/ha). Other species had lower basal area (< 2.5 m2/ha), i.e. Xylocarpus granatum, R.mucronata, Ceriops tagal, and Scyphiphora hydrophyllacea. The sum of the above three relative measures for a species is an index called the Importance Value (IVI). IVI = RDi + Rfi + Rci. The IVI may range from 0 to 3.00 (or 300%). The surveyed area of Bintuni was B.gymnorrhyza with IVI of 105.02%, followed by R.mucronata, R. apiculata, Ceriops tagal, Xylocarpus granatum with IVI's of 95.87%, 35.71%, 32.31%, and 27.80%, respectively. The other two species, Avicennia marina and Camptostemon sp. had a very low IVI (1.65%). The most important species in Teminabuan site was B. gymnorrhiza with IVI of 109.56%, followed by R.mucronata, Avicennia marina, R.apiculata, Xylocarpus granatum (57.14%, 56.43%, 27.83%, and 23.26%, respectively). Other species had a low of IVI, which ranged from 6.09% to 2.19%, i.e. B.cylindrica, B.parviflora, Heritiera litoralis, Hibiscus tiliaceus, and Sonneratia alba. The most important species of Timika site was R.apiculata with the IVI of 163.65%, followed by B. gymnorrhiza as the second with the IVI of 64.37%. Some species had an IVI of less than 30% to 2%, i.e. Xylocarpus granatum, R.mucronata, Ceriops tagal, Scyphiphora hydrophyllacea, Canarium indicum, and Camptostemon philippinense. Among these three mangrove forest, Bintuni mangrove contained the largest mean C stock of 1311.6 Mg C ha-1, followed by Timika mangrove at 1243.8 Mg C ha-1 and Teminabuan mangrove at 853.2 Mg C ha-1. Base on the trees diameter classes, the highest above ground C (AGC) was found in the diameter of 50-100 cm for all study areas of mangrove. Bintuni mangrove had the largest AGC for all trees diameter classes and the smallest was in Teminabuan mangrove. Most of these three mangrove areas had low level of C stock in the tree diameter classes of 0-10, and >100 cm. Most of the above ground C storage dominated by trees and down wood which contained up to 246.6 Mg C ha-1. Analysis of biplot to C stock of mangrove revealed that C stock in geomorphic position among sites were significantly different. More C stock was in Bintuni and Timika than those in Teminabuan sites. The data presented show that mangrove ecosystems stored exceptional high carbon comparing to other ecosystem in the tropics. The quantities of carbon were hold two fold in the soil pools comparing to that holding in the biomass of vegetation. However according to biplot analysis, it is clear that the live trees were also contributed importantly to the C stock of the ecosystems. The result implies that mangrove is unique ecosystem that need to be considered in their management so that we could get the benefits from those present for local, regional, and global communities.

Keywords: *Carbon stock, ecosystem mangrove, important value index (IVI), Wetland Papua*

P2-370

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Is the Scale-Dependent Variation of Soil Carbon, Nitrogen and Moisture Stationary over Time?

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The term `scale' is extensively used in many environmental related sciences and the scale-dependent nature of the variation of soil processes and properties is also a known phenomenon among soil and environmental scientists. Soil variation is unavoidable, therefore it is necessary to understand the dominant spatial scales of variation and focus our modelling and sampling efforts at these scales. In spatial studies the scale-dependent nature is measured as a one off evaluation and it is assumed that the scale-dependency is stationary for many soil properties. However, this assumption can be debated due to the dynamic nature of soil moisture in the landscape on a daily basis and its role as a driver of many other soil variables. Nested designs appear more suitable for studying scale-dependency as it facilitates the analysis of multiple disparate scales with fewer sampling points as compared to grid/transect sampling, however the design does not account for the slope of the landscape. In the hydrological sense, the slope position is very important for the movement of moisture under wet conditions, therefore the variation in relative to slope position is worth investigating. The objectives of this research are to identify the dominant scales of variation for soil carbon, nitrogen and moisture and to study the time course of scale-dependency of them in a eucalyptus forest with the hypothesis that the variation is scale-dependent and non-stationary over time.

This study explores the variation of moisture of surface (0-10cm) and sub surface (10-20cm) soils at four spatial scales (5m, 30m, 100m and 567m) using a nested sampling design over seven sampling events during three consecutive years. A balanced nested (transect) design was used with 32 sampling points along the SW-NE direction of the slope of the catchment. Sampling events represents the dry weather (<130mm/four months prior to sampling (FMPS)), wet weather (approximately 300-600/FMPS) and a gradual drying out after wet weather (approximately 120-140mm/FMPS). Similarly the variation of surface (0-10cm) soil carbon and nitrogen were studied during dry weather and gradual drying after the wet weather (four sampling events). A trend model with ten predictive variables was developed for soil moisture and scale-dependency of residuals was also evaluated. Soil moisture was determined by gravimetric method and total carbon and nitrogen was analysed using a Vario MAX CNS analyzer (Elementar Analysen systeme, GmbH). The data were treated as random variables and statistical analysis was performed in the form of a random-effect nested ANOVA.

The dominant scale for soil carbon was the finest scale (5m, about 60% of variation) followed by 30m scale where 40% of variation was observed during the early sampling events, however 30m scale effect disappears when soil gradually decreases its soil moisture level at later sampling events. A dominancy of about 50% at 30m scale and 34-45% at 5m scale was observed for nitrogen during the early sampling events, however 30m scale effect replaces with 100m and 5m scale dominancy, just after the wet weather as in soil carbon and moisture. Approximately 50% of the variation in the soil moisture was attributable to the 5m scale and the rest of the variation was spread among 100m and 567m scales in the first sampling event. In the second sampling event, the dominancy at 5m scale (40%) continues along with the 30% at 567m scale followed by 10% at 100m scale and 20% at 30m scale. The 5m scale dominancy of moisture is very clear; however the percentage dominancy fluctuated with actual soil moisture level in the surface soil both under dry and wet soil conditions. No contribution from 30m scale for moisture variation was seen during last five sampling events. A similar dominancy fluctuation pattern of soil moisture was observed in the sub surface soil and the residuals of the moisture model (adjusted R2=0.78). The study clearly indicated the scale-independent nature of soil carbon, nitrogen and moisture during the consecutive dry months. Study also confirms the current knowledge on scale independency of soil moisture under dry conditions in Australia. Findings of the non-stationary nature of scale-dependency of carbon and nitrogen in this study is new to the current knowledge and should consider when long-term monitoring of them, however further research need for confirmation for frequent and longer periods.

Keywords：*Nested sampling design,moisture modelling, eucalyptus catchment*

P2-371

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Organic Carbon Storage of Cultivated Topsoil in Jilin Province

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Soil organic carbon (SOC) is the largest terrestrial organic carbon pool, of which the content and distribution features not only affect soil quality and fertility, but also have great influence on emissions of regional CO2 and other greenhouse gases. Many researchers have done a lot of research on soil organic carbon pool and mostly they use the data coming from the second national soil survey, lacking of the latest soil data. Previous researchers mainly studied on the estimation of soil organic carbon storage of 1m thickness soil profile, less on soil organic carbon of cultivated topsoil. Researching on soil organic carbon storage of cultivated topsoil with the latest data has substantial significance on how to take the conservation tillage measures and researching on dynamic changes of soil carbon pool under the human disturbance. This research is mainly to estimate the soil organic carbon storage of cultivated topsoil (0~20cm) in Jilin province. The research in Jilin province provides the basis for the evaluation of soil fertility, soil quality, soil health and scientific management of agricultural ecological system. Also it has great significance to study the changes of soil carbon pool and the soil carbon sequestration potential. The soil profile data we used was coming from the soil fertility evaluation data of the year 2010, collected by Soil and Fertilizer Station of Jilin province. We took the soil type as the research unit and selected the typical soil profiles for a total of 5743. We estimated soil organic carbon storage by using soil type method. All of the soil profile information included profile location, soil type, soil bulk density, soil profile's thickness and soil organic carbon content. The computation formula of soil organic carbon density SOCDD of layer i is as follows:

SOCDD=CiDi Ei (1-Gi)/100

where SOCDD (kg.m-2)is Soil organic carbon density; Ci (g.kg-1)is soil organic carbon content of layer i; Di(g.cm-3) is soil bulk density of layer i; Ei(cm) is the soil profile's thickness of layer i; Gi(%) is the volume percent of > 2 mm gravel content of layer i.

According to soil organic carbon density of different profiles, all the soil organic carbon density of 5743 survey sample points are from 0.02 kg.m-2to 21.05 kg.m-2, and the mean organic carbon density of each soil types' cultivated topsoil is from 2.80 kg.m-2to 8.40 kg.m-2, and the mean organic carbon density of cultivated topsoil in Jilin province is 3.95 kg.m-2. The total soil organic carbon storage of Jilin province is 2.06 x 1011 kg. The total distribution area of soil in Jilin province is approximately 18.74×104km2, and the total distribution area of cultivated soil is approximately 5.36×104km2. From the soil types, soil organic carbon storage of cultivated topsoil in the most is the Chernozem, accounting for 22.57% of total storage. Second is black soil, which is accounting for 14.45% of the total storage. The least is solonchaks, of which the storage is accounted for less than 0.1%, and maybe the less distribution area has a lot to do. For various soil types, the carbon storage of dark brown earths, Albic soils, black soils, chernozems and meadow are accounting for 75.37% of total cultivated topsoil organic carbon storage of Jilin province. Soil organic carbon storage of these five soil types accounts most of the cultivated topsoil organic carbon storage of Jilin province. For this reason, making full use of these five kinds of soil types is an important factor of the rapid agriculture development in Jilin province.

This research was performed based on the China 973 Program (2011CB100503), National Natural Science Foundation of China (41171188)

Keywords: *Soil organic carbon storage, cultivated topsoil, Jilin province, China*

P2-372

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Soil Organic Carbon Sequestration of a Paddy Soil Chronosequence

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Abstract: Though many studies suggest that soils have a finite capacity to sequester organic carbon and C saturation is more evident in soil with higher SOC (soil organic carbon) concentrations, there are also some researches finding that the C sequestration capacity is higher in well-developed paddy soils than in undeveloped young paddy soils. Therefore, in order to prove the hypothesis that long term cultivated paddy soils also have a higher capacity of C sequestration, we designed the laboratory incubation experiment of chronosequence paddy soil within maize straw residual. In this study, a series rice paddy soils developed from marine deposits was collected from Cixi, Zhejiang Province. We incubated the soils within 13C naturally labeled maize straw residual for 180 days and then measured the δ13C to determine the C derived from maize straw. SOC of bulk soil accumulated along the paddy soil chronosequence, but the increase rate of SOC reduced with the duration. After 180 days incubation, the least maize straw derived C was found in the wetland that have not been used as cropland, and maize straw derived C content enhanced with the duration but there was no significant changes between soils that have cultivated for above 100 years. The amount of new carbon stabilized in soils suggested that the capacity of C sequestration enhanced along the paddy soil formation from 0 year to 100 years. The old paddy soils although have higher C sequestration capacity compared with new developed paddy soils. The results we got may be due to the specific mechanisms of paddy soil.

Keywords：*soil organic carbon, paddy soil chronosequence , carbon sequestration capacity , soil incubation, maize straw carbon*

P2-373

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Spatial Distribution Characteristics of Soil Organic Matters in Mountain Meadow Soil at Wugong Mountain

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Research purpose:

Soil organic matter (SOM) is an important index in assessing the soil quality and has an important role in soil physical and chemical properties regulation, soil structure improvement, the soil fertility cultivation, etc.

The sustainable and steady content of SOM is the foundation of soil productivity. Thus, by analyzing the spatial distribution characteristics of SOM can understand the current level of soil development and nutrient utilization.

Research meathods:

By taking mountain meadow soil along different altitudes and different disturbance intensity at Wugong mountain as research object, and SOM of mountain meadow soil were measured.

Determination method:

SOM was determined by potassium dichromate oxidation method (external heating method)

Result and Discussion:

（1）The content of SOM decreased with the soil depth increased, while with the altitude increased；

（2）The maximum value of SOM content were at the altitude of 1850m in non-disturbance and light-disturbance treatment and at the altitude of 1900m in mid-disturbance and heavy-disturbance treatment.

(3)It showed that the change trend of SOM content was have a little clearly with the altitude increased.

Acknowledgement: The work reported here has been funded by IPNI (Jiangxi-29) and the National Natural Science Foundation of China (31260194）,(30960312),（31360177）and National Science and Technology Support Project (2012BAC11B06),The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Soil organic matter ;Mountain meadow;Soil quality*

P2-374

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Precipitation and Temperature Determine Soil Organic Carbon and Nitrogen Response to Land-Use Change in a Semiarid Region

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Abstract Semiarid and arid regions cover about 41% of Earth's land surface and are particularly sensitive to global change and human activities. The relationships between land-use change and soil organic carbon (OC) and N in semiarid regions are not well understood. To assess how soil OC and N respond to land-use change under different climatic conditions in a semiarid region, we investigated soil OC and N concentrations and stocks from 0 to100 cm depth in adjacent grassland, farmland and forest at five sites of the Loess Plateau that varied in mean annual precipitation (MAP) and temperature (MAT). The farmland and forest were derived from adjacent grassland in each site. The conversion from grassland to farmland significantly reduced both concentrations and stocks of soil OC and N, with greater decreases occurring in drier, colder site than in wetter, warmer site. The conversion of grassland to Chinese pine (Pinus tabulaeformis) and shrub increased soil OC and N under wetter and warmer climate conditions, but decreased them in colder and drier areas. The changes in soil OC and N through 100 cm depth after grassland conversion to forest in the Loess Plateau increased with the MAP and MAT with a threshold of 480 mm for MAP and 8.4°C for MAT, below which soil OC and N will loss after grassland converted to forest. Changes in soil OC and N after grassland converted to forest in semiarid region responded more quickly and sensitively to temperature than to precipitation. Our findings suggest that precipitation and temperature determine the response of soil OC and N to land-use changes in the semiarid region.

Keywords：*afforestation; cultivation; grassland; organic carbon; mean annual precipitation; semiarid region;*

P2-375

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Effects of Land-Use Change on Soil Organic Carbon and Nitrogen in Density Fractions and Soil δ13c and δ15n in Semiarid Grassland

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The mechanisms behind the losses of soil organic carbon (OC) and nitrogen (N) in semiarid grassland due to changes in land use are unclear but are essential for understanding the responses of OC and N to soil management. To learn how soil looses OC and N, we measured δ13C and δ15N in soil organic matter and the contents of OC and N in both total soils and density fractions in adjacent tracts of native grassland, cropland and shrubland in a semiarid region in China. The cropland and shrubland were established on existing grassland 27 years ago. The conversion of grassland to cropland and shrubland decreased the contents and stocks of OC and N in both total soils and density fractions to a depth of 0-80 cm. The decreases in the stocks of OC and N in the heavy fraction accounted for >90% of the total decrease in the 80 cm of soil after grassland cultivation and afforestation. The conversion of grassland to cropland and shrubland increased δ13C but decreased δ15N in soil organic matter. The results from our study suggest that the losses of soil OC and N after changes in land use in this semiarid grassland were primarily due to losses in the OC and N associated with the heavy fraction.

Keywords：*δ13C; δ15N; density fractions; land-use change; nitrogen; organic carbon; semiarid grassland*

P2-376

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Modelling Carbon, Water and Heat Fluxes Using a Process-Based Model in Temperate Sown Grasslands under Mowing and Grazing Management Systems

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Grasslands are one of the most widespread terrestrial ecosystems, covering approximately 40% of the global land surface, and containing the largest share (39%) of terrestrial soil carbon (C) stocks (about 580 Gt C). Any change in storage in this large grassland soil C reserve would have a significant and long-lived effect on global C cycles. Although it is very difficult to separate management effects on grassland ecosystem from climatic effects due to their complex interactions, different management practices directly and indirectly affect different biotic, abiotic and soil processes in the grassland ecosystem. Grassland management practices such as mowing (cutting) and grazing directly influence C assimilation by frequent defoliation events which reduce both leaf area index and above-ground biomass. This, in turn, affects the amount of C accumulation which in turn governs the availability of respiratory substrate (assimilates and litter), and thus also feeds back on ecosystem respiration. In addition, management practices like fertilization affects grassland ecosystem by affecting nutrient availability, and thus photosynthetic activity, as well as ecosystem respiration. Grass mowing systems differ from grazing systems with respect to their harvesting, fertilization and C recycling process. Where the entire harvested biomass C is generally exported out of the mowing system as herbage/silage/hay, a large part (20-40%) of the ingested biomass C is returned/recycled within the grazing system. We therefore hypothesize that CO2 flux as well as water and heat fluxes under grazing system could be different compare to mowing system. Greater understanding of how different grassland management practices influence CO2, water and heat fluxes is important to adapt different management strategies and reduce risk of C losses from grassland ecosystems. In the present study CO2, water and heat fluxes were simulated by using a process-based model (CoupModel) for a time period of six years (2006-2011) in temperate sown grasslands in France with two different management system viz. mowing and grazing. Different climatic parameters (air temperature, precipitation, global radiation, net radiation, wind speed, relative humidity etc.) were recorder at one hour time steps by an automatic weather station to drive the model. CO2, water and heat fluxes were measured by eddy covariance technique and data in one hour interval were used for model validation. Uncertainties in parameters, model assumptions and measurements were identified by generalized likelihood uncertainty estimation (GLUE). Diurnal and seasonal course of sensible heat flux, latent heat flux and CO2 fluxes were successfully simulated in different contrasting years under both the management systems. Total gross plant productivity (GPP) was similar in magnitude under both the management systems. However, total ecosystem respiration was higher under grazing, whereas, net ecosystem exchange (NEE) was higher under mowing. Soil temperature was simulated with less uncertainty than soil moisture. The largest uncertainty range of both soil temperature and soil water content was found mainly in deep soil layers. CO2 flux showed sensitive to the management systems, air temperature, soil water and nitrogen supply. Thus, result indicates strong coupling among different abiotic, biotic and soil process. The GLUE process reduced overall model parameter uncertainty after calibration. The simulated surface heat fluxes after calibration are of important outputs to compare with different climate models and micrometeorological measurements. Our approach prove robust for modelling CO2, water and heat fluxes by coupling an uncertainty estimation procedure (GLUE) and combining different independent measurements. Two different management systems (mowing and grazing) influence CO2, water and heat fluxes in temperate sown grassland differently.

Keywords：*Carbon, water and heat fluxes; process-based model; CoupModel; grass mowing and grazing systems*

P2-377

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Changes in Soil Organic Carbon and Total Nitrogen Stocks in a Chronosequence of Perennial Pastures

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Agricultural soils in the wheatbelt of Western Australia are thought to have lost over half of their total carbon (C) stock since clearing, with ramifications for soil health. Combined with challenges such as declining rainfall, reduced commodity prices and salinisation, some farmers are now trialling non-traditional grazing management practices that also have strong potential for soil C sequestration. Perennial pastures may increase soil C storage, due to their deeper and more extensive root system compared with annual grasses, and at the same time reduce soil C losses through erosion. Some studies have also reported reduced respiratory loss of soil C in perennial pastures, as perennial pastures can utilise soil moisture from summer rains which would otherwise fuel increased decomposition by soil microbes. The scarce available field evidence supports the theoretical link between perennial pastures and increased C storage. Some studies found significant increases in soil organic carbon but others found no difference in C sequestration beneath annual and perennial pastures, but noted that pasture has significant potential to sequester C compared with cropping.

Gains in soil C take place over a long timescales. For these reasons, this chronosequence was selected to investigate the long-term effect of perennial pastures on improved soil health and productivity along with soil carbon storage. In some cases, paddocks sown with annual and perennial pastures are adjacent to one another, making for an ideal comparison. The aim of this study was to clarify the potential role of perennial pastures in soil carbon and nitrogen storage by evaluating how the time since pasture establishment influenced soil carbon storage up to 30cm in the profile.

Soil organic carbon and total nitrogen were assessed in pastures established in 2003, 2005, 2007, 2008, 2011 and 2012. There is a range of perennial pasture species at these sites. Soil samples were collected from each of 4 randomly selected grids of 25m × 25m at each pasture site. In each grid, soils were collected both from under perennial and between perennial pasture plants (10 points) at 3 depths (0-10, 10-20 and 20-30 cm). Soil carbon and nitrogen at the 2003 perennial site was greater than at any of the other 5 sites within the chronosequence. Although perennial pasture plants are well established at each site, the ground cover is dominated by the annual pasture species between the perennials in these permanent pastures. Soil carbon and nitrogen (0-30cm) were both greatest at the 2003 perennial site. However. there was no clear relationship between the time of pasture establishment and soil carbon and nitrogen at the other sites within the chronosequence. These findings suggested that while the chronosequence of perennial pastures has potential to demonstrate an increase soil carbon and nitrogen storage with the perennial pasture age at all varying soil depths, other soil characteristics at the site, location in the landscape and water availability can have overriding effects.

Keywords：*Soil organic carbon, total nitrogen, chronosequence, perennial pastures*

P2-378

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Vertical Distribution of Water-Extractable Organic Carbon in a Sandy Soil as Affected by Biochemically Contrasting Organic Residues Applied Yearly for 13 Years

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Water-extractable organic carbon (WEOC) is a constituent of soil solution that plays a key role in many chemical and biological processes in soils, notably forming organo-mineral complexes with micronutrients increasing their availability, mobilizing pollutants in soils and acting as microbial substrates. In addition, vertical distribution of WEOC in soils may influence soil organic carbon accumulation in soil profiles. We investigated the effects of biochemically contrasting organic residues applied yearly for 13 years on vertical distribution and dynamics of WEOC in a sandy soil under a field experiment conditions in Northeast Thailand. Soil samples were collected before and 2, 4, 8, 16 and 52 weeks after organic residue incorporations at 5 soil depths (e.g., 0-15, 15-30, 30-60, 60-80 and 80-100 cm). Residue-treated soils showed higher content of WEOC than the control soil throughout the 52 weeks. All residues produced the highest content of WEOC at week 8 after their incorporations. Organic residues with higher lignin and polyphenol contents e.g., groundnut, tamarind and dipterocarp, relative to rice straw produced high WEOC content in the topsoil layers (0-30 cm) in weeks 2 and 8. Meanwhile, rice straw, containing the highest cellulose but the lowest N, lignin and polyphenol contents among all the residues studied, produced higher WEOC content in the subsoil layers (60-80 cm) especially at week 8 than the other residue treatments. We hypothesized that cellulose led to production of low molecular weight WEOC which was less adsorbed to soil colloid, while lignin and polyphenols led to production of high molecular weight WEOC compounds with higher affinity for adsorption to soil colloid. Further research should be conducted to characterize WEOC, such as through molecular weight and molecular structure characterization, in order to gain understanding into mechanisms determining the differential vertical distribution among these contrasting quality organic residues.

Keywords：*Cellulose, Lignin, Long-term experiment, Northeast Thailand, Polyphenols, Soil depth*

P2-379

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Effect of Oil Palm Trunk Chips Application on Greenhouse Gases Flux from Tropical Peat Soil: Incubation Experiment

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The contribution of tropical peat soil in the global budget of greenhouse gases (GHGs); carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), has raised much concern nowadays especially in the oil palm industry. Generally, after 25 years of productivity, an oil palm plantation will reach an economic declination threshold that permits replantation. Upon replantation, the old biomass is spread evenly over the plantation area to decompose. This method is environmentally safe and it improves the recycling of nutrients and organic matter, thus retaining soil fertility over longer periods (Fairhurst and Härdter, 2005). On the contrary to its advantages, quantitative information on the environmental impacts of old biomass dispersion before replanting is scarce. Therefore, an incubation study is conducted to investigate the effects of old biomass application in reducing GHGs emission, thus establishing a best management practice.

Treatment was done by comparing the oil palm chips added on the surface of peat soil; T3, with the oil palm chips incorporated into the peat soil; T4. Control treatments of oil palm chips; T1, and peat soils; T2, were prepared. The CH4, N2O and CO2 concentrations were monitored daily by gas chromatography analysis for 7 days.

It was observed that CH4 and CO2 emission from control treatment of T1 was higher at the initial stage compared to other treatments and N2O emission remained the same. The cumulative flux showed an uptake of atmospheric CH4 for T3 (-1.60 x 10-4 mg C kg-1h-1) and T4 (-3.00 x 10-6 mg C kg-1 h-1). The cumulative flux of CO2 and N2O for T3 and T4 has similar trend with T3 showing higher flux than T4. The results showed that the application of oil palm trunk chips creates aerobic space that may stimulate the CH4 oxidation. The presence of moisture and oxygen also promotes nitrification as a more dominant process compared to denitrification. This was shown by the high availability of N-NH4+ ions for T3; (56.84 mg/kg), as compared to T4; (13.61 mg/kg).

From the study, it is observed that the application of oil palm trunk chips promotes CO2 and N2O emission during the initial stage of application before it decreases and stabilize at later stages. In conclusion, incorporating old biomass into the peat soil could reduce the emission of CO2 and N2O gases as compared to spreading it out on the surface. Even so, the changes in the application method have no effect on CH4 emission.

Keywords：*Oil palm plantation, greenhouse gas emission, tropical peat soil*

P2-380

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

The Discussion on 'black Carbon' in Soils: A Plethora of Hypothesis

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Research on the organic geochemistry of black carbon became one of the priorities in the environmental Earth Sciences after publication of Goldberg's book 'Black carbon in the environment'. In this paper, Goldberg suggested the idea of 'black carbon' as a highly durable material remaining after combustion of biomass and suggested that 'black carbon' has a very long characteristic time of existence, making a significant contribution to the slow cycle of the Earth's carbon pools. Organic geochemistry of 'black carbon' has become even more relevant in connection with the matters of the carbon cycle and climate change, including long-term preservation of organic matter in ocean sediments and soils. Geologists have shown that ancient sediments contain 'carbon black' possibly of pyrogenic origin, which they believe might be separated from the carbon formed during the low temperature diagenesis (kerogen). Thus, initially in the literature 'carbon black' was associated only with pyrogenic products, but nevertheless researchers soon have encountered so that combustion products varied widely in composition and stability depending on the combustion conditions, and that it was methodically difficult to distinguish between the products of low and high temperature organic matter oxidation. It has been proposed several methods of separation of 'black carbon' from fossil and modern soil organic matter; all methods were based on the oxidation of organic matter by a set of acids, sometimes followed by heat treatment (100-375°C), or exposure to extreme ultraviolet radiation. Different methods show different results on the order, which is associated with a wide range of properties and stability of combustion of organic matter. Many researchers succumbed to the temptation to include in the 'black carbon' concept an extremely wide range of carbon-containing components and declare the pyrogenic origin of the major part of carbon in marine sediments and soils. Since much of the carbon in soil organic matter not extracted by acid and alkaline treatments has been regarded as 'black carbon', a number of experts subjected the revision of existing views on the mechanisms of accumulation and transformation of organic matter in soils. In particular, it has been postulated that a significant proportion of dark-colored soils of chernozem type owes its color pyrogenic carbon. Despite the apparent inconsistency of these statements to actual views on pedogenesis, this theory has spreaded and has been published in leading scientific journals, up to Nature. Also it was concluded that on the basis of the degree of stability of 'black carbon' in the soil one can draw conclusions about the temperature of the combustion of organic matter that is separate carbon, formed as a result of fires and industrial high-temperature combustion. So far it is not clear whether these views are unfounded. The main argument against the theory of the genesis of pyrogenic exclusively coal-like components in soil organic matter is that the geographical distribution of 'black carbon' in the soil does not match the geography of wildfires in neither the present nor the past. We believe that a significant part of the so-called 'black carbon' in the soil has a low-temperature origin, and therefore difficult to draw far-reaching conclusions based only on the availability of coal-like components in soil organic matter.

Keywords：*hydromorphic soils, soot, soil colour, carbonization*

P2-381

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Fingerprint of Dissolved Organic Carbon and Hydrolytic Activity in Soil Solution as Factors to Implement Biochemical Activity in Carbon Dynamic Models

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Carbon (C) storage and dynamics in soil are fundamental components of terrestrial C cycling with significant impacts on soil health and climate change. Although a number of models have been developed to quantify carbon stocks in soil, characterize pools of different stability, and predict potential lose or sequestration of C, biochemical processes for C stabilization in soil have not been systematically incorporated in C dynamic models. Therefore, the implementation of a biochemical component in C models might consider the incorporation of factors representative of metabolic activity in soil such as enzymatic activities. Accordingly, hydrolases activities are directly related to C cycling. Otherwise, dissolved organic carbon (DOC) is one of the key defined pools of C in soil since it is the most available fraction for microbiological degradation while being a major component for C turnover in soil. The DOC has been classically defined in C dynamic models according to total concentration and less often its aromaticity. However, DOC can be characterized for a number of components based on their chromophoric character. Currently, up to 10 quantifiable components have been differentiated in DOC, and such composition can be correlated with variations in C dynamics for a particular environmental scenario, such as those associated with changes in land use.

A sequence of four soil samples representative of a change in land use from extensive cropping to afforestation to native forest was collected in Kingaroy (Red Ferrosol), a district of southeast Queensland (Australia), corresponding to a native undisturbed forest (KF), forest to cultivation since 1950 (KC), cultivation to pasture since 1980 (KP) and pasture to afforestation since 1997 (KPF). Soil samples were normalized for water content to 60% of their water holding capacity and incubated at 25 °C for 2 weeks. Soil solution was then extracted by centrifugation, filtered (0.22 μm) and analysed for cellulose and phosphatase activity using fluorogenic substrates. Fluorescence corresponding to the fluorogenic product of the enzymatic reaction was determined on a FLUOstar Optima multidetection plate reader, with excitation at 360 nm and emission at 460 nm. In addition, fingerprints of the DOC were obtained for each soil solution as excitation-emission matrices (EEM) from fluorescence scans acquired using a Shimadzu spectrofluorometer RF5301 with excitation from 220 to 450 nm and emission from 220 to 550 nm. Enzymatic activities reached a plateau within 5 min after addition of the fluorogenic substrate and followed the order KS<KPF<KP<KC. Thus, for cellulose activity 31 (KS), 16 (KPF), 12 (KP) and 4% (KC) of added substrate (cellobioside) was metabolized in the first quantifiable reading cycle in the plate reader and the rate kept constant during 40 cycles. Similarly, phosphatase activity resulted in 11, 6, 6 and 2% of phosphate metabolized in the first cycle following the same order. Variance in the fluorescence readings was below 5% in all cases and ANOVA test indicated that differences among soils were statistically significant ($p<0.05$). The DOC fingerprints showed the presence of humic acid-like (biochemically stable) component in KS and KPF that was not present in KP and KC fingerprints, which were dominated by a component related to soluble microbial by-products, corresponding to a readily available source of C.

The consistency of the variation in enzymatic activity and DOC composition with the sequence in land use change has provided a preliminary evidence of a significant correlation of these parameters with C dynamics. Thus, higher cellulose and phosphatase activity were associated with native forest and afforested land, consistently with a higher presence of recalcitrant aromatic compounds, while lower enzymatic activity was determined for pasture and cropping soils, where the humic component was substituted by a less biochemically stable component. Thus, results support the hypothesis that biochemical stabilization of C in soil might be a more relevant contribution to C sequestration than chemical or physical stabilization. Further evaluation of kinetic parameters for the enzymatic activities and quantification of the DOC components might provide a significant contribution to the development of C models with more accurate soil C storage prediction capacity.

Keywords：*carbon sequestration, biochemical stabilization, soil enzyme activity, dissolved organic carbon, spectrofluorometry*

P2-382

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Tracing C Fluxes through the Metabolic Network of Soil Microbial Communities by Position-Specific Labeling

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Understanding the soil organic matter (SOM) dynamics is one of the most important issues in the scope of C sequestration, climate change and maintenance of soil fertility and ecosystem sustainability. The majority of the processes in soil organic carbon (SOC) cycle are performed by the soil microbial community. Isotope biogeochemistry developed as one of the most promising fields during the last 70 years to trace C fluxes through the SOC cycle. Besides investigating the natural abundance of 13C and 14C, enriched tracers, like labeled plant residues, were used. Later, after the 70ties, individual substances like sugars, amino acids or carboxylic acids as well as their oligo- and polymers were applied to not only trace the C fate but also specific microbial transformation processes. The investigation of turnover and transformations of low molecular weight organic substances (LMWOS) became a key topic in soil biogeochemistry as all high molecular substances pass this stage during their decomposition.
Nearly all previous studies used uniformly labeled organic substances i.e. all C atoms in the molecules were labeled with 13C or 14C. However, this classical approach did not allow to distinguish whether the initial substance was involved in a certain processes, or whether the substance was first transformed and its metabolites entered a specific process. In contrast, position-specific labeling provides a unique tool to trace the biogeochemical fate of individual C atoms in the molecules. We show the advantages of position-specific 13C and 14C labeling to investigate microbial uptake and decomposition as well as the formation of new microbial compounds. We present results from a representative spectra of LMWOS of sugars, amino acids and carboxylic acids. Position-specific labeling enabled to distinguish the fate of initial substance and its metabolites. Such metabolite tracing allowed to evaluate contribution of individual functional groups of one substance to various processes in soil. Furthermore, coupling position-specific 13C labeling with compound-specific 13C analysis of various microbial metabolites enables to trace the utilization of individual C atoms by the microbial community in soils. Formation of microbial cell membranes was investigated by gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS) of phospholipids fatty acids (PLFA) as well as cell wall formation by liquid chromatography-oxidation-isotope ratio mass spectrometery (LC-O-IRMS) of the microbial amino sugars. This allows the reconstruction of microbial metabolization pathways in soils. In combination with the investigation of biomarkers like PLFA and amino sugars, specific transformations of ecophysiological groups within the microbial community can be traced. We found that LMWOS are mainly transformed according to major cellular C metabolization pathways but could also identify individual pathways driven under special conditions or by special microbial groups. More complex substances like fatty acids are rarely incorporated into basic C metabolism but preferentially used as entire building block by microorganisms, but they transform them according to their cellular demand. In summary, specifics in the transformation of individual molecule positions can be identified and C transformation pathways of various substances reconstructed.
To reflect the differences between the fate of individual C atoms independent of the concentration and pools of the substances in soil we introduced the divergence index. The divergence index reveals the convergence or divergence of C from individual molecule positions during microbial utilization and stabilization. It enables identification of specific molecule positions which reflect characteristic changes in the C transformation pathways in soils. Consequently, changes of the C metabolization e.g. under varying environmental conditions can be traced. This provides a highly sensitive tool for detection of changes in the SOC cycle. Thus, observing single C atoms and their transformation pathways provides unique insights into mechanisms and kinetics of biogeochemical processes in soils and therefore will strongly improve our understanding and generalization of soil carbon fluxes.

Keywords: *metabolic pathways, position-specific labeling, microbial metabolism, biomarker of soil microbial communities, low molecular weight organic substances, C transformations, soil organic C cycle, soil organic matter formation*

P2-383

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Role of Climatic Single Events and Pedohydraulic Factors in the Mobilization and the Transport of Mobile Organic Matter in an Arable Soil

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Soils are the largest terrestrial pool for organic carbon. To improve our understanding of local and global carbon cycles, factors and conditions that effect release, redistribution and transport of organic carbon should be known. Besides dissolved organic substances, organic particles with sizes up to several micrometers are mobile in soils. The aims of this work are (i) to investigate the impact of external factors (climatic, anthropogenic) and pedohydraulic conditions on the mobilization of mobile organic matter (MOM) and (ii) to characterize the MOM with focus on the particulate fraction. We monitored spatially resolved water and carbon fluxes at an agricultural site (Luvisol) with wheat and maize cultivation. Climatic and pedohydraulic boundary conditions were measured continuously with a climate station and a soilhydraulic monitoring pit. The seepage water has been collected in two depths (plough horizon and subsoil) with twenty-eight tension lysimeters. In a first setup, macropores to the lysimeters has no continuity, whereas in a second setup the continuity of the macropores is enabled. The results from 4 years observation suggest that release of MOM in soil is mainly triggered by single events like heavy rain and snowmelt. The pedohydraulic data support that preferential flow along biopores plays a major role for the MOM release during these events, whereas the hydraulic gradient was not observed as a major factor for MOM release. Including macropore flow, MOM transport into the subsoil increased both for the dissolved organic matter and the MOM > 0.45 µm. We found that the fraction of particulate MOM on the total MOM has a considerable amount and should not be neglected. The MOM in seepage water, transported into the subsoil after snowmelt events, includes bacteria that are found on the rhizoplane at the field site (Dibbern et al., accepted). Further, the translocation of dissolved and particulate organic substances depends on the cultivation type. With regard to probably increasing occurrence of extreme events as a consequence of the climatic change, the influence of MOM translocation should be considered in future balances of carbon cycling.

Keywords：*carbon transport, colloids, bacteria transport*

P2-384

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

A Stepwise Modeling of Copper Sorption onto Kaolinite and Montmorillonite in Field Ph Range as Affected by Dissolved Organic Carbon

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Application of composts can promote soil physical, chemical, and biological properties. However, heavy metal movement in soils is an important issue while applying metal-enriched composts such as swine manure compost (SMC) and municipal wastewater sludge compost (MWSC). Dissolved organic carbon (DOC) was known to have high affinity to Cu and may remain more Cu in soil solutions in certain soil pH conditions. However, the overall vision of the DOC-Cu-clay interactions in wide pH range is not clear because of the interactions between DOC, metals, and surfaces on clay minerals. Moreover, it is difficult to describe the Cu retention by the solids in clay-DOC suspensions using an existing simple model since the properties of DOC solutions are usually depend on their sources and the surface properties can be significantly altered after adsorption of DOC or DOC-Cu complexes.

In this study, we used the modeling program, Visual Minteq, to find out the reaction parameters of each reaction of DOC including precipitation, Cu-complexation, and sorption by clay and finally to describe the solid Cu fraction in the Cu-DOC-clay suspensions using the parameters. DOC solutions extracted from two composts (one commercial SMC and one prepared MWSC) and two source clays (kaolinite and montmorillonite) are used to investigate solid-liquid distribution of Cu in filed pH range (pH 3-9). The total acid site density of DOC was 151 and 126 mmol mol^{-1}-C for SMC and MWSC, respectively. The batch experiments were conducted in the condition of 0.025 M KNO_3, 0.005 M DOC, darkness, and 25℃ and reacted for 4 h. Initial concentrations of Cu were 0–320 μM. The solid:liquid ratio was 1:25 for kaolinite and 1:400 for montmorillonite, respectively (about 1.5 mM of total surface acidity).

In the DOC-Clay systems, DOC can be retained on clay surfaces while the quantity was decreased by increased pH value. Hydrolysis-precipitation of Cu was unapparent in the presence of clay or DOC. In the Cu-DOC systems, Cu coordinated with DOC directly and was remained in the solutions even in high pH conditions while its precipitation occurred even in acid condition. In the DOC-Cu-Clay systems, 10% of total Cu was increased by DOC and retained on kaolinite at pH 3 while 50–80% of that was decreased at pH 7–9. The Cu retention on montmorillonite was decreased both in acid (by 10–35%) and alkaline (by 7–60%) conditions. In this study, we revealed a clear vision of the interactions between Cu, DOC, and clay at pH 3–9. The simulation results of Visual Minteq were used to obtain the least square of differences between simulation results and experiment data and the stepwise processes were repeated to find out the apparent reaction parameters of DOC precipitation (Ka_{DOC} and Ksp_{DOC}), adsorption ($K_{S\text{-}DOC}$ and complexation with Cu ($K_{DOC\text{-}Cu}$ and $Ksp_{DOC\text{-}Cu}$). These parameters and probable products were re-input into Visual Minteq. The final simulation results were revealed which gave a better description of Cu retention in the DOC-Cu-Clay systems.

Keywords：*Copper, dissolved organic carbon (DOC), kaolinite, montmorillonite, modeling, adsorption*

P2-385

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Recovery of Decomposing Plant Residue in Soil: An Evaluation of Three Fractionation Methods Based on Size and Density

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Soil is often physically fractionated by size and density to isolate and identify biologically meaningful pools of soil organic matter (SOM) and characterize their biochemical makeup and susceptibility to decomposition. We incubated soil amended with ^{13}C-labelled barley (Hordeum vulgare L.) residue (10 atom%) and used three fractionation methods based on size (>250 µm: coarse sand; 53-250 µm: fine sand; 5-53 µm: silt; <5 µm: clay) and density (< 1.7 g cm^{-3} = light fraction [LF]) to determine the quantity of C recovered in these pools at different points along the trajectory of decomposition. One method was based on size fractionation (particle size), another involved density separation followed by size fractionation (density-size) and the third method separated SOM fractions by size first and the two coarsest fractions were then subjected to fractionation by density (size-density). The amount of residue C recovered in each fraction changed significantly during the incubation, indicating that residue C changed in size and density as decomposition proceeded. Across all three fractionation methods most of the residue C was isolated in the largest and lightest fractions, but there were significant differences in the quantity recovered in these fractions. For example, at time zero (i.e., no decomposition) the coarse sand isolated by particle size contained 86% of the residue C, the LF isolated by density-size contained 60% and coarse sand-LF isolated by the size-density method contained 76%). The differences suggest that LF did not capture all of the most recently added (and therefore the least decomposed) residue. These large, light fractions also showed the greatest change (decline) of any fraction during the incubation, reflecting their dynamic nature and confirming their role as sensitive indicators of SOM change. Furthermore, the amount of residue C in the two smallest fractions (silt and clay fractions) increased significantly after time zero and early during the incubation, but then decreased towards the end. The increase was likely due to accumulation of microbial by-products of decomposition; the subsequent loss of C can be attributed to mineralization of C as decomposition continued. This suggests that clay is a sink for residue C during early stages of decomposition but that it is still in relatively labile and decomposable forms so that some of this C is eventually mineralized and lost from the smallest fractions as decomposition proceeds.

Keywords: *decomposition; physical fractionation; size and density fractionation; ^{13}C*

P2-386

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Changes in Light Fractions of Soil Organic Carbon after One Year Application of Raw and Composted Recycled Paper Mill Sludge

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Changes in total soil organic carbon (SOC) with changes in land use and management can be partly explained by the way C is allocated to different fractions of soil organic matter. Physical fractionation of SOM is a powerful tool in land use change studies of organic matter turnover in soil and this type of study has increased steadily over the past two decades. Total organic carbon might not be sensitive to changes in soil quality resulting from relatively recent changes in soil management practices, as it often takes many years before changes in agricultural management can lead to detectable changes in the quantity and quality of SOC. However, light fractions play an essential role in the short-term turnover of nutrient in soils. Light fraction is commonly referred to a plant-like and less stable fraction with high C concentration. The importance of light fractions (including free (F-LF) and occluded (O-LF) organic C) is widely recognized for its role in the formation and stability of soil structure, especially in the stability of soil macroaggregates. Recycled paper mill sludge (RPMS) is the final processed waste from pulp and paper industries generated from different stages of papermaking and one of the underutilized organic by-products in Malaysia. The high organic matter content and low trace metals and organic pollutants in pulp and paper mill sludge suggest that these residuals may provide a valuable resource as soil amendments. Therefore, this study was conducted to investigate the effects of one year application of raw and composted RPMS on changes of soil organic carbon by quantifying mass distribution of free and occluded light fractions.

The field study was located at the University Agricultural Park, Selangor, Malaysia. Twelve plots were established and each plot consisted of 9 plants of Khaya senegalensis seedlings planted at 4m x 3m with 4 treatments and 4 replications arranged in a randomized complete block design (RCBD). The treatments were control, 100 kg N ha^{-1} of inorganic fertilizer (recommended rate) and 200 kg N ha^{-1} of raw and RPMS compost, respectively. Treatments were applied once at the beginning of the experiment during transplanting of seedlings. This study was carried out of for 1 year growth of K. senegalensis.

The results show that the F-LF fraction resulted in higher dry weight of soil compared to the O-LF for all treatments. Concentrations of carbon and nitrogen of L-OF and O-LF in soils treated with RPMS compost were significantly different compared to the raw RPMS followed by inorganic fertilizer and control treatments during 1 year of study. However, C/N ratio was not significantly affected and was observed to range from 9.99 to 33.41 in F-LF and from 7.02 to 20.88 in the O-LF. The F-LF showed a greater variation in the concentration of C and N compared to the O-LF and the whole soil. The greater C/N ratio of F-LF than the C/N ratio of the O-LF and whole soil indicates the significant influence of paper mill sludge in the soil organic matter pool revealing its response to the change in soil management. The mass proportions of three aggregate size classes in the topsoil depth (0-15 cm) also shows that application of raw and RPMS compost was dominated by 53-250 μm aggregates followed by the 250-2000 μm, 53 ? 250 μm and >2000 μm class sizes compared to the control. Based on fractionation results, raw and composted RPMS could change soil organic carbon and its fractions and thus soil aggregate stability after one year of treatment.

Keywords：*Light fraction, free and occluded fractions, carbon and nitrogen, paper mill sludge, soil amendment,*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Soil Disturbance Effects on Decomposition on Plant Residues in Canadian Agricultural Soils

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No-till cropping systems, where soil is left largely undisturbed, are often advocated as a way of increasing soil carbon, in part because they slow the rate of plant litter decomposition. To evaluate the effects of soil disturbance on plant residue decomposition and C retention, a study was initiated in humid (Ottawa, Ontario; 880 mm annual precipitation) and semi-arid (Lethbridge, Alberta; 400 mm annual precipitation) environments in Canada. Our objective was to determine the effect of residue placement (no-till surface vs. conventional incorporation) in controlling residue-derived C retention in the whole soil and the soil microbial biomass. In the fall 2007 barley straw enriched with ^{13}C (0-9 cm layer) was applied to microcosms at a rate of 200 g C/m^2. The microcosms (15 cm long, 10 cm diam.) were inserted to 10 cm depth and covered with a nylon mesh screen (1 mm^2 openings). Each year thereafter, non-labeled barley residue (200 g C/m^2) was either incorporated or applied to the surface, according to treatment, and microcosms were fertilized in the spring (40 kg N/ha). At each site, soil temperature probes were placed at a depth of 5 cm inside of a microcosm; hourly soil temperature (5 cm depth) was logged and the probes were replaced each fall. Soil samples (from 0-5 and 5-10 cm depths) were removed at about 0, 0.5, 1.0, 2.0, and 3.0 years after residue application to estimate decomposition, microbial incorporation, and retention of the ^{13}C-enriched barley residues applied in fall-2007. Soil samples from both depths were analyzed for whole soil organic C and its ^{13}C enrichment, lipids were extracted from field-moist soils, and phospholipid fatty acids (PLFA) and the ^{13}C enrichments in these biomarkers were analyzed. Decay rates were greater at Ottawa than at Lethbridge, where decay was constrained by aridity and cold temperatures in soil, sporadically unprotected by insulating snow. During the first 0.5 years, surface-placed residues decayed more slowly than residues mixed into soil at both sites. The influence of residue placement on residue C remaining was short-lived at Ottawa, but persisted over the 3-year period at Lethbridge, where aridity constrained decomposition of the surface-placed residues. Within the first year, moisture infiltration combined with faunal activity transferred ^{13}C from the surface-placed residues to the 5-10 cm layer at Ottawa; such movement was not apparent in the more arid conditions at Lethbridge. The appearance of enriched ^{13}C in PLFA was consistent with the vertical transfer of 13C within the microcosm. ^{13}C-enriched PLFA was detectable in both the 0-5 and 5-10 cm layers when residues had been incorporated into the soil, but when residues were surface-placed, ^{13}C was detected after two years at Ottawa but was never detected in the 5-10 cm layer at Lethbridge. While the complement of PLFA we measured provided only a broad distinction between microbial and fungal decomposers catabolizing the labelled barley residue, the relative contribution of each group showed complex interactions among residue placement, soil layer, and sampling time. The structures of the microbial communities inferred from the PLFA suggested a parallel between the two disparate sites when residues were incorporated into the soil, but when residues were left on the surface, active microbial communities were structurally distinct. The relationships among microbial community, residue placement and climate suggested that all three influenced decay rates; consequently, the mechanisms determining soil C retention in no-till systems are site-specific and more complex than commonly assumed.

Keywords：*decomposition, soil tillage disturbance, ^{13}C labelling*

P2-388

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Carbon Sequestration Potential of Soils Under Maize Production in Irrigated Agriculture of Punjab - Pakistan

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Carbon sequestration (CS) potential of different crops in irrigated agriculture of Punjab - Pakistan (IAPP) is unknown under the changing climate. We calculated trends in climate extremes and estimated CS potential of maize crop in a representative IAPP region Nuclear Institute of Agriculture and Biology (NIAB) Faisalabad and Gojra. A total of 13 climate change indices were calculated using daily minimum and maximum temperatures and analyzed for trend using RClimDex, a program written in the statistical software package R. A nonparametric Mann?Kendall test and Sen's slope estimates were used to determine the statistical significance and magnitude of a trend, respectively. Base values of soil carbon were achieved through field experiments by growing a local variety of maize (Monsanto-919 Hybrid) in NIAB-I, N1AB-II and Gojra sites during autumn of 2012. Above and below-ground biomass of maize was quantified from shoot and root sampling. Soil samples from 0-15, 15-30, 30-45, 45-60, and 60-75 cm depths were collected before and after cultivation for soil major properties and net CS estimation. Average values of above- and below-ground biomass carbon at NIAB-I, NIAB-II and Gojra were 9.60, 8.21, and 9.61 Mg ha-1, respectively. Average below-ground biomass carbon values were found to be 1.5, 1.3, and 1.4 Mg ha-1 at the three experimental sites, respectively. Resultantly, 6257.59 Mg of C is sequestered annually in biomass and 8604.68 Mg in soil in the IAPP.

Keywords：*carbon sequestration, SOC pool, Pakistan, Maize*

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Soil Organic and Microbial Biomass Carbon Dynamics in Relation to Soil Microbial Population under Different Cropping Systems in Salt Affected Coastal Soils

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Soil carbon stocks and microbial population under different cropping systems were studied in coastal salt affected soils. Different cropping systems significantly change the soil physical and chemical properties, and hence plant growth and crop yields will be affected. Soil samples were collected from different farming systems such as cereal, oilseed, horticulture, vegetables, pulses, cashcrop, fodder, spices and wasteland from salt affected coastal soils of Gujarat, India. Soil physical, chemical, biochemical characteristics, exchangeable cations, available nutrient status and microbial biomass varied considerably with different cropping system. The microbial communities more closely related to different properties of soil. The microbial biomass consists mostly of bacteria and fungi, which decompose crop residues and organic matter in soil. This process releases nutrients into the soil that are available for plant uptake. Soil properties such as pH, EC, texture and organic carbon content influences the size of the microbial biomass.

Soil microbial biomass carbon (MBC) was observed to be higher in soil under spice crops about 600 mg/kg in compare to cashcrop like cotton where it was observed lower. Microbial biomass nitrogen (MBN) was maximum (87.5 mg/kg) in soils under cereals and minimum (19.5 m/kg) in wasteland system. Carbon stocks such as organic and inorganic C stock were observed to be maximum in soils from vegetable and cashcrop system, respectively having content of 21.68 Mg/ha and 9.91 Mg/ha and minimum in oilseed (6.21 mg/ha) and wasteland (2.82 Mg/ha), respectively. Soil enzyme activities such as alkaline phosphatase activity was observed maximum of 54.25 µg PNP/g/h in sub-surface layer in cereal in compared to wasteland having minimum of 15.25 µg PNP/g/h in sub-surface layer whereas acid phosphatase activity was higher (24.75 µg PNP/g/h) in surface layer of soil in Horticulture system and lower (5.25 µg PNP/g/h) in sub-surface layer of soil in pulse system; dehydrogenase activity was maximum of 85.35 µg TPF/g/h in surface layer in cashcrop and minimum of 1.465 µg TPF/g/h in sub-surface layer in waste land.

Keywords: *soil carbon, microbial biomass, enzyme activity, cropping systems, saline soil*

P2-390

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Exploring Phenolic Distributions from the Tmah Thermochemolysis of Peatland Vegetation

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Soil organic matter (SOM) is a major store of terrestrial carbon (C), and peat soils make up a large proportion of this terrestrial C sink. Northern peatlands cover an area of around 4 x 106 km2, and currently store around 547 Gt of organic carbon as waterlogged peat (Yu et al. 2010). Some of the major peat forming plants are the Sphagnum mosses but there is also a significant contribution from vascular plants as well as other non-Sphagnum mosses. Lignin is the second most abundant biopolymer in vascular plants, however, bryophytes such as Sphagnum do not synthesize lignin (Weng and Chapple, 2010). Previous work in our laboratory (Abbott et al., 2013) has proposed that four TMAH thermochemolysis products from Sphagnum (Methylated 4-isopropenylphenol (IUPAC: 1-methoxy-4-(prop-1-en-2-yl)benzene), methylated cis- and trans-3-(4′-hydroxyphen-1-yl)but-2-enoic acid (IUPAC: (E/Z)-methyl 3-(4-methoxyphenyl)but-2-enoate), and methylated 3-(4′-hydroxyphen-1-yl)but-3-enoic acid (IUPAC: methyl 3-(4-methoxyphenyl)but-3-enoate)) are markers of trans-sphagnum acid, and are therefore specific to the Sphagnum mosses. In this study, Sphagnum vegetation and peat samples from a variety of locations will be depolymerized using thermally assisted hydrolysis and methylation in the presence of tetramethylammonium hydroxide (TMAH thermochemolysis) in order to confirm the presence of these proposed biomarkers and examine any possible spatial variability in the abundance of the four proposed Sphagnum marker compounds. Given that there is a range of different compound types that can act as antioxidants in soils and vegetation (Schlichting et al., 2013), results of tests on the potential antioxidant activity of trans-sphagnum acid will also be described.

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[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Soil Disturbance Effects on Plant Residue Decay in Canadian Agricultural Soils

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No-till cropping systems, where soil is left largely undisturbed, are often advocated as a way of increasing soil carbon, in part because they slow the rate of plant litter decomposition. To evaluate the effects of soil disturbance on plant residue decomposition and C retention, a study was initiated in humid (Ottawa, Ontario; 880 mm annual precipitation) and semi-arid (Lethbridge, Alberta; 400 mm annual precipitation) environments in Canada. Our objective was to determine the effect of residue placement (no-till surface vs. conventional incorporation) in controlling residue C retention in the whole soil and composition of the soil microbial community. In the fall 2007 barley straw enriched with 13C (0-9 cm layer) was applied to microcosms at a rate of 200 g C/m2. The microcosms (cylinders 15 cm long x 10 cm diam.) were inserted to 10 cm depth and covered with a nylon screen (1 mm2 openings). Each year thereafter, non-labeled barley residue (200 g C/m2) was either incorporated or applied to the surface, according to treatment, and microcosms were fertilized in the spring (40 kg N/ha). At each site, soil temperature loggers were placed at depth 5 cm inside of a microcosm to record hourly soil temperature. Soil samples (0-5 and 5-10 cm depths) were removed at about 0, 0.5, 1.0, 2.0, and 3.0 years after residue application to estimate decomposition, microbial incorporation, and retention of the 13C-enriched barley residues applied in fall-2007. Soil samples from both depths were analyzed for whole soil organic C and its 13C enrichment, lipids were extracted from field-moist soils, and phospholipid fatty acids (PLFA) and the 13C enrichments in these biomarkers were analyzed. Decay rates were greater at Ottawa than at Lethbridge, where decay was constrained by aridity and cold temperatures in the soil, sporadically unprotected by insulating snow. During the first 0.5 years, surface-placed residues decayed more slowly than residues mixed into soil at both sites. The influence of residue placement on residue C remaining was short-lived at Ottawa, but persisted over the 3-year period at Lethbridge, where aridity constrained decomposition of the surface-placed residues. Within the first year, moisture infiltration combined with earthworm activity transferred 13C from the surface-placed residues to the 5-10 cm layer at Ottawa; such movement was not apparent in the more arid conditions at Lethbridge. The appearance of enriched 13C in PLFA was consistent with the vertical transfer of 13C within the microcosm. 13C-enriched PLFA was detectable in both the 0-5 and 5-10 cm layers when residues had been incorporated into the soil, but when residues were surface-placed, 13C was detected after two years at Ottawa but was never detected in the 5-10 cm layer at Lethbridge. While the complement of PLFA we measured provided only a broad distinction between microbial and fungal decomposers catabolizing the labelled barley residue, the relative contribution of each group showed complex interactions among residue placement, soil layer, and sampling time. The structures of the microbial communities inferred from the PLFA suggested a parallel between the two disparate sites when residues were incorporated into the soil, but when residues were left on the surface, active microbial communities were structurally distinct. The relationships among microbial community, residue placement and climate suggested that all three influenced decay rates; consequently, the mechanisms determining soil C retention in no-till systems are site-specific and more complex than commonly assumed.

Keywords：*long-term decomposition, 13C-labelled, isotopes, tillage, soil carbon, PLFA*

P2-392

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Evolution of Soil Humic Substances in Antropogenic Disturbed Soils

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We carried out researches of soils HS structurally functional parameters in soils of natural climatic belts from taiga up to a forest-steppe and steppe. Investigations have been compiled both in natural, and antropogenically altered soils - arable and buried. The data about HS molecular structure obtained by 13C-NMR and ESR) and the results of studying the important functional parameters of HS (Chukov 2001; Orlov, Chukov 2004; Kechaikina, Ryumin, Chukov, 2011), allow to formulate the basic stages of their evolution in soils.

The first stage is the formation of an original matrix which consists from rather low-molecular organic ligands, occupying the strongest complexing positions on a surface of a mineral particles. These fractions are present not only in a soil profile, but frequently also in top subsoil layers of parent materials, getting there with soil solutions. Very small on weight from 0,05 up to 0,3 % C (from soil weight) these compounds are rather inert. However the following strengthening and completion of high-molecular HS during humus formation take place namely on this matrix.

The second stage is the formation of soil HS system. The basic backbone of their macromolecules is rather closely connected with soil mineral part, both through the matrix mentioned above, and due to new organic-mineral bonds formed during humus formation and distribution of humic film on a surface of mineral particles. The peripheral part of these biochemical active macromolecules possesses a lot of free radicals and high physiological activity.

It is exposed to constant biotical attack and stays in dynamic balance with prehumic compounds of soil solution through the mechanism of constant fragmentary updating. There is a loss of the certain part of the open peripheral chains and heteroatomic fragments of HS, and the tendency to increase in HS molecular weight is observed.

The further development of soil HS system depends in a strong degree on volume and character fresh organic residues obtained. If the hydrothermal conditions of humification and the quantity of these residues is enough for humic-accumulative process, then a gradual escalating of spatial 'skeleton' of humic acids macromolecules occur, that leads to increase in thikness of humic coating (“raincoat”) on a surface of mineral particles.

The third stage of HS evolution is connected with processes of the further transformation and humification the frame structure of 'raincoat' in a direction of selection of biothermodynamically steady products. These processes are especially accelerated in conditions of sharp deficiency of fresh residues and lead to strong polycondensation of macromolecules, formation of polyaromatic systems, growth of interface to simultaneous increase in quantity free electrons. Formation and relative accumulation of such polycondensed structures of coal type was observed by us at studying spectra 13C-NMR humic acids in arable and buried soils (Orlov, Chukov 2004; Kechaikina, Ryumin, Chukov, 2011). For structures of such type appreciable decrease in biochemical and physiological activity is tipical.

It is possible to draw a conclusion, that at this evolutionary stage properties of HS are determined not so much by functional groups, but the general features of redistribution of electronic density in molecular structure of HS.

On the basis of the analysis of processes of evolution and definition of a level of HS biothermodynamic stability it is possible to create correct forecasts of their behavior during the change of biohydrothermal conditions of humification which can be result of change of land use or global climate change is the latter is especially important, as the contribution of a soil HS mineralization in CO2 emission in atmosphere is great enough to influence the fate of climate of our planet.

Keywords：*humic substances, evolution, 13C NMR, antropogenic disturbed soils*

P2-393

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Investigation of Chemical Interactions Between Humic Substances and Calcium Compounds in Fertile Soils

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Carbon particles containing mineral matter promote soil fertility, helping it to overcome the rather unfavorable climate conditions of the humid tropics. Intriguing examples are the Amazonian Dark Earths, anthropogenic soils also known as “Terra Preta de Indio’’ (TPI), in which chemical recalcitrance and stable carbon with millenary mean residence times have been observed.

Organic matter or black carbon atoms of Terra Preta de Indio (Amazonian Dark Earth) soils are composed of oxidized carbon groups as phenols, epoxide, carbonyl and carboxyl groups in their surface. At the pH of soil, carboxylate groups are deprotonated generating carboxylate anions leaving the surface of these soils with negative charges. Calcium cations can interact with oxidized carbon groups by chemisorption interactions lowering the total system energy. In this work, Terra Preta de Indio was examined by X-ray photoelectron spectroscopy and Infrared spectroscopy in order to compare its organic fraction, rich in calcium, with calcium containing samples, such as: calcium carbonate, calcium oxide, calcium phosphate, calcium hydroxide and calcium-doped graphene oxide.

Humic acids fraction (i.e.: the alkaline soluble soil organic matter that precipitate at low pH) of a typical TPI was compared to synthetic humic acids and fulvic acids (i.e.: the alkaline fraction that remain in solution after the pH drop) obtained by chemical oxidation, with sodium hypochlorite, of activated charcoal. The similarity between the spectra indicated the success in the synthesis of an organic amendment similar to the peculiar soil organic matter (SOM) of TPI and the obtained products were polycondensed aromatic structures with carboxyl groups: a soil amendment that can contribute to soil fertility and to its sustainable use. All these findings drive us step-by-step to the ending goal of producing synthetic TPI’s organic matter improving soil usage, with implications in agriculture and climate change.

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Keywords：*Humic substances, Terra Preta de Indio, calcium compounds, organic matter, carbon stabilization*

P2-394

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Carbon, Pedo-Transfer Functions and the Irish Soil Information System

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In response to national requirements to address the need to provide soil with a level of protection similar to water and air and, at international level, whereby 'Communication on a Thematic Strategy for Soil Protection in Europe' has been adopted . The Irish SoiI Information System (ISIS) was created to conduct a programme of structured research into the distribution of soil types over the whole of Ireland ,and construct a soil map, at 1:250,000 scale, which identified and described the soils according to a harmonised national legend. On completion in spring 2014, the map will be in digital form and will be the basis of the new soil information system for Ireland.

ISIS provides a new classification for Ireland that (a) reappraises, rationalises and updates data capture for surveyed areas; (b) predicts maps of un-surveyed areas, based on soil-landscape models and data from surveyed areas, including additional capture of new data for soils not previously encountered, using traditional soil survey techniques; (c) construction of a soil information system for Ireland (SIS) that will provide a data infrastructure for organising, managing and disseminating soil information at national and international level.

A requirement of ISIS was to describe and classify 300 soil profile pits. These pits represent the majority of soils in Ireland that were not covered by the modal profiles in the previous soil survey by An Foras Taluntais (AFT), 1960-1980. The 300 pits were selected from a database generated by a field survey of 15,000 auger bores, surveyed in 2010-2012. Profile pits were allocated if the soil was deemed representative (i.e. it occurred frequently across the soil auger survey) and/or had not been described in detail (physical, chemical and biological parameters) previously (AFT survey). ISIS also required the correlation of soils from the updated Irish classification into World Reference Base (WRB) classification. The profiles have generated an extensive database as they were sampled for the following laboratory analyses; pH, C:N, OC, CEC, Base Satuation, Fe/Al (oxalate, dithionite and pyrophosphate extractions),texture, bulk density, Microbial biomass C, Multiple Substrate Induced Respiration, Phospholipid Fatty Acids (PLFA), Nematodes.

Using the same digital soil mapping and modelling techniques used for general soil map, predictions will be made of a range of soil properties at the national scale (soil organic carbon, depth, bulk density, texture). These parameters will then be compared to measured data in the 300 pits. Properties of greater predictability will be identified. It is also envisioned that pedotransfer functions will be developed from the measured pit data. Estimates of organic carbon contents in relation to soil series (soil types) with depth (15 cm , 50 cm and 100 cm) and bulk density estimates in relation to organic carbon content and soil texture, will be calculated. These will help fill gaps in parameters from the old AFT survey.

Keywords：*Carbon, Bulk Density, Pedotransfer funcions, Soil properties, ISIS*

P2-395

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Carbon Stock in Different Types of Caatinga Forest in the Semiarid Region of Paraiba State, Brazil

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Forests play a significant role by storing large amounts of carbon in their biomass and other forest compartments, as in the understory, in forest litter and soil, sequestering of carbon in the atmosphere. Aiming to determine the amount of organic carbon in the caatinga area under different successional stages in dry and rainy season, a field trial was carried in the Nucleus of Desertification of "Serido", in the Cachoeira de Sao Porfirio farm, in Varzea municipality (Paraiba State / Northeastern Brazil). The experiment was conducted in a 4 x 2 factorial arrangement, four areas of 3,000 m² each, with vegetation in four successional stages (native pasture, secondary early caatinga, secondary late caatinga and mature caatinga), and two periods (dry and rainy) in 15 repetitions. We evaluated samples of plant material in the understory and litterfall and also soil samples to determine the levels of carbon. Samplings of understory and litter amounted to 120 samples in each compartment. The ground plant material was sent to the laboratory of Embrapa SemiArid to determine the organic carbon contents. The soil was collected at 04 depths (0-5.0 cm, 5.0-10.0 cm, 10.0-15.0 cm and 15.0-20.0 cm), totaling 96 samples in both seasons, whose analyzes were performed in the Soil and Water Laboratory of the Federal University of Campina Grande, in Patos, Paraiba State, Brazil. Data were subjected to analysis of variance at a significance level of 5 %, using the statistical software SAS STAT. Carbon stocks were assessed in the understory, in leaf litter and soil. To compartment understory was observed only significant interaction between areas and periods. The unfolding of the interaction it was verified that the largest amount of carbon in the understory in the rainy season has been found in the area of secondary early caatinga, with 0.74 kg ha-1. Already in the dry season the higher carbon content was found in the caatinga late secondary (0.68 kg ha-1). In litter, the carbon content did not differ between successional stages during the rainy and dry season. For the soil compartment, it was found that the data for the carbon content in soil significantly different seasons, areas and depths studied independently. The depth of 0-20.0 cm, it was found that higher carbon content in the soil during the dry season (14.99 Mg ha-1), in the area of mature caatinga. Analyzing depths, it was found that higher levels of carbon in the soil are found in initial depth (0-5 cm). The highest concentrations of organic carbon were found in the area of mature caatinga. Regardless of successional stage, carbon concentrations showed seasonal variation, recording the highest values in the dry season, and these data an important indication that the caatinga is efficient in accumulating carbon during the water deficit. Regarding the understory in the rainy season the area of caatinga late secondary showed a higher concentration of carbon in the dry season and the area of caatinga late secondary scored the highest concentration of organic carbon. Among the plants compartments, the largest concentration of carbon occurred in the litter of the most preserved areas. In soil, the highest content and carbon occurred in the surface layer (0-5.0 cm) with decreasing values as far as the depth increases. It is emphasized that anthropogenic interference in this compartment will release to the atmosphere the CO2 that is retained in the soil. The data obtained in the different compartments give an indication that the mature caatinga or restore process has the potential to absorb and retain carbon may include the carbon credit market. This possibility may encourage the preservation of caatinga forest along to farmers, thereby increasing forested areas, with positive consequences for CO2 mitigation.

Keywords：*desertification, organic carbon, dry forest*

P2-396

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Soil Organic Carbon Sequestration Potencial for Brazilian Cerrado Pastures Estimated by Modelling

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In the last years, Brazil has become one of major players in the world beef cattle market. The majority of theBrazilian beef cattle production is based on extensive or semi-extensive systems, where the pastures are the main source of herd feeding. There is a lot of discussion about which is the total contribution of Brazilian livestock to the GHG emissions and how it can be mitigated. One possible mitigation action is the carbon sequestration by soil. The literature has showed that production systems involving the use of tropical pastures can sequestrate significant quantities of carbon in soil. The aim of this study was to parameterize the Century model and simulate the dynamics of soil carbon under different pasture managements for the Cerrado region of Brazil.

In this study, we used the version 4.0 of the Century Model to simulate the soil carbon stocks for the 0-20cm depth. In order to initialize the model, firstly we made a 3,000 years equilibrium simulation of a natural Cerrado vegetation (forested savanna). After that, to derive the initial soil carbon stocks for this study, we run a base simulation with the Cerrado clear-cutting and a low productivity pasture planting without fertilization, and continuous light grazing as it is usual in the region. For all simulations, the model parameterization was done using a climatological normal 1961/2010 data for Campo Grande, MS (20º 26' 34' S; 54º 38' 47' W) and a soil characterized as Oxisol (Latossolo Vermelho) with 530, 200, 270 g.kg-1 of clay, silt and sand respectively. After the equilibrium and base runs, we made 30 years simulation run using four pasture management conditions:

a) Low productivity pasture (NPP?4Mg.ha-1.y-1), No fertilization, continuous light grazing, based;

b) Low productivity pasture (NPP?6Mg.ha-1.y-1), with nitrogen fertilization (15kg.ha-1.y-1), continuous light grazing;

c) High productivity pasture (NPP?12Mg.ha-1.y-1), with nitrogen fertilization (100kg.ha-1.y-1), rotational heavy grazing; and,

d) High productivity pasture (NPP?20Mg.ha-1.y-1), with nitrogen fertilization (200kg.ha-1.y-1), rotational heavy grazing.

After the equilibrium and base runs, the model simulated a soil carbon stock of 35.7 Mg.ha-1.y-1. This value was in agreement with data observed in the literature. After the 30 years simulation the model estimated a final soil carbon stock for the depth 0-20cm of 30.1, 33.7, 51.8 and 64.7 Mg C.ha-1 respectively for the managements a, b c and d.

The simulation for the managements systems a and b estimated a reduction in the stocks throughout time, with losses of 0.19 and 0.07 MgC.ha-1-1.year. These two management scenarios are quite common in central Brazil, where there are extensive areas of degraded pastures. For the management b, an annual fertilization with 15 kg N.ha was almost enough to keep the C stocks in equilibrium. For managements systems c and d, the model estimated C sequestration rates of 0.54 and 0.97 MgC.ha.ano-1. These values of sequestration are in agreement with values that have been reported in the literature. The last two managements systems(c and d) are examples of high performance systems that represent a new tendency in Brazil.

Several research works have argued that carbon sequestration in soil depends largely on the availability of nitrogen in addition to the plant primary production. The simulations have confirmed this fact. From the standpoint of C sequestration in soil as mitigation GHG emissions from livestock production practice, caution is necessary in recommending the use of high doses of nitrogen fertilizers. Such use may compromise the final balance of C in the production systems because of the GHG emissions associated with the manufacture of these fertilizers and losses by volatilization of ammonia and denitrification in soil.

Keywords：*soil carbon, soil carbon sequestration, soil carbon modelling*

P2-397

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Two-Dimensional Chromatographic Characterization of Dissolved Organic Matter from Forest Floor Leachates and Ground Water

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Dissolved and colloidal phase organic carbon (DOC) plays an important role in the carbon cycle and in formation of soil organic matter. It is a highly diverse composition of organic compounds and consists of, for example, humic acids, fulvic acids, phenols and amines. The amount and composition of DOC varies significantly as a function of parent material and land use. Our point of interest hereby is to see differences in the amount and composition of DOC at different landscapes and soil depths. To investigate the distribution and composition of DOC, we obtained dissolved organic matter from forest floor, soil horizons and aquifers along a land use gradient near Hainich national park, Thuringia, Germany. To explore the DOC composition we use comprehensive two-dimensional gas chromatography (2D-GC) with flame ionization detection. DOC is thereby chromatographically separated along the molecular mass and the amount of functional groups. The resulting two dimensional diagrams are then analyzed with image analysis and spatial statistical tools to detect differences in composition and to identify patterns.

The composition and amount of DOC varies with respect to site, land use and depth. Highest DOC concentrations were found in the eluate of O horizons (cDOC = 233.3 mg/l), decreasing with depth for all sites (Ah horizon cDOC = 20.0 mg/l; groundwater cDOC = 0.6 mg/l). The number of 2D-Chromatogram features observed for the 2D-GC images were highest and most intense for the O-horizon eluates. Yet, both soil and groundwater DOC exhibited a comparable high chemical diversity, but at lower intensities. We identified 2D-Chromatogram patterns that persisted through all compartments. We interpret these patterns to represent compounds formed in the forest floor that are chemically stable and mobile, so that they will migrate along the vertical flow path. We can receive possible organic compounds based on their molecular masses in the first dimension and their functional groups in the second dimension of the 2D-Chromatograms. Another class of 2D-Chromatogram features were present only in one compartment, indicative of eventually less stable compounds rapidly recycled or strongly reactive towards surfaces thus suffering strong retardation. We can show that there are differences in the composition and also in the amount of DOC at different landscapes and also different soil depths. By providing images that can be analyzed for characteristic DOC patterns this method afford the potential to study the fate of DOC along large-scale flow paths.

Keywords：*DOC, comprehensive two-dimensional chromatography, colloidal organic carbon, ground water*

P2-398

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

The Magnitude of Alkalinity Priming Induced by Organic Compounds Depends on Initial Soil Ph and Native Organic Carbon Content

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Organic compounds, commonly found indecomposing organic residues and root exudates, had different effects on soil pH change.This study examined the relative contribution oforganiccompounds to pH changes in soils differing in initial pH and organic matter content.Three organic compounds (malic acid, glucose and glucosamine) were added at 1 g C kg-1 toKandosol (pH 5.4 - 5.8), Podosol (pH 4.4 - 4.5), Tenosol (pH 4.7 - 6.1) and Calcarosol (pH6.0) and incubated for 15 d. The addition of malic acid immediately (0 d) decreased pH forall soils due to dissociation of H+ from carboxyl functional groups. The magnitude of the pHdecrease varied among the soil types. The pH then increased to exceed the initial valueduring subsequent incubation, resulting in “alkalinity priming”, in all the soils except thePodosol. The alkalinity priming upon the addition of malic acid mainly resulted from nitrateimmobilization, ammonification and decomposition of native soil organic C. The extent ofalkalinity priming was positively correlated with native soil organic matter content. Glucoseand glucosamine did not have any immediate effect on pH in any soil. With incubation time,addition of glucose increased soil pH except for Podosol and Tenosol subsoil. The addition of glucosamine generally decreased soil pH except forthe Podosol where no pH change was detected. The pH changes upon addition of glucose andglucosamine were mainly attributed to soil nitrogen transformation. This study concludedthat initial soil pH and organic matter content played an important role in soil pH changecaused by the organic compounds, and that stimulated decomposition of native soil organic Ccontributed to the alkalinity priming upon the addition of malic acid.

Keywords：*Acidification, decomposition, nitrogen transformation,soil respiration*

P2-399

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Changes in Soil Organic Carbon in Response to Climate Manipulation under Cassiope Tetragona in Zackenberg, Greenland

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It is projected that climate change will be more pronounced in the Arctic than further south. Climate change will affect the quantity and/or quality of soil organic carbon (SOC) which is directly related to carbon dioxide fluxes. Thus, it is crucial to understand how soil will respond to climate change in the Arctic where large amount of SOC is accumulated due to low temperature. In this study, we aimed to understand the characteristics of SOC and the effects of climate manipulation on SOC under the high arctic heath. We hypothesized that change in temperature and in growing season length would affect microbial activities and thus the amount and chemical composition of SOC. This study was conducted in the long-term climate manipulation plots established in Zackenberg, Greenland in 2004 by Prof. Michelsen and coworkers. There are one control (C) and four treatments plots: warming (T), shading (S), short growing (SG), and long growing (LG). Soil sampling was conducted in the Cassiope tetragona site in 2011. Three 15 cm depth soil cores (5 cm diameter) were taken in one plot, and each soil core was divided as the litter layer, 0-5, 5-10, and 10-15 cm depths, and then three cores in the same depth interval were pooled together. SOC was measured by a combustion method (950 ºC). Density fractionation (sodium polytungstate, 1.55 g cm-3) separated SOC as free light fraction (FLF), occluded light fraction (OLF), and heavy fraction (HF). 13C NMR was conducted for one FLF sample per each treatment. Preliminary analyses showed that thawing depth and litter layer thickness were not significantly different among treatments. Soil temperature in the T treatment was 1.2-1.5 °C higher than in the other treatments. Bulk density, moisture content, and soil pH did not vary among treatments. There were no statistical differences in SOC, and SOC in the 0-5 cm depth was in a range of 3.5 to 5.2 %. Total inorganic carbon was rarely or never detected across all treatments. Density fractionation showed that there were differences in FLF, with a lower amount of FLF in the T and SG treatments than that in control. 13C NMR showed that in the T treatment, the ratios of the O/N-alkyl C (labile) and that of the alkyl C (recalcitrant) groups were relatively lower and higher than the others, respectively. Warming did not alter the amount of SOC, however, it might cause the change in SOC quality by decreasing a labile portion of SOC.

Keywords: *climate manipulation, soil organic carbon, density fractionation, 13C NMR*

P2-400

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Coal Fly Ash Amendment Reduced Soil Carbon Loss in Temperate Rice Paddy

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Introduction

Agricultural soil can be a substantial carbon (C) sink when their C content is below the C saturation point, an equilibrium C content at which no more C can be sequestered under steady C inputs (West and Six, 2007). When compared to upland soils, fine-textured paddy soils are considered to be more effective for C sequestration due to the slow decomposition of organic C under submerged anaerobic conditions during cultivation (Sahrawat, 2004). Fine-textured and Ca-enriched coal fly ash (FA) has the potential to reduce soil C (SC) loss by adsorbing CO_2 through carbonation as well as by enhancing soil organic matter stabilization through organo-mineral complexation; however, its effects on SC content remains unknown. We conducted a field experiment to study the effects of FA on rice growth (grain yield and yield components) and SC content over three consecutive temperate rice cropping seasons. To address the interactive effects of FA and other types of nutrient additions on rice yield and SC content, the experiment included treatments with various nutrient sources, including synthetic fertilizer, humified organic input (livestock manure compost), and fresh organic matter input (green manure).

Materials and Methods

In 2010, thirty-six plots (1 × 1 m^2) were prepared for three FA treatments (0, 5, and 10%; coded as FA0, FA5, and FA10, respectively) and four N inputs (no input, NI; urea, U; pig manure compost, PMC; hairy vetch as a green manure, HV) in a completely randomized block design with triplicates. Two days before transplanting rice in the first year (2010), FA was applied with nutrient inputs and mixed into the surface soil (0 to 20 cm). In the second and third years, only the application of other nutrients was repeated. In each year, three 30-day-old seedlings (referred to as a hill) of rice (Oryza sativa L., cv. Ilmybyeo) were hand-transplanted into each plot (a total of 21 hills per plot). At 120 days after transplanting, rice plants were harvested and analyzed for dry matter, C and nutrient contents. Rice growth parameters were determined for three selected hills. Soil samples were collected and analyzed for C and nutrient contents. The effects of FA application rate on plant and soil parameters were statistically evaluated with the analysis of variance (ANOVA) using the general linear model procedure of the AASW statistics (IBM Corp. Amonk, NY, USA). When the treatment effects were significant, the means were separated by the Duncan's multiple range tests.

Results and Discussion

Across the three rice cultivation seasons, FA5 produced grain yield comparable to FA0. In FA5, FA application substantially decreased tiller and panicle numbers, but grain yield was redeemed by increased grain mass. However, FA10 reduced grain yield by up to 10% relative to FA0 probably due to the adverse impact of FA on soil environment such as P immobilization and B and As toxicity. At the end of 3-yr rice cultivation, FA application increased SC content over FA0 by 12.2 and 9.6% in NI, by 17.1 and

4.9% in U, by 10.9 and 11.3% in PMC, and by 28.0 and 30.3% in HV, for FA5 and FA10, respectively, after excluding the direct contribution of black C from FA. Because the production of plant residues (straw and root) was lowered by FA application, the increased SC content by FA application was attributed to reduced SC loss through biochemical (inhibition of microbial decomposition of organic matter), chemical (reduction of gases C loss by formation of $CaCO_3$), and physical (protection of organic matter) mechanisms (Lim and Choi, 2013). This study highlights the potential use of FA as a soil amendment for soil C sequestration without undermining grain yield for paddy rice particularly when FA was applied at a low rate (5% in this study) and HV was co-applied as a nutrient.

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Keywords：*Soil carbon sequestration, Paddy soil, Paddy rice, Fly ash, Carbon loss*

P2-401

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Statistical Optimization of Medium Components for Chitinase Production by Pseudomonas Fluorescens Strain HN1205; Role of Chitinase on EGG Hatching Inhibition of Root-Knot Nematode

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In this paper, statistical Plackett?Burman design (PBD) and central composition design were used to optimize the medium components to enhance the chitinase activity of Pseudomonas fluorescens strain HN1205. Among the seven nutritional elements studied, crab shell powder, CaCl2?2H2O and yeast extract were proved to have significant effects on chitinase activity by PBD first. An optimal medium was obtained by using a three factor central composite design, which consisted of crab shell powder (1.0 g l-1), CaCl2 (0.5 g l-1) and yeast extract (0.5 g l-1), respectively with the highest chitinase activity of 1.03 U ml-1. This value was 2.87 fold of chitinase activity compared to the lowest productive medium in the design matrix. The chitinase produced by the HN1205 was partially purified with 80% ammonium sulfate and anion-exchange chromatography, and assessed for inhibition of nematode' eggs hatch. The partially purified chitinase significantly reduced to 41.3 and 46.6% of egg hatch compared to SDW and boiled chitinase, respectively. In this present study, we demonstrated the optimal production and the role of chitinolytic enzymes by the HN1205 that may be useful for further development of a biotechnological use and biological control.

Keywords：*Pseudomonas fluorescens HN1205; Plackett?Burman design; Chitinase; Central composite design*

P2-402

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Nematicidal Activity of Lactic Acid Produced by Lysobacter Capsici YS1215

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Lysobacter capsici YS1215 isolated from soil previously showed nematicidal potential for biological control of root-knot nematode. In this study, lactic acid, nematicidal compound, was isolated from culture filtrate of the YS1215, and its ovicidal activity was investigated. Purification and identification of lactic acid was performed by series of column chromatographies and identified by 1H and 13C-NMR spectrum and GC-MS analysis. Our results showed that bacterial culture filtrate containing lactic acid significantly inhibited egg hatch. The lowest egg hatch rate (5.9%) was found in high concentration (1,250 mM) of lactic acid at 5 days after incubation, followed by 1,000 (15.2%), 750 (23.7%), 500 (29.8%) and 250 (36.4%) mM while egg hatch in control (sterile distilled water) was 44.5%. Additionally, crude compounds extracted from bacterial culture filtrate with ethyl acetate also showed significant suppression of egg hatch. This is the first report of lactic acid as an ovicidal compound and it may be considered as alternative of chemical pesticide against root-knot nematodes.

Keywords：*Lactic acid, Lysobacter capsici YS1215, Bacterial culture filtrate, Crude extract, Egg hatch*

P2-403

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Effects of Nitrogen and Carbon Contents in Different Soils Cooperated with Organic Composts and Bio-Char during Incubation Periods

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Objectives of this study were to estimate the carbon sequestration and to evaluate the change of total nitrogen content in soils cooperated with organic composts and bio-char during incubation periods. The soils used in this study were sandy loam and clay loam types. For micro incubation experiment, soil moisture was kept 40% of water holding capacity with continuously maintaining by weight method with adding deionized water. The teferon tube charged with soil was placed in incubator at 27℃. Application rates of chemical fertilizer and bio-char were recommended amount after soil test and 2 % to soil weight, respectively. The soil samples were periodically taken at every 5 day intervals during the experimental periods. The treatments were consisted of 5 levels such as non-application, pig manure compost, pig manure compost with swine digestate from anaerobic digestion system, pig manure compost with bio-char, pig manure compost and swine digestate with bio-char.

For the experimental results, soil pH to different treatments during incubation periods was high in the treatments of pig manure compost and swine digestate and its bio-char in both sandy loam and clay loam soils. Nitrogen contents in the treatments of pig manure compost and swine digestate and its bio-char in both sandy loam and clay loam soils were higher at 0.5 times than the other treatment after 20 days of incubation periods. For the soil carbon sequestration, it was appeared that soil carbon in the treatments of pig manure compost and swine digestate and bio-char was estimated to be stored more 256 t C/ha than the control in the sandy soil.

Keywords：*Carbon sequestration, nitrogen, organic compost, swine digestate*

P2-404

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Physicochemical Properties of Soils as Affected by Minimum Tillage and Direct Seeding Cultivation on Dry Rice Paddy

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In order to evaluating physiochemical properties of soil under minimum tillage and direct seeding cultivation on dry rice paddy, we conducted to analyze the soil physiochemical characteristics in treatment with 2-year minimum tillage and dry direct seeding(2MT), 3-year minimum tillage and dry direct seeding(3MT), and tillage transplanting cultivation(TT). As results of analyzing soil organic matter (OM) contents with 2 cm soil depth of interval from surface to 30 cm, OM contents with surface soil from 0 to 2MT and 3MT were higher than TT, recorded 34.6, 28.1 and 19.8 g kg-1, respectively. But until 20cm in soil depth, it was not so large on the deviation of OM contents among the 3 treatments comparing with 2cm surface. Beneath 20 cm in soil depths, 2- and 3-year, OM contents in TT were distributed to be lower than 2MT and 3MT. The contents of total nitrogen in 2MT and 3MT were higher than the content in TT cross the soil profile. Consequently, though minimum tillage and direct seeding farming is obviously the practice to saving of machinery work and labor, other practices such as continuously input OM should be needed to achieve carbon sequestration goal through minimum tillage and direct seeding on dry paddy.

Keywords：*Minimum tillage, Direct seeding on dry paddy, Low carbon farming*

P2-405

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Impact of Maize Growth on Soil Carbon Dynamics in 13C-Labeled Plant Residue Incorporated Soil

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Plant growth has been known as one of the interactive factors for soil carbon (C) dynamics but its effects on soil C sequestration are still controversial. It is also important to validate how addition of fresh plant residue becomes incorporated into pre-existing soil C while plant grows. To investigate changes in soil C dynamics in relation to plant growth, we performed a pot experiment with and without maize crops after application of 13C-labeled plant residues (2.1 13C atom %) to the soil at a rate of 2.3 kg ha-1, and then measured periodically CO2 emission. The size-density fractionation of soil C was conducted at the start, harvest of aboveground biomass and 3 months after harvest to assess temporal changes in soil carbon's stability, and the corresponding 13C signature of each size-density fraction was determined. Throughout the experiment, soil C storage was not affected by maize growth, and CO2 emission was about 35.4 % higher in uncropped soils than in cropped soils during the growing season but was similar at harvest. The high δ13C value (+10.7 ‰ in average) of CO2 emitted from uncropped soils indicated that CO2 emissions from uncropped soils during the growing season were mostly from 13C-labeled plant residues. In contrast, the δ 13C signatures of the free light fraction in cropped soils increased gradually throughout the experiment. The δ13C signature of each size-density fraction showed that maize growth did not influence the patterns of association of new plant residues in each size-density fraction. This result suggested that maize growth affected decomposition of newly introduced plant residues into CO2 but not affected their association with soil particles.

Keywords：*maize, δ13C, size-density fractionation, soil carbon, 13C-dilution*

P2-406

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Composition of Soil Organic Matter in Moist Acidic Tussock Tundra, Council Alaska

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Soil organic matter (SOM) plays crucial roles in the global carbon cycle. Especially, SOM in the Arctic tundra region has lately gained much attention because of a huge amount of carbon storage for a long time related to recent rapid warming. Understanding the quality as well as the quantity of SOM is important to predict the decomposability of SOM under future climate scenario. Therefore, we investigated the composition of SOM under moist acidic tussock tundra in Council, Alaska where the thick organic soil layer is well developed. We collected soil samples from 36 spots at two depths (0~10 cm and 10~20 cm) in 2011. We also surveyed plant species composition and their coverage before soil sampling to investigate whether SOM composition would be related to vegetation. Pyrolysis-gas chromatography/mass spectrometry (py-GC/MS) was used to identify SOM composition. Pyrolysis-GC/MS data and subsequent principal component analysis (PCA) results preliminarily showed two distinct patterns of SOM composition. One group of soil was composed of relatively large size of compounds that were detected at later retention time during GC analysis, but the other group showed opposite results. The soil samples containing small size of SOM compounds were positively related to moss coverage. More specific and detail investigations for the pyrolysis products and their probable origin are currently underway.

Keywords：*soil organic matter, moist acidic tundra, py-GC/MS*

P2-407

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Carbon and Nitrogen Stocks of Trees and Soils in a 'niitaka' Pear Orchard

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To report country-specific carbon and nitrogen stocks data in a pear orchard by Tier 3 approach of 2006 IPCC guidelines for national greenhouse gas inventories, an experimental pear orchard field of the Pear Research Station, National Institute of Horticultural and Herbal Science, Rural Development Administration, Naju, Korea (35°01'27. 70" N, 126°44'53.50"E, 6 m altitude), where 15-year-old 'Niitaka' pear (Pyrus pyrifolia Nakai cv. Niitaka) trees were planted at a 5.0 m x 3.0 m spacing on a Tatura trellis system, was chosen to assess the total amount of carbon and nitrogen stocks stored in trees and orchard soil profiles. At the sampling time (August 2012), three trees were uprooted, and separated into six fractions: trunk, main branches, lateral branches (including shoots), leaves, fruits, and roots. Soil samples were collected from 0 to 0.6 m depth at 0.1 m intervals at 0.5 m from the trunk. Dry mass per tree was 4.7 kg for trunk, 13.3 kg for main branches, 13.9 kg for lateral branches, 3.8 kg for leaves, 51.3 kg for fruits, and 14.1 kg for roots. Amounts of C and N per tree were respectively 2.3 and 0.02 kg for trunk, 6.4 and 0.07 kg for main branches, 6.4 and 0.09 kg for lateral branches, 6.5 and 0.07 kg for roots, 1.7 and 0.07 kg for leaves, and 3.2 and 0.03 kg for fruits. Carbon and nitrogen stocks stored between the soil surface and a depth of 60 cm were 138.29 and 13.31 Mg ha-1, respectively, while those contained in pear trees were 17.66 and 0.23 Mg ha-1 based on a tree density of 667 trees ha-1. Overall, carbon and nitrogen stocks per hectare stored in a pear orchard were 155.95 and 13.54 Mg, respectively.

Keywords: *Carbon stocks, IPCC 2006 guideline, Nitrogen stocks, Net primary productivity*

P2-408

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Distribution of Carbon and Nitrogen in Soil Aggregation Fraction under Long-Term Application of Rice Straw and Rice Straw Compost in Paddy Field

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Organic matter is a major binding agent to stabilize soil aggregates, while soil aggregates protect the organic matter and act as an important reservoir of carbon and other mineral nutrients. The aggregate-associated organic carbon and nitrogen are protected from mineralization because of their being less vulnerable to physical, microbial or enzymatic degradation. Therefore, it is important to investigate the aggregate pools of soil organic carbon and total nitrogen as influenced by long-term application of rice straw and rice straw compost. The objectives of this study were to investigate the long-term effect of rice straw and rice straw compost in paddy field on (ⅰ) Distribution of water stable aggregates in the soil (ⅱ) Amount of total organic carbon (TOC) and total nitrogen (TN) in different aggregate sizes fractions. This experiment was initiated in 1979 to investigate the effects of long-term application of rice straw and rice straw compost with different levels of nitrogen fertilizer in paddy field at research farm of Department of Rice and Winter Cereal Crop, National Institute of Crop Science, Iksan, Korea. The organic matters were applied 5 Mg/ha/year as rice straw and 10 Mg/ha/year as rice straw compost, respectively. Five rice cultivars were cultivated as follow: 'Iri 326' in 1979, 'Saetbyeolbyeo' in 1980, 'Pungsanbyeo' in 1981-1986, 'Pungsanbyeo' and 'Hwachungbyeo' in 1987-1990, 'Hwachungbyeo' in 1991-2001, and 'Dongjin 1' since 2002. After rice harvest in 2012 (the 34th year after the onset), soil sample were collected from the surface (0-15 cm) and air-dried for analysis. The total water stable aggregates (WSA) by organic matters treatment were 22.3, 27.3 and 31.9% in control, treated rice straw and rice straw compost, respectively. An aggregate fraction of 0.25-0.1 mm made up the largest (11.66-15.85%) whereas >2 mm fraction made the least contribution (0.56-3.87%) in total WSA. Mesoaggregates (1-0.25 mm) had higher TOC content as compared to macro (2-1 mm) and microaggregates (0.25-0.1 mm) at all treatment. Mesoaggregates had the highest (56.44-79.62 g/kg) and microaggregates had the least TOC content (28.37-34.30 g/kg) in the soil. The application of organic matters either rice straw or rice straw compost increased the accumulation of TOC in almost aggregation fraction over control except for 2-1 mm fraction. Mesoaggregates were richer in TN content as compared to macroaggregates. The highest TN content observed in 1-0.25 mm fraction (3.41-4.78 g/kg), whereas lowest TN concentration was recorded in 2-1 mm fraction (1.47-3.03 g/kg). The TOC and TN concentration increased further when rice straw compost was treated. It is carried out that soils can be rehabilitated and can sustain the TOC and TN levels with long-term application of rice straw compost. This will also help in controlling the rising levels of atmospheric carbon dioxide.

Keywords：*Soil aggregation, long-term application, rice straw , rice straw compost, total organic carbon, total nitrogen*

P2-409

[C2.2-2] Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Monitoring Chemical Properties of Up-Land Soils in Chungbuk Region

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Studies were conducted to provide basic data for production of safe agricultural products by reducing soil and water pollution, and to establish soil improvement and fertilization policy for environmentally friendly agriculture. Field monitoring was performed to evaluate the soil chemical properties of 180 upland soil samples every four years from 2001 to 2013 in ChungBuk province. Soil chemical properties such as pH, Electrical Conductivity (EC), Organic matter(OM), Available phosphate(Av. P_2O_5), Exchangeable cation (potassium, calcium and magnesium) contents were analyzed. The chemical properties of upland soil in 2013 increasesd in pH, OM and Av. P_2O_5 compared with 2009 and while EC, Ex. K, Ex. Ca and Ex. Mg was deminished.

Frequency distribution of chemical properties from upland soils decreased insufficient levels of nutrient in top soil compared with 2009, 2005 and while pH, EC, OM, Av. P_2O_5, Ex. K, and Ex. Ca was significantly increased in excessive level.

These results indicated that a balanced management of soil chemical properties can improve the amount of fertilizer applied for environmentally friendly agriculture in controlled Uplands.

Keywords：*Upland soil, Chemical property , Soil fertility*

P2-410

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Effect of Cattle Manure Inoculation with an Alkaline Phytase Producing Bacilli in Organic P Mineralization, Bacterial Community and Wheat P Uptake

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The aim of this work was to evaluate the effect of manure inoculation with an alkaline β-propeller phytase producing bacterium (PBB) in the organic P mineralization, changes in bacterial community structure, inoculum survival and plant P uptake. Eleven strains selected from previous rhizosphere phosphobacteria screening studies were had their phytase activity briefly biochemically characterized. Six strains with cell associated acid phytase activity and two strains with alkaline phytase activity were identified. Most studied strains showed phytases expression inducible by phosphate deficiency. Bacillus sp. MQH-19 was the only strain with extracellular alkaline phytase activity, and was selected to be tested as an inoculant in neutral to alkaline wastes environments. The inoculation of manure with Bacillus sp. MQH-19 bacterium strain at under unbuffered (no pH control) and non-sterile conditions promoted an 8 and 13% increase in the NaHCO3 and NaOH-EDTA extracts respectively. Changes in bacterial community structure due to PBB inoculation were studied using denaturing gradient gel electrophoresis analysis of 16S gene (16S-DGGE), which was PCR amplified from environmental genomic DNA extracts. Bacterial community structure was significantly affected by PPB inoculation up to 6 days after inoculation. Principal component analysis of 16S-DGGE relative band volumes showed that higher effect of inoculation on the bacteria community structure was at day 3. Inoculum persistence was evaluated using quantitative PCR of β-propeller gene harbored by Bacillus MQH-19. The relative abundance of β-propeller gene in respect to total 16S showed a rapid decrease pattern in time, caused by both bacterial biomass growth and absolute inoculum decrease. Curiously, the absolute increase of 16S gen copies during incubation was reduced by phytate addition to both inoculated and uninoculated samples. The potential use of cattle manure inoculated with PPB as biofertilizer was evaluated. Although PPB inoculation resulted in a significant P hydrolysis in manures, the application of PPB inoculated manure to P deficient volcanic soils (Andisol) did not led to a significant response in wheat growth and P acquisition.

Keywords：*Phytase, Andisol, Manure, Bacteria, Bacillus.*

P2-411

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Relationship between Vegetation Indices and Biological Activity of Different Types of Biological Soil Crusts

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Global environmental change is considered the main environmental problem of the last century. Global change is promoted by anthropic activities, which modify land uses and increase atmospheric CO2 concentrations, affecting the structure and functioning of terrestrial ecosystems. Vegetation and soils play an active role in carbon (C) storage which is crucial for assessing the impacts of increasing atmospheric CO2 concentration on global environmental change and on the terrestrial biosphere. Thus, accurate continuous information about C stocks and C fluxes in the different ecosystems constitutes an essential issue for scientists and researchers from many different disciplines. Several tools and methodologies have been developed with the aim of quantifying the role of terrestrial ecosystems in global C balance. Remote sensing images constitute one of the most promising tools to achieve this goal, since they provide spatially explicit information with high temporal resolution. Based on remote sensing data, numerous vegetation indexes have been intensively used to asses biophysical conditions of vegetation and to quantify gross primary production. However, most of these efforts have been made in humid regions, and information about arid and semiarid areas is rather scarce despite the demand for an increasing knowledge of the functioning of these areas which cover about 40% of the global land surface. Semiarid ecosystems usually show a patchy distribution in which sparse and patchy vegetation cover is interspersed over a bare open matrix. These bare areas are often covered by biological soil crusts (BSCs), a complex community formed by a close association between soil particles and cyanobacteria, algae, microfungi, lichens or bryophytes that live within or immediately on top of the uppermost millimetres of the soil surface, and may cover up to 80 % of the soil surface. These surface components are able to trigger metabolic activity with limited rainfalls or using air humidity, and fix CO2 through photosynthesis, thus contributing high amounts of C to soils. Moreover, the C stored in soils covered by BSCs may constitute an important nutrient surplus for soil microbial communities or vegetation. Thus, quantifying the biological activity and C fluxes on BSC areas using remote sensing data constitute an essential step to advance in the knowledge about the role of arid and semiarid regions in global C balance.

The objective of this study is to compare gross photosynthesis (GP) in BSCs with the most widely used vegetation indexes, such as the normalized vegetation index (NDVI), the enhanced vegetation index (EVI) and the photochemical reflectance index (PRI), to finally assess the potential of remote sensing information for quantifying the effect of BSCs in semiarid ecosystem C fluxes and in the global C balance. To achieve this objective, GP was calculated, after a rainfall event on different BSCs and on bare field plots, as the sum of net primary production, measured with an IRGA Li-6400 and soil respiration measured with a respirometer EGM-4 (PP Systems). Once we evaluated the effect of the different types of BSC on GP, we used field spectrum acquired on each plot with a spectroradiometer to calculate NDVI, EVI and PRI, to later evaluate their applicability to quantify the biological activity of BSC. Our results showed an increase in GP, NDVI, EVI and PRI, measured after a rainfall event, from bare soil to more developed BSCs. The relations of these indexes with the ratio GP/PAR were lower than expected, and only EVI and PRI indexes showed a significant relation with the ratio GP/PAR (r2= 0.39 and 0.31 respectively, p value < 0.05) whereas no significant relationship was observed between NDVI and the ratio GP/PAR. In spite of the weak relation observed, our results demonstrate the capability of spectral indexes to quantify the biological activity of BSCs and the possibility of using remote sensing data for a better quantification of GP at ecosystem scale. This ultimately will contribute to advance in the knowledge about the role of arid and semiarid regions in global C balance.

Keywords：*biological soil crust, vegetation indices, gross photosynthesis*

P2-412

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Effect of Drying-Rewetting on Soil Microbial Biomass and Community Level Physiological Profile in Soil Amended with Wheat Straw

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An incubation experiment was conducted to evaluate the effects of drying-rewetting treatment on soil microbial biomass, activity and community structure in an arable loam calcareous soil under wheat straw amendment. The straw amended soil was subjected to twice drying-rewetting cycles at an interval of 14 d during a 44-day period. The results showed that soil biomass C decreased by about 19%-55% after drying-rewetting events. However, they rapidly recovered within 7 d after rewetting. Drying-rewetting regimes caused shifts in soil community-level physiological profile measured by the sole C source utilization profile done by Biolog Ecoplate. The utilization of six guilds of C sources by microorganisms decreased due to drying, and then recovered rapidly after rewetting in a short-term period. The shifts of the sole C source utilization pattern caused by drying showed rapid resilience after rewetting. Our results indicated the dynamics of soil microbial biomass C was mainly due to the shifts of community level physiological profile induced by drying-rewetting cycles. The wheat straw amended resulted in more complex changes of these parameters.

Keywords：*Community level physiological profile; drying-rewetting; microbial biomass C; wheat straw ameded*

P2-413

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Effect Of Long-Term Fertilization On Soil Microbial Activities And Community Structure In Volcanic Ash Citrus Orchard Soil

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This study was carried out to evaluate the effect of long-term(13 yrs) different fertilization management on soil microbial biomass and community structures using phospholipid fatty acid(PLFA) profiles in volcanic ash citrus orchard soil. Experiment plots composed no-fertilization(Control), Compost, half of recommend application plus Compost(1/2NPK+Compost), recommend application (NPK), recommend application plus Compost(NPK+Compost), 3 times recommend application(3NPK). Soil samples were taken earlier in March, May, July, and September, 2007.

Total PLFA content was significantly higher at NPK+Compost than 3NPK in March and May. Distribution of microbial group by using PLFA profiles as biomarkers were high in September and that was in the order of bacteria>fungi>actinomycetes>mycorrhiza. However, Distribution of fungi and mycorrhiza were decreased significantly in control and 3NPK. Biological index such as G-/G+, F/B, cy19:0/18:1ω7c, and Unsat/sat ratios were increased with increasing temperature and those were high in September.

Cluster analysis of microbial community by PLFA pattern showed that PLFA profiles in 3NPK was different other treatments in March. Microbial biomass C and N contents were high 1/2NPK(including NPK)+Compost compared with Compost only and chemical fertilizers(NPK, 3NPK). Thus, metabolic quotients(qCO2) was highest in 3NPK among the other treatments.

Our results showed that composition change in microbial biomass and community structures affected by fertilization effect and environmental factors such as soil temperature and moisture. In conclusion, Microbial activities were low in 3NPK and the Control compared with NPK(1/2NPK)+Com., which showed difference in community structures.

Keywords：*PLFA, Community structures, Fertilization, Volcanic ash soil, Citrus*

P2-414

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Variibacter Gotjawalensis Gen. Nov., Sp. Nov., Isolated from Soil of a Gotjawal Forest

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A novel alphaproteobacterial strain, designated GJW-30T, was isolated from soil of the Gotjawal forest located in Aewol, Jeju, Korea. Cells of strain GJW-30T were strictly aerobic, Gram-stain-negative, non-motile rods and the strain produced white colonies on R2A agar. The isolate contained Q-10 as the predominant ubiquinone, C18:1ω7c, C16:0 and C17:0 as major fatty acids, diphosphatidylglycerol, phosphatidylglycerol, phosphatidylethanolamine, phosphatidylcholine, an unidentified aminolipid and an unidentified lipid in the polar lipid profile, glucose, ribose and rhamnose as whole-cell sugars, and meso-diaminopimelic acid as the diagnostic diamino acid in the cell-wall peptidoglycan. The DNA G+C content of strain GJW-30T was 62.2 mol%. Phylogenetic analysis based on 16S rRNA gene sequencing showed that strain GJW-30T formed a deep branch within the order Rhizobiales, sharing the highest level of sequence similarity with Rhodoplanes elegans AS130T (93.5%). Combined genotypic and phenotypic data supported the conclusion that the strain represents a novel genus and species, for which the name Variibacter gotjawalensis gen. nov., sp. nov. is proposed. The type strain is GJW-30T (= KCTC 32391T).

Keywords：*novel alphaproteobacteria, Gotjawal, Variibacter gotjawalensis*

P2-415

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Microbial Functional Structure of Lava-Formed Gotjawal Soils in Jeju Island, Korea

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Lava-formed Gotjawal forests are unique within the primitive ecology of the mountainous areas of Jeju Island and are the richest biota shelter sites from urbanization. Gotjawla in Jeju Island covers 6% of the landmass. The forest is crucial for recharging the only source of water for the half-million population of Jeju Island, and also for nursing its unique flora and fauna, including some endangered species and other species endemic to the island.

Here we report the first study of microbial community functional structure in Gotjawal soils, Jeju Island and the overall goal of this project is to interpret microbial community functional structure that may play important roles in soil of Gotjawal forest. Twenty soils from Gotjawal forests were sampled in November 2010 at the four large regions across the island: Hankyung-Andeok Gotjawal Terrain in the west, Aewol Gotjawal Terrain in northwest, Jocheon-Hamduck Gotjawal Terrain in northeast and Gujwa-Seongsan Gotjawal Terrain in the east. The results showed that the diversity index had from 9.59 to 9.85 of Shannon index(H) and reclassified into three clusters with remaining Hankyung-Andeok, Aewol and Gujwa-Seongsan Gotjawal Terrains. Gyorae Gotjawal from Jocheon-Hamduck Gotjawal Terrain regrouped into Aewol Gotjawal Terrain and Dongbaekdongsan Gotjawal from the Gotjawal reclustered into Gujwa-Seongsan Gotjawal using Hierarchical clustering of GeoChip microarray, moreover we will present the results of microbial community structure, canonical correspondence analysis (CCA) and principal component analysis (PCA) between soil chemical characteristics and FGA.

In addition to microarray analysis, culture-based study of bacteria members were conducted on soil samples from Gyorae Gotjawal and Sanyang Gotjawal. Three different bacteria, Pseudomonas, Flavobacterium and Chryseobacterium member at Gyorae Gotjawal and only Bacillus at Sanyang Gotjawal were most abundant from cultured bacteria.

Our study about Gotjawal soils have now suggested that the soils are high level of microbial diversity and high concentration of nutrients and organic matters, but further study is necessary in order to increase the general understanding of microbial functional structure of Gotjawal soils.

Keywords：*Lava-formed Forest, Gotjawal Forest, Microarray, Microbial Diversity, Bacteria*

P2-416

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Comparison of Soil Characteristics and Soil Microbial Activities According to Sections of Hiking Trails for Hallasan National Park

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Jeju Island, formed in Cenozoic era and is located in southeast of the Straits of Korea with area of around 1,848 ㎢. Sectionally its shape is cone centering Mt. Halla with the height above sea level of 1,950m. While south and north slopes of Mt. Halla are steep, east and west slopes are relatively gentle. This study aims to provide basic sources for efficient management system of natural sources of Mt. Halla by measuring chemical characteristics of soil, particle size analysis, distribution of soil microbial and enzyme activation focusing on sections of hiking trail in Hallasan National Park.

The research of soil was conducted from March to November 2012. Focusing on hiking trails in Eorimok, Yeongsil, Seongpanak, Gwaneumsa and Donnaeko, topsoil(0～15cm) and subsoil(15～30cm) were collected by allocation of height above sea level of 100m after removing fallen leaves layers. In fact, hiking trails were mostly unavailable for collecting soil samples due to rail ties and stone. So the samples were collected from relatively intact areas nearby hiking trails.

Chemical characteristics of soil and particle size analysis were done in accordance with NIAST(1998). Soil pH was measured by making soil and distilled water in the ratio of one to five with pH meter while electric conductivity was measured by using the remaining liquid with EC meter. For the content of organic matters, Walkley and Black method was used and available phosphate content was measured by Lancaster method and the total nitrogen content was applied with Kjeldahl method. Exchangeable cations of K, Ca, Mg and Na were measured by extracting them with 1N ammonium acetate(pH 7.0) and using AAS. The content of cation exchanges were measured by saturating with 1 N-NH4OAc(pH 7.0) and washing with 80% ethyl alcohol and quantitating NH4+ from soil through Kjeldahl distilling device. Particle size analysis was done by Pipette method and sifting analysis after dissolving organic matters. For the PLFA analysis, Bligh/Dyer first-phase extraction(Bligh and Dyer, 1959) method was used. For the ratio of microbials distribution, the analyzed fatty acid was classified to bacteria, actinomyces, filamentous fungi and mycorrhiza by using patty acid analysis index and each processed PLFA value was expressed in percentage of the total PLFA(Li et al., 2006: Rahman and Sugiyama, 2008).

For sections of hiking trails of Hallasan National Park, generally, average soil pH were 4.8 in topsoil and 5.0 in subsoil, respectively. Soil pH of Mt. Halla tended to be higher in subsoil than in topsoil like that in ordinary soil. Average electric conductivity in topsoil was 0.59 dS/m while that of subsoil was 0.37 dS/m. These concentration may ignore effects of minerals on plant growth. Average organic matter contents were 214.5 g/kg in topsoil and 157.9 g/kg in subsoil. Organic matter content was higher in topsoil than in subsoil, on the contrary to soil pH and organic matter content seemed to be accumulated in topsoil. Average available phosphorate contents were 10 mg/kg in topsoil and 7 mg/kg with very high values in both cases. Average total

nitrogen content was 1.16% in topsoil and 0.94% in subsoil. At the point of 1500m Eorimok hiking trail, total nitrogen content was 4.04%, very high and particular. Generally, average exchangeable K, Ca, Mg and Na of topsoil were 0.25, 0.69, 0.46 and 0.06 cmol+/kg, respectively, while those in subsoil were 0.13, 0.28, 0.19 and 0.03 cmol+/kg, respectively, with very low contents. Such phenomena seems to have been caused by base leaching due to heavy rain. Exchangeable cation is an indicator index for representing land fertility. Volcanic ash soil in Jeju Island contain very abundant organic matters with very higher exchangeable cation content because of accumulation of non-degradable organic matters. Average exchangeable cation content was 20.98 cmol+/kg in topsoil and 20.91 cmol+/kg in subsoil, almost identical in both and with higher values. Soils of Hallasan National Park were classified into various soil textures. soil texture in hiking trails in Yeongsil and Gwaneumsa dominated with clay and sandy clay loam while that of hiking trails of Seongpanak showed various textures of sandy clay loam, clay, sandy loam and clay loam and that of Donnaeko was predominant with clay.

Soil microbial is greatly influenced by soil environmental conditions such as temperature, moisture content and nutrient and plays a important role for circulation of materials in soil. As the result of the ratio of distribution of microbials using PLFA content by hiking trail of Mt. Halla, Gram-positive bacteria, actinomyces and mycorrhiza were 17.4%, 12.7% and 3.4%, respectively, in Seongpanak with the highest results while fungi were higher in Gwaneumsa with 13.1% than in Seongpanak with 9.4% For Gram-negative bacteria, Yeongsil was 34.5% and Gwaneumsa was 34.4%, about 9% higher than Seongpanak and Eorimok. These results seemed to be due to difference by height according to suitable environmental conditions for microbials depending on sampling points by five hiking trail courses. Especially, Gram-positive bacteria in Seongpanak was highest while distribution rate of fungi was lower, indicating low carbon nutrient available for using by microbials in spite of its higher organic mater content and contribution of actinomyces on decomposition of soil. As the results of rate of distribution of soil microbials originated from PLFA by allocation of 100m for each course of hiking trails, Gram-negative bacteria showed highest value and mycorrhiza was lower. But distribution according to sampling points by height of Mt. Halla did not show a constant trend. Soil temperature has influences on density and activation of microbial and it seems to have been caused by soil environmental condition when collecting samples.

As the results of the analysis of biological index using PLFA content by course of hiking trails of Mt. Halla, the ratio of (G-/G+), index of carbon nutrient motion was 4.0 in Gwaneumsa, 2.5 time higher than that of Seongpanak and Eorimok areas. It seems that carbon nutrient in soil of Gwaneumsa area is increasing while that of Seongpanak and Eorimok areas is decreasing. As temperature becomes higher, the ratio of Gram-negative and Gram-positive bacteria is lower. These areas seemed to be affected by lower ratio of Gram-negative bacteria in the researched spot by section of hiking trails or by condition of soil environment such as distribution of flora and amount of sunshine in addition to lower temperature of soil by influences of height of Mt. Halla when collecting soil samples. B/F ratio for index of organic matter content was high in Yeongsil with 4.8 and Seongpanak with 4.7 while was low in Gwaneumsa and Seongpanak areas with 3.5. As G-/G+ ratio was low and B/F ratio was high in Seongpanak, organic matter content of soil seemed to be higher but available carbon nutrient was low, considering different physical environments such as soil temperature and moisture contents at the sample collecting by height and roots and fallen leaves of plant which affected soil organic matter contents, it seemed to be influenced by flora.

Therefore, basic data for understanding soil characteristics of hiking trails and non-hiking trails of Mt. Halla and for efficient management system of its natural sources will be suggested if flora, topography, geological features and meterological factors are integrated and interpreted based on the results of this study.

Keywords：*Hallasan National Park, Hiking Trails, PLFA, Soil Microbial Activities*

P2-417

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Characteristics of Soil and Soil Microbial Distribution by Gotjawal Terrain in Jeju Island

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According to Jeju Dialect Dictionary(Jeju Special Self-Governing Province, 1995), gotjawal is defined as a place where trees and vines are tangled like woods. It's informed of at an important habitat of main animals and plants recently, and it's recognized the area with the high preservation value. The 'Support for Conservation and Application of wood in lava of Jeju Island, Gotjawal' was selected one of five agenda for Jeju Island in WCC(World Conservation Congress) in 2012.

In this study, Hangyeong-Andeok Gotjawal, Aeweol Gotjawal, Jocheon-Hamdeok Gotjawal and Gujwa-Seongsan Gotjawal were investigated during between March and October in 2012, in order to figure out chemical characteristics of soil, particle size analysis, characteristics of minerals and microbials. Accordingly, it aims at providing basic data for efficient and systematic management of gotjawal terrains. .

Soil samples were collected by sorting them arbitrarily to representative soil of gotjawal and perimeter soil of gotjawal. Representative soil of gotjawal is where a typical scene of the terrain is seen and is difficult to collect samples because of its rocky topography while perimeter soil of gotjawal means where collecting soil samples is relatively easy. For samples of both representative and perimeter soil of gotjawal, topsoil(0～15cm) was collected by removing fallen leaves layers and considering soil horizon. While, in a source, oreum, topsoil and subsoil were sorted for collecting. These soil samples were used for microbial analysis, X-ray Diffractometer and X-ray Fluorescence Spectrometer. Topsoil was also used for soil samples for analyzing soil microbials by not air-drying but screening with 2 mm sieve, putting in polyethylene sample bottle and lyophilizing them for storage.

Chemical characteristics of soil and particle size analysis were done in accordance with NIAST(1998). Soil pH was measured by making soil and distilled water in the ratio of one to five with pH meter while electric conductivity was measured by using the remaining liquid with EC meter. For the content of organic matters, Walkley and Black method was used and available phosphate content was measured by Lancaster method and the total nitrogen content was applied with Kjeldahl method. Exchangeable cations of K, Ca and Mg were measured by extracting them with 1N ammonium acetate(pH 7.0) and using AAS. The content of cation exchanges were measured by saturating with 1 N-NH4OAc(pH 7.0) and washing with 80% ethyl alcohol and quantitating NH4+ from soil through Kjeldahl distilling device. Particle size analysis was done by Pipette method and sifting analysis after dissolving organic matters.

X-ray Diffractometer(XRD) was conducted by using sifting analysis and precipitation to separate clay less than 2μm. X' Pert MPD System by Philips was used and X-ray by CuKa Lines and Ni-filter was applied. Limiting separated clays, the included clay minerals were identified by treating with ethylene glycol and heating. For X-Ray Fluorescence Spectrometer(XRF), Sjimadzu's XRF-1700 was used and the analyzed 11 items included SiO2, Al2O3, Fe2O3, K2O, Na2O, CaO, TiO2, MgO, P2O5, MnO and LOI.

For the PLFA analysis, Bligh/Dyer first-phase extraction(Bligh and Dyer, 1959) method was used. For the ratio of microbials distribution, the analyzed fatty acid was classified to bacteria, actinomyces, fungi and mycorrhiza by using patty acid analysis

index and each processed PLFA value was expressed in percentage of the total PLFA(Li et al., 2006: Rahman and Sugiyama, 2008).

As the results of particle size analysis, gotjawal terrains contained higher silts and soil textures mainly consist of silt and silt loam. Generally, average soil pH was mild acid over 5.6 and Hangyeong-Andeok Gotjawal terrain showed the highest pH. Average electric conductivity, organic content and total nitrogen content were 1.14 dS/m, 229.4 g/kg and 0.96%, respectively and Seongsan-Gujwa Gotjawal showed the highest value. And then, average available phosphate content was lowest with 13 mg/kg in Seongsan-Gujwa Gotjawal but some areas of Hwasun, Mureung and Napeup Gotjawals showed very high available phosphate content. For exchangeable K, Ca and Mg contents, except for Jocheon-Hamdeok Gotjawal terrain, averagely values were 0.50 cmol+/kg, 9.57 cmol+/kg and 2.92 cmol+/kg, respectively with very high exchangeable Ca content. Especially, it is far higher in representative soil of Hangyeong-Andeok Gotjawal terrain and it seems to be caused by use of artificial fertilizer. For exchangeable cation content, except for Jocheon-Hamdeok Gotjawal, it showed very high vale of 30 cmol+/kg and the highest value was in Seongsan-Gujwa Gotjawal terrain.

As the result of X-ray Diffractometer, every sample included quartz and then feldspar such as albite and anorthite, mica and iron oxide were identified but clay mineral was not. Gotjawal terrains were generated relatively long time ago and at first clay minerals existed there. However, as the result of this study, it was not identified and the X-ray Diffractometer peak should be reanalyzed more minutely. As the result of X-ray Diffractometer, chemical composition were SiO_2 18.82 ~ 53.14%, Al_2O_3 5.94 ~ 24.22%, Fe_2O_3 5.21 ~ 18.39%, TiO_2 1.21 ~ 4.87%, MnO 0.04 ~ 0.24%, MgO 0.77 ~ 2.17%, CaO 0.47 ~ 10.19, Na_2O 0.49 ~ 1.89%, K_2O 0.30 ~ 1.68%, P_2O_5 0.37 ~ 1.20% and LOI 10.04 ~ 49.59% in ranges. Main chemical elements, SiO_2, Al_2O_3 and Fe_2O_3 showed 39.96～76.04% of contents. Ignition loss ranged in 10.04～49.59% with very high contents, caused by moisture and organic matters.

For soil microbials in gotjawal terrains, average distribution ratios of Gram-positive bacteria, Gram-negative bacteria, actinomyces, fungi and mycorrhiza were 12.8%, 33.5%, 11.4% and 2.4%, respectively and their decreases seemed to be bacteria, fungi, actinomyces and mycorrhiza in order. For Gram-positive bacteria, it showed 19.3% in perimeter soil of Napeup Gotjawal, twice higher than 7.6% in Nokkome oreum. Gram-negative bacteria was highest in representative soil of Gyorae Gotjawal with 42.3% and lowest in perimeter soil of Napeup Gotjawal with 26.1% Accordingly, because Gyorae Gotjawal showed lower concentration of minerals, the share of Pseudomonas seems to be higher. Actinomyces showed generally less than 11% in Byeongak oreum, Nokkome oreum, Min oreum and Begyaki oreum. Fungi was 18.7% in representative soil of lower part in Aewol Gotjawal, twice higher than that of representative soil in Hwasun Gotjawal. mycorrhiza was highest in Sangdo Gotjawal with 4.3% and lowest in perimeter soil of Gyorae Gotjawal.

For the ratio of Gram-negative and Gram-positive bacteria(G-/G+), index for motion of carbon nutrients, Nokkome oreum was highest with 5.2 while representative soil of Hwasun Gotjawal and perimeter soil of Napeup Gotjawal were lowest with 1.4. It means carbon nutrient in soil of Nokomme oreum is increasing while that of Hwasun and Napeup Gotjawal is decreasing. 4 times difference of the ratio of G-/G+ between Hwasun Gotjawal, stock farm area and Napeup Gotjawal nearby farming lands and Nokkome oreum, non-farming land seems to have been caused by excrements of horses and cows and use of chemical fertilizer, requiring future studies such as extension of samples and seasonal researches in future.

Summarizing these results, representative soils of gotjawal with typical characteristics of gotjawal, showed higher contents of chemical components, soil microbial distribution ratio and G-/G+ ratio, compared to perimeter soil of the topography. The reason seems that representative soil of gotjawal owns its own original features without artificial intervention such as soil disturbance. It is necessary to conduct additional researches if contents of exchangeable Ca and Mg and available phosphate content in gotjawal terrains are higher because of geological particularity or if it is by artificial interruption such as use of fertilizer.

Keywords：*Gotjawal, oreum, PLFA*

P2-418

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Effects of Cover Crops on Nutrient Contribution and Soil Microbial Community in Organic Citrus Orchard in Jeju

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This study was conducted to assess the influence of different cover crops on nutrient contribution, especially nitrogen and soil microbial biomass and community in citrus organic cultivation system. Four cover crops viz. hairy vetch (Vicia villosa Rot, HV), crimson clover (Trifolium incarnatum, CC), barley (Hordeum vulgare L., BA) and rye (Secale cereale L., RY) were tested for the same at a organic citrus orchard in Jeju, Korea. They were seeded on March 13th of 2012 for spring season and seeded on September 7th of 2012 for winter season. We analyzed the biomass of cover crops and the bacterial community in soil samples collected by using cultured-dependent and pyrosequencing methods, comparing with a conventional grass planting site(as a control). The greatest DM shoot biomass of 531kg 10a-1 was obtained for crimson clover and the lowest of 347kg 10a-1 was obtained for rye and the greatest amount of nitrogen were found in hairy vetch(13.8kg 10a-1) and the lowest in control(5.3kg 10a-1) for spring season. For winter season, the greatest DM shoot biomass of 819kg 10a-1 was obtained for rye and the lowest of 354kg 10a-1 was obtained for control and the greatest amount of nitrogen were found in hairy vetch(13.7kg 10a-1) and the lowest in control(4.3kg 10a-1). The bacterial density of HV and CC soils had significantly higher than that of others in culture method. A total of 17,171 reads were obtained from 4 soil samples in the pyrosequencing analysis. All sequences were classified into 2,096 OTUs for HV, 1,938 OTUs for CC, 1,701 OTUs for BA and 1,693 OTUs for control. The dominant taxonomic groups across all samples (>2% of all sequences) were Proteobacteria(38 ~ 41%), Acidobacteria(18 ~ 21%), Actinobacteria(13 ~ 19%), Chloroflexi(5 ~ 6%), Planctomycetes(4 ~ 6%), Nitrospirae(3 ~ 5%), Bacteroidetes(2 ~ 4%) and Gemmatimonadetes(2 ~ 3%). No major changes in the community composition due to different cover crops were found. However, some differences were observed e.g. Actinobacteria were more frequent in the green manured soils in comparison to the control soil at the bacterial phyla level. Furthermore the distribution of Alphaproteobacteria were markedly different ranging from 20.6 to 28.5%. The bacterial diversity and species richness of HV sample was the highest among those of the other samples. This study showed that the leguminous cover crops would be available as the crops provided sufficient amount organic matter and nitrogen into the soil. Also these findings showed that the bacterial diversity and community structure were affected by the cover crops in organic citrus orchard.

Keywords：*citrus, cover crops, organic farming, pyrosequencing*

P2-419

[C2.3-3] Microbial Biodiversity and Ecosystem Functions in Volcanic Soils

Functions Recover after Fumigants Removal in Different Soils

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Soil fumigation can significantly control the level of pests and pathogens in continuous cropping system such as greenhouse vegetable producing system. The current studies are focused on the positive effects of fumigation and the application of technology, such as fumigation on the kill target pathogens, recurrence process and control fumigant volatilization loss, with little attention to non-target microbial community structure and the substance transformation.

In a laboratory experiment, the soil dissolved N components and contents, N mineralization enzyme activity and C-metabolism fingerprint were monitored in soils came from different ecosystems after chloropicrin (CP), metham sodium (MS), or 1,3-dichloropropene (1,3-D) was added as fumigant, respectively.

CP, MS, and 1,3-D increased the contents of NH4+, dissolved organic nitrogen (DON), and dissolved amino acides (DAA) ($P<0.05$) 1.3-3.7 times than the un-fumigated soil. Meanwhile, fumigation reduced soil microbial activity and changed N mineralization enzymes activities and functional diversity of microbial carbon metabolism. After removal of the fumigants, with a lag through the early stage, NH4+, DAA, NO3-, and DON were gradually recovered combining the increase of enzymes activities and the change of carbon metabolism fingerprint.

Fumigation effects significantly increased when CP combined with composted steer manure, wheat straw, biochar, or ammonium thiosulfate. Meanwhile, the combination of CP and composted steer manure or wheat straw significantly increased ($P<0.05$) soil respiration rate, microbial activity, and the activities of protease, arylamidase and L-glutaminase. Adding wheat straw in CP-fumigated soils significantly decreased NO3-and DIN contents ($P<0.05$).

The dissolved N components in soils of grassland, coniferous forest, wheat-corn cropland and greenhouse were significantly increased ($P<0.05$) after CP fumigation, whereas microbial biomass C and N and activity were significantly reduced, and N mineralization enzyme activity and C-metabolism fingerprint were changed significantly. Among them, the coniferous forest and meadow soils were affected larger than the two soils. During post-incubation period, the contents of NH4+ and DIN in grassland soil and coniferous forest soil kept increase.

Soil fumigation has a significant impact on the dissolved N components and contents and the corresponding of N mineralization enzyme activity and C-metabolism fingerprint also have a certain degree of change, and vary with fumigants and soil properties. These changes not only directly relate to the soil N supply and crop nutrition, but also to N loss and its eco-environmental effects.

Keywords：*soil fumigation; enzyme activities; microbial community; carbon metabolism fingerprint*

P2-420

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Conocarpus Waste for Improving Water Management of Calcareous Sandy Soils

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Recently, it has been reported that biochar application has the potential to sequester carbon in the soil and mitigate global climate change. More attention has also been given to the use of biochar as a soil amendment to improve soil functions. Therefore, a laboratory column experiments were conducted to investigate the application effect of biochar pyrolyzed at 400 oC on soil moisture retention, cumulative evaporation, total amount of conserved water in the soil, advance wetting front and infiltration. Specifically, transparent plastic soil columns (40 cm long and 5 cm ID) were packed with light-textured sandy loam soil treated with 5, 10, 15, and 20 mg Kg-1 of the biochar, and subjected to 5 weekly cycles of wetting and drying under laboratory conditions. The results showed that the amount of cumulative water evaporation reduced by increasing the amount of biochar amendment leading to an increase in the amount of water retained in the soil by 1.2, 9.9, 20.4, and 23.3%, respectively. Water holding capacity also increased from 20.4% for the non-treated soil to 21.9% for soil treated with 20 mg Kg-1 of the biochar amendment. The amount of water conserved increased considerably as indicated by the increase in water content at 100 and 15000 hPa retention (representing field capacity and permanent wilting, respectively). It is important to note that differences in water retention were not significant between the two highest application rates of 15 and 20 mg Kg-1. Therefore, our results suggest that an application rate between 10-15 mg Kg-1 would be optimum for practical and economic reasons.

Keywords：*Biochar, soil amendments, inflitration, cumulative evaporation*

P2-421

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Drought Monitoring System for Austrian Agriculture - Agrodroughtaustria

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The most regions of Austria are humid or semi-humid but the main important crop production regions are frequently and with an increasing trend over the past decades affected by agro-meteorological droughts (often combined with heat stress), where water deficit and/or heat effects leads to significant yield decrease of various crops. Crop model studies show that these conditions will accelerate under future climate scenarios in Central Europe including Austrian crop production regions.

The aim of the project is to develop and test a crop specific drought monitoring and forecasting system for agriculture in Austria by reaching the following objectives:

1. Establish a set of calibrated indicators and methods on crop specific drought and heat vulnerability and impacts based on field experiment data and crop model application;
2. Assess crop drought and heat stress at high spatial resolution by using improved spatial precipitation and temperature input;
3. Establish a near-time (up to 10 days) now- and forecasting method for drought occurrence;
4. Adapt and validate methods for crop drought and heat stress detection implemented in a GIS-based monitoring system with high spatial resolution (1x1km) for main vulnerable arable crops in Austria;
5. Test crop specific drought monitoring system for operational use including active stakeholder involvement.

The AgroDroughtAustria drought monitoring system will be developed from the combination of already existing tools (SpatialGRAM and SoilClim), which will be adapted and calibrated to the purpose of monitoring and forecasting of crop specific drought status and impacts at a high spatial and temporal resolution. Further, a web portal will be established for presentation of the drought monitoring results. The main parameters, to be presented as results in high resolution maps and tables will be crop and site specific soil water content and soil water deficit and crop drought stress indicators. These parameters will be calculated and presented on a daily basis, with at least weekly update and with a 10-day forecast period. The operational use of the drought monitoring system will be tested with the active participation of stakeholders. During the test of the system, beyond the participating Institutions, selected farmers will also be directly involved in order to gather further feedback regarding results presentation considering the needs of farmers.

Keywords：*drought monitoring, forecasting drought, Austria,*

P2-422

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

A New Technique Placing White Painted Water-Filled Polyethylene Bottles on Soil Surface Beside Plant Bases to Reduce High Soil Temperature Damages

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Under the hot weather condition, high soil temperature retard the plant water absorption even soil water sufficient to plant growth. To reduce soil temperature damages, we developed a new technique to place white painted and water-filled polyethylene (PET) bottles beside the plant bases. Experiments were conducted in greenhouse in Japan International Research Centre for Agricultural Sciences in Ishigaki Island, Okinawa, Japan. In the first experiment, effects of vertical burying and horizontal placing water-filled PET bottles on soil temperature were evaluated. Soil temperature reduction at 10 cm depth in horizontal placing water-filled PET bottles was highest (1.5˚C) at mid day. Soil temperature reduction at 10 cm depth in vertical burying watered PET bottle was 0.5˚C around 15:00 which is less than horizontal placing. In the second experiment, effects of water-filled PET bottles horizontal placing beside the plant bases of chilli and cucumber with drip irrigation were evaluated. The PET bottle placing increased the leaf growth of chilli and the yield of cucumber, 30% and 40%, repectively. The technique named water bottle technique (WBT) is effective especially for developing countries due to no energy and less capital cost.

Keywords：*chilli, cucumber, PET bottle, soil temperature*

P2-423

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Soil Hydraulic Properties and Moisture Regime as Affected by Agronomic Management Practices in a Clayey Ultisol

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Soil erosion and seasonal drought are the constraints limiting yield in sloping farmland in southern China. The poor hydraulic properties of the red soil (Ultisol) are usually worsened with the soil structure degradation by rain-induced soil erosion in wet season. Subsequently, crops often undergo water stress even in a short dry spell in summer, due to the increased evaporation rate at high level. Many studies focus on water erosion in red soil, but few attention has been paid to the soil water management in dry season. Despite many well-recognized practices in arid land farming, neither the practice could be implemented in the humid area, nor the benefit could be remained in clayey red soil. Therefore, for the viable water management strategy in red soil, it is important to estimate the effects of agronomic conservational practices on temporal variability in soil hydraulic properties and root-zone water dynamics.

A four-year experiment was performed at a 8° field growing maize from June to September in 2008-2011. The field is located in Xianning, China (114°21′E and 30°01′N). The soil is characterized by poor properties, with 55.7% of <0.002 mm clay and 0.61% of organic matter. Agronomic conservational practices were employed to reduce soil erosion and to improve soil water conditions in the field. There were four treatments including (1) no conservational practices (CK), (2) application of polyacrylamide mixed with surface soil at the rate of 2.0 g per square meter (PAM), (3) straw mulching in soil surface with 10 cm long rice straw at the rate of 1.0 kg per square meter (SM), and (4) growing bahiagrass as contour strips at 0.5 m wide and 5.0 m interval (GS). In the maize growth period which is the transition between humid and dry seasons, the temporal variability of soil hydraulic properties and soil water storage in the root-zone of 0-40 cm were simultaneously investigated.

After each intense rainfall in wet season, soil crust were formed with more than 70% coverage in PAM, GS and CK treatment. The application of PAM significantly decreased the crust size distribution, hardness and coverage, but SM treatment completely avoided crust. Compared with CK, the treatment of SM and PAM improved water-stable soil aggregation with a redistribution of micro-aggregates (<0.25 mm) into macro-aggregates to resist the tendency to form surface crust. The most notable change in soil hydraulic properties is that soil saturated hydraulic conductivity, Ks, significantly declined due to intense rainfalls. As expected, the conservational practices mitigated the degradation of soil Ks. However, the temporal decrement of soil Ks was much greater than the effects of the conservational practices. Despite the benefits on soil hydraulic properties, the practices slightly increased soil water storage as demonstrated by the root-zone water weekly dynamics in wet season, suggesting the soil's pore spaces were already filled with rainwater because the soil water holding capacity was low. In dry season, on the other hand, the soil water storage were significantly different between the treatments. Soil water storage in 0-40 cm in SM was the highest, followed by PAM and CK, and GS was the least because of the vigorous grass growth for water uptake. The noteworthy is that the soil moisture difference between the treatments became larger and larger over the period of soil drying. The soil unsaturated hydraulic conductivity, Ku, measured in situ by a tension infiltrometer showed that a slightly decline in soil moisture (tension from 0.3 to 0.9 KPa) resulted in a dramatically decrease in Ku (from 3.2 to 0.04 mm/h). Hence, the Ku of the red soil is basically governed by water moisture in dry season. This kind of relationship between Ku and soil water content is the reason why crop water stress occurs easily even in short dry period. From this perspective, remaining soil moisture is more urgent than improving soil properties to resist seasonal drought. As a result, the treatment of SM is the most effective soil water management practice compared with PAM and GS in dry season, although they all had benefits on protecting soil hydraulic properties in wet season. The result suggests the best strategy on water management in erosion- and drought-threatened red soil is residue cover.

Keywords：*Hydraulic properties, Soil crust, Soil moisture profile, Temporal variability*

P2-424

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

The Effect of Mixing Zeolite in Soil with Application of Wastewater and Sewage Sludge on Lead in Lepidium Sativum

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In most countries with water shortages, the wastewater would be considered as the cheapest and the most accessible source supplying water for irrigation. The presence of heavy metals in wastewater and sewage sludge and the lack of refinery in most industries that producting sewage in developing countries to remove this contaminants, are a major challenge to used of wastewater and sewage sludge in agricultural land. Application of Zeolite in agricultural land is a way to overcome the limitations of usage wastewater and sewage sludge on this land. Therefore, our aim of this study was to evaluation effect of mixing different levels of Zeolite in Soil with application of untreated wastewater and sewage sludge in decreasing entry of lead in Lepidium sativum. Factorial arrangement of treatments within main design of completely randomized blocks with three replicates was used. Three rates (0, 1 and 2 mass percent) of natural zeolite and two type of soil (sandy and clayey) with four type of pollution by wastewater and sewage sludge (untreated wastewater, sewage sludge, enriched wastewater and application of untreated wastewater and sewage sludge together) were applied to this experiment. Results show that among pollution treatments, plants that grown in treatments including sewage sludge had the lowest lead uptake. Also, type of soil does not have significant effect to absorb Pb by plants, but however absorbing Pb by plants in sandy soil was more than clay soil. Consequently, Application of zeolite reduces the absorption of Pb by plants, than the control treatment.

Keywords：*Lead, Lepidium sativum, Nickel, Sewage sludge, Wastewater, Zeolite*

P2-425

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

How to Save Agricultural Production in Sahelian Zone Prone to Drought: Case of Burkina Faso

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Climate change induces negative effects on agricultural production. The Sahel, most vulnerable, is subject to shortage, irregularity, unequal distribution and early cessation of rains. Effective and efficient technology is not yet found to make rain happen during the critical period of crop growth. Sahelian areas should then develop adaptation strategies to climatic hazards to save their agricultural production.

The present study was conducted in Burkina Faso and is intended to share experience and disseminate the country's efforts to cope with water stress that can comprise crop yield and lead to food shortage.

A runoff water collection basin of 250 m3 is coupled with 0.25 ha of maize field managed with stony cord, zai pits and half-moon promoted at the country level since 2012. The tool for irrigation can be a watering can, a pump coupled to a tricycle to allow mobile irrigation operation. Beneficiary farmers were interviewed after two cropping season and maize field equipped with runoff water collection basins were visited.

The results show that the effectiveness of this adaptation strategy is related to:

? The occurrence of heavy rains that can generate runoff during the rainy season;

? Responsiveness of the individual farmer and his commitment to adopt the technological package.

The results show that it is possible to get two cropping cycles within a single wet season with short cycle maize (70-75 days) or with any other crop with the same length of cycle.

Therefore it is advisable to scale up the technology of runoff water collection around cropland in the Sahel, to protect them in order ensure a high crop yield.

Keywords：*Food insecurity, rain full lack, technologies of production security*

P2-426

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Shade and Water Management: A Viable Option for Soil Temperature Reduction and Root Development in Plantation Crop Establishment.

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Field experiments were conducted in rain forest zone of Nigeria at the Teaching and Research Farm of the Federal University of Technology, Akure, Ondo State. The combined and single effect s of shade and irrigation were tested on soil temperature and cacao seedling establishment on the field. The result indicated a significant difference between the irrigated plots with shade and the unshaded control. Shaded plots with irrigation help in soil temperature maintenance within the range of 26-320C throughout the four months of dry season and also improve percentage seedling establishment from 61.5% to 99.12%. Percentage seedlings survival was highest under irrigated plots with no record of dead stand as a result dry season water stress as recorded under non irrigated plots. The seedling vigor was highest under the shade + irrigated plots. Soil temperature was significantly higher in the unshaded plots compared with other treatments. Shade alone and the combination of shade and irrigation was found to significantly reduce soil temperature and enhanced seedling survival compared to the non-shaded plots.

Keywords：*Establishment, irrigation, Root, Seedling, Shade, Temperature*

P2-427

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Assessment of Soil Degradation Processes with the Help of the Statistic Analysis Method

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Until now, the variety of degradation processes can not give us a chance to create a unified theory of soil degradation. It fully applies to the soil cover of halomorphic areas where virtually no systematic information on the development of degradation processes. Despite the considerable number of work and the popularity of research on the problems of soil degradation, so far there is no prove of quantitative relationships and fundamental violation objective laws of biospheric soil functions.

The objective of this research was the development of a new methodology for assessment of soil degradation processes on the basis of the transformation of the biospheric functions and modern methods of statistic analysis.

The most unfavorable situation is in dry areas, in the South of Russia and especially in the northern part of the Caspian lowland, where the environmental vulnerability of soils intensely made worth by anthropogenic presence. This region has been chosen as the object of research. The soil cover is characterized by a large variety and diversity. The selection criterion was the visual assessment of soil quality and the degree of degradation of the vegetation cover, soil surface, anthropogenic load and geomorphological features. The features of the morphological structure of the soil section were an extra criterion.

Degradation assessment is based on a mathematic description of the processes and spatial changes in environmental conditions and biosphere functions with the preparation of thematic maps of existing types and degradation levels. While mathematic and mapping processing of data amount obtained by degradation, it was correlated with selected 'benchmark' soils. Cluster analysis was conducted for the partitioning a set of objects (soils) into homogeneous groups on the properties, the classification of data on average values. According to Ward's method, all objects are distributed in classes on the similarity of properties. In addition, a regression analysis was performed with the definition of dependencies and a regression model of discrete ordered selection with the help of Probit-model or Logit-model of random residuals, which is the appropriate tool for quality of soil assessment on the basis of the measured values for these indicators.

The approbation of models was carried out, it helped us to state that a discrete choice models are far superior to the accuracy of prediction than the discriminant analysis model, which is traditionally used for objects classification. Based on predictive values for certain properties, soils are classified by quality and categories.

Composit latent indicator of soil quality was plotted with the use of expert assessments. The coefficient of variation was calculated for each property separately to identify the qualitative differences of soil. To obtain objective assessments, the sites were previously devided into groups of similar sites on the set of values of the six signs with the help of cluster analysis. In the result we obtained homogeneous characteristics that are equally important for classification. Therefore, we used Euclidean distance as the distance between the objects.

Hierarchical procedures of cluster analysis were used for classes. Different distances between the classes and the related classification procedures were originally used. Finally, Ward's method was chosen because it gives the most reasonable clusters in terms of the soil quality. Clusters are built on the principle of a minimum of within-group dispersion in the Ward's method. 15

research objects were divided into five clusters based on the similarity of the properties in the result of this analysis and dendrograms that allow us to classify the soil quality on the basis of the indexes (soil properties).

Discriminant functions were built on the basis of the object division into clusters. It allows us to classify a new object (soil type) on the quality to one of the existed classes. The object belongs to the class due to the discriminant function which has the largest value for a given soil. The use of the model for further classification should be considered a failure as in 4 out of 6 cases there were mistakes (mismatches with the expert). Analysis of histograms raises serious doubts about the normal distribution of properties).

All models are satisfactory rated. It is indicated by the small probability values of LR- statistics - in all cases they are less than the significance level of 0.01. However, the probability of t-statistics for the threshold value is very high (from 0.06 to 0.15), indicating the low accuracy of the estimates. The precision of the estimates of the regression function coefficients was very low. Only the density of the soil affects its quality according to the results (the corresponding probability is less 0.05). Such precision of the estimates is primarily related to small sample number. All models are almost the same in terms of accuracy. Probit-model is a little more precise than the rest.

Keywords：*Soils, degradation, statistic analysis, mathematical modelling*

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[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Nutrient Removal from Intensive Shrimp Farming Wastewater Using Red Seaweed (Gracilaria Verrucosa)

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Shrimp wastewater contains a range of pollutant sources including high levels of organic matter, nutrients, and growth promoting substances. The nitrogen (N) and phosphorus (P) concentrations increase with pond age and are likely to have a positive linear relationship with pond age. An increase in nutrient concentration will affect the structure of the phytoplankton community thereby leading to eutrophication in the pond. The discharge of shrimp wastewater containing high nutrient load without proper treatment is likely to impact aquatic life, water quality and the environmental system. Red seaweed (Gracilaria verrucosa) is one the most common species of the Gracilaria family in the Tam Giang lagoon, Vietnam. In this study this species was selected and tested to optimize the biomass production for maximizing the nutrient removal efficiency over 8 days treatment in a shrimp farm wastewater treatment system. Around 1000 liters of wastewater from intensive shrimp farming after enhancing dissolved oxygen (DO) and removal of ammonia (NH3) toxicity by splash board treatment over three hours was then transferred into the treatment tank which was stocked with 500 g of Mugil cephalus and 200 g of Cerithidea obtuse for biodegradation of organic matter. After 84 hours biodegradation of organic matter, wastewater was moved into four different treatment tanks (250 L) that were stocked with three different levels of G. verrucosa biomass: 300 g/m3 (G-300), 400 g/m3 (G-400) and 500 g/m3 (G-500) and a control (CT). The removal efficiency of total ammonium nitrogen (TAN) and nitrite (NO2) increased with increasing seaweed biomass in the range from 300-500 g/m3. The final removal capacities were 89%, 95.6% and 98.1% for TAN and 95.5%, 97.3% and 98.9% for NO2 in treatment G-300, G-400 and G-500, respectively. The removal of total N (TN) increased from 40.3% to 64.1% with increasing G. verrucosa biomass from 300-500 g/m3. The PO4P decreased from 0.91 mg/L to < 0.42 mg/L in all G. verrucosa biomass treatments while it significantly increased by 58.4% in the control. The highest total phosphorus (TP) removal was achieved in treatment G-500 (72.5%), followed by treatment G-400 (66.5%) and G-300 (59.8 %). In the control, treatment TP increased from 5.34 mg/L to 6.27 mg/L (17.42%) within 8 days. The study demonstrated seaweed, G. Verrucosa treatment reduced both N and P concentration in shrimp wastewater and the nutrient removal efficiency increased with increasing seaweed biomass level.

Keywords：*shrimp farming, nutrient removal, gracilaria verrucosa*

P2-429

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

The Contribution of Simple Irrigation Technologies to Crop Production in the Arid Lands of North Eastern Uganda

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Rationale: Season river streams are potential sources of water for domestic use, agriculture and in maintaining the ecological balance. Crop productivity under simple irrigation technologies was examined in north eastern Uganda.

Findings: simple irrigation technologies are becoming more important to peoples' livelihood. The study revealed that maximum profits are realised when a combination of cereal crops and vegetables are grown together and irrigated using water from various sources. The productivity and profitability varied within zonal dimensions. Areas with wider valleys registered higher achievements; the experience was lower in terms of achievements in flood plains, areas close to marketing centres and areas with good road networks. Major problems limiting productivity included; declining soil fertility, water shortage and crop pests and diseases.

Conclusions: Strategies to ensure water availability includes; opening of small shallow wells in wetlands or sometimes in river tributaries, valley diversions of tributaries to farms and conservation of indigenous tree species.

Implications: proper management of simple irrigation technologies could sustain productivity.

Keywords：*Crop production, Simple irrigation technologies, arid lands.*

P2-430

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Boosting Crop Productivity through Irrigation Water Systems

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Rationale: A vital agricultural resource such as, irrigation water is important for the productivity of crops as a livelihood. With a common belief in the importance of irrigation in agricultural development, Uganda has promoted irrigation development over recent decades. This study aims to empower water users with information on agricultural waste water.
Findings: Through these benefits, irrigation water is linked to poverty alleviation, both directly and indirectly. This study examined agricultural intensification through the practice of irrigation as a strategy for poverty reduction.
Conclusions: These efforts have sought to achieve such broad objectives as economic growth, rural and agricultural development, food security, and protection against adverse drought conditions, with all of these goals expected to contribute to improved social outcomes.

Keywords：*Irrigation water, Productivity, Agricultural waste water, Poverty alleviation, Liveliho*

P2-431

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Influences of Environmental Conditions and Agricultural Conservation Practice on Growth and Yield of Cassava with No-Irrigation in Northeast Thailand

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Two experiments were conducted from November 2012 to May 2013, in farmers field at Wang-wa and Phea-fan village in Khon Kaen province, Northeast of Thailand. Two cultivar varieties named Kasetsart-50 (KU-50) and Rayong-11 (RA-11) were planted in sandy soils at the upper paddy field areas. Split plot design was used in this study. The field monitoring system (FMS) and soil moisture sensors were installed to monitor and automatically record climatic and soil moisture data in real-time . This study aims to 1) investigate the influence of environmental factors such as rainfall, air temperature, humidity, evaporation, and also soil properties, and 2) to evaluate effect of agricultural conservation practices (planting on ridges and flat soil with mulch and without mulch by using rice straw) on growth and yield of cassava in the dry season with no-irrigation. Soil samples were taken and determined about the physical and chemical properties. We observed and recorded growth data at 30, 60, 90, 120, 150 and 180 day after transplanting (DAP) . At the initial stage (30 DAP), the result shows that KU-50 gave higher crop survival ratio than Rayong-11 at both sites (at Wang-wa field, KU-50 was 85.88% and Rayong-11 was 70.37%, respectively, and at Phea-fan the KU-50 was 97.22% and Rayong-11 was 94.10%, respectively). This study indicated that the KU-50 was well adapted in sandy soils with no-irrigation and provided significantly higher root yield than the Rayong-11. And the result indicated that growth and yield of cassava at both locations were influent significantly by soil moisture, soil temperature and local climate factor. Planting on ridges and flat soil with mulch and without mulch showed a significantly different on survival ratio at the initial stage, and its effect on tuber root yield at final stage.

Keywords：*Cassava, Soil Moisture, local climate, No-Irrigation, Agricultural conservation practice*

P2-432

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Increasing Water-Use Efficiency and Crop Value through Surfactant Application in Sprinkler-Irrigated and Rain-Fed Potatoes

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Water scarcity, climate change, and global population growth are significant global challenges for producing sufficient food, fiber, and fuel in the 21st century. In order to feed an increasingly hungry world, innovative strategies and technologies need to be developed and implemented to maximize crop production outputs while simultaneously increasing crop water productivity. In the 20th century major, advances in precision irrigation enabled producers to increase productivity while more efficiently applying water to crops. Pressurized irrigation systems can deliver water effectively to the soil however the efficiency of delivery to the rootzone may be compromised by intrinsic soil wetting characteristics related to soil organic matter and hydrophobic coatings on soil particles. Improving the efficiency of applied irrigation water is critical to increasing crop yields and quality as we are faced with increasingly water stressed environments and a demand for increased food production.

We propose that management of soil water access by surfactants is a viable and sustainable strategy to maintain or increase yields under deficit irrigation scenarios in diverse crops and a range of irrigation options.

Our goal has been to compare yield and crop quality of potatoes under both sprinkler-irrigated and rain-fed conditions when produced under standard production practices or with the inclusion of an aqueous nonionic surfactant formulation (10 wt% alkoxylated polyols and 7% glucoethers), applied at 10L ha-1 between emergence and tuberization. Crop responses from multi-year evaluations conducted on irrigated potatoes in Idaho (USA) were compared to multi-year on farm grower evaluations in Australia and China.

Surfactant treatment (15 locations) resulted in statistically significant increases in yield (+5%) and US No. 1 grades (+8%) while reducing culls (-10%) in trials conducted in Idaho, USA. Similar responses were observed in seven commercial grower evaluations conducted in Australia (+8% total yield, +18% mean tuber weight) and in China in 2011 (+8% total yield and +18% premium, -12% culls). Results in China in 2012 showed profit increases (up to +15%) in six of ten commercial fields despite unusually rainy conditions. Initial analysis of 2013 results from 17 commercial fields with multiple varieties (included seed potatoes), application rates, and soil conditions indicate consistent, statistically significant increases in yield (up to +20%, excluding one outlier at +42%) under water-deficient conditions, despite very cold early-season weather.

Under diverse production conditions, a single application of the surfactant formulation improved crop water productivity and quality under both sprinkler irrigation and rain-fed situations in water-stressed environments. Results from these trials suggest that ACA1848 may be a viable management practice to improve crop water productivity in irrigated crops.

Keywords: *water, surfactant, potato, yield, China*

P2-433

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Chemical Co-Precipitation of Iron And Magnesium Oxides on Biochar Produced from Conocarpus Wastes Increases NO3 Removal from Aqueous Solutions

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Batch kinetic experiments were conducted to investigate the capacity of biochar produced from conocarpus as well as chemically modified biochar by co-precipitation of iron and magnesium oxides to remove nitrate (NO3) from aqueous solutions.Various kinetic models (Zero-order, First-order, Second-order, different types of Pseudo-second-order and Power function) wereapplied to describe the nitrate (NO3) removal using each sorbent.The experimental data showed that removal efficiencies of sorbents for NO3 were found to be highly pH dependent. The higher sorption capacities of sorbents for NO3 (89-97%) were generally in aqueous solutions having lower pH of 2. However, with increasing pH of aqueous solutions, the sorption capacities of each sorbent tended to be declined. Among all sorbents, at lower pH of 2, FeO-Biochar generally showed the higher sorption capacities for NO3 (97%) than MgO-Biochar (94%) and biochar (89%). However, at higher pH of 4-8, MgO-Biochar demonstrated much higher sorption capability (49-70%) than biochar (24-38%) or FeO-Biochar (20-32%). Overall, the most experimental data were best fitted to the pseudo second-order kinetic by linear method. It could be concluded that the chemically modified biochar of MgO-Biochar may be more appropriate to remove NO3 from aqueous solutions.

Keywords：*Nitrate; Kinetic models; MgO-Biochar; FeO-Biochar; Sorbents*

P2-434

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Practicing Conservation Agriculture and Balanced Fertiliser Use Improves the Yield and Economics of Farmers in Semi-Arid Tropical Region

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In most of the semi-arid regions of southern India, only single crop, preferably a cereal (maize) is grown during the rainy season with the land remaining fallow for the rest of the period. As a result, 20 to 30% of the annual rainfall that occurs during the post rainy season goes largely underutilized. However, following conservation agricultural practices through residue retention of previous crop, reduced tillage and crop rotation with a drought tolerant, short duration legume like horsegram (Macrotyloma uniflorum) can utilize the conserved residual moisture and off-season rainfall for additional crop production and farm profit. Improving nutrient use efficiency in rainfed areas has been a major challenge, and balanced nutrient use coupled with practicing principles of conservation agriculture could improve the productivity and profitability of farmers. A study was undertaken to develop strategies of nutrient management under conservation tillage systems.

A field experiment was initiated in June 2010 for three consecutive years at Gunegal Research Farm (17°40'40.4" N latitude and 78°39'55.7" E longitude) of CRIDA, Hyderabad. The experimental soil was sandy loam in texture, acidic in reaction (pH 5.1), low in organic carbon (0.34 %), low in available N (141-153 kg/ha), medium in available P (16-19 kg/ha) and K (154-188 kg/ha) and deficient in Zn (0.48 mg/kg). The experiment was laid out in split plot design consisiting tillage treatments (conservation and conventional) as main plots and nutrient management (control, optimum treatment of NPKSBZn and successive omission of nutrients) as sub-plots. Hybrid maize (DHM 117) was grown in monsoon season (June-October) at 60 x 20 cm spacing and optimum treatment of 150-60-40-30-10-0.5 kg/ha N, P2O5, K2O, S, Zn and B was applied considering the yield target and native soil fertility. Horsegram (CRIDA 18R) was sown after maize in the experimental plots with similar treatment design and grown on residual soil fertility and residual soil moisture. Influence of tillage and nutrient management on growth and yield of both the crops were recorded and nutrient uptake was determined after harvest of each crop.

Highest yields of grain (4.7 t/ha) and stover (7.9 t/ha) were seen with the optimum nutrient treatment and no significant difference in grain and stover yield of maize was observed among the tillage systems. In case of horsegram, yields varied significantly from 264 to 443 kg/ha in conventional tillage system, whereas, in conservation tillage system, yields were in the range of 464 to 643 kg/ha. The higher yield in conservation tillage could be attributed to high nutrient uptake in this system. In conservation tillage, N, P and K content in seed was in the range of 1.62-2.63%, 0.2-0.7% and 0.77-1.17% across different nutrient treamtnets, whereas, the corresponding values in conventional tillage were 1.54-2.49, 0.2-0.6 and 0.74-0.97%, repectively.

Practicing principles of conservation agriculture (CA) improved soil organic carbon, which varied from 0.31- 0.45% and it was slightly higher than conventional system (0.29-0.42%). Microbial biomass carbon (MBC) was also higher in CA (31-89 μg/g)

compared to conventional (28-78 μg/g of soil). Higher MBC was found in case of balanced fertilization of NPKSZnB. Active C varied from 267-314 mg/kg . Very labile, labile and less labile C was in the range of 0.35-0.67, 0.11-0.23 and 0.12-0.4 mg/kg. The combination of reduced tillage with crop residue retention increases the SOC in the topsoil. Also, lack of major disturbance event with practicing conservation agriculture likely provides a steady source of organic C to support the microbial community compared to conventional system where a temporary flush of microbial activity with each tillage event results in large losses of C as CO2 . Soil moisture content and residual soil moisture also improved with practicing conservation agriculture.

Maize yields increased with adoption of conservation tillage (CA) and balanced fertilization and effect of CA was more pronounced in sequence crop (horsegram) as it minimized the effect of moisture stress for succeeding crop and prolonged the crop growth for several more days. Thus, practicing CA with improved nutrient management can improve productivity and profitability of farmers in semiarid tropical area.

Keywords：*Conservation Agriculture, Balanced Fertilisation, Soil Moisture, Soil Carbon, Semi-arid regions*

P2-435

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Indicators to Promote Sustainable Agricultural Intensification

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Increased demand for food, energy and bio-products have increased pressure on land, water and inputs prompting calls for 'sustainable intensification'(SI) that increases agricultural productivity using practices that simultaneously protect the environment and human well-being. Assessment tools that track the status of finite and precious soil resources are needed to allow users to visualize phenomena, highlight trends, index dimensions of sustainability, quantify, simplify and analyze complex information. Our ability to use indicators and frameworks to achieve SI goals will depend upon the: 1) quality and character of the data used, 2) models used to extrapolate and synthesize that data 3) metrics or results derived from tools, 4) and the interpretation frameworks that have been developed for use by 5) various decision makers. This paper will review important land/soil resource indicators employed in modeling and analytic frames used by governments and businesses before considering critiques of blanket SI approaches that advocate for 'ecological intensification'(EI) as an alternative to SI that is amore locally nuanced and famer-focused approach seeking to increase biologically based management by promoting nutrient recycling. Many key indicators associated with sustainable development efforts are collected and supplied by international organizations. The Harmonized World Soils Database, Winrock International's remote sensing data base are prime examples data used in modeling and analytic frames by governments and business to inform policy and investment. The quality and consistency of data is variable and the scale of resolution is often too coarse to be relevant to individual farms. Models, empirical methods and case studies are often used to adapt results to describe situational dynamics. Advocates for EI endorse use of participatory methods to develop and contextualize both the indicators that allow practitioners to evaluate and adapt new technologies while monitoring resource status and the interpretation frameworks that reflect local priorities, markets and value chains.

P2-436

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Simulating Dry-Season Hardening of Lowland Soils and Assessing the Impacts on Sawah Rice Performance under Three Water Regimes

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Lowland soils in most of tropical Africa harden during the dry season, but the agronomic implications of suchhardening for sawah systemsare unknown.Sawah, an Indonesian word, as currently used in sub-Saharan Africa refers to a bund-demarcated, puddled and leveled lowland field of a high-yielding rice variety under regulated flooding and routine fertilization. Dry-season hardening of lowland soils was simulated in 2010 and 2011 and its effects, and those of water regime during rice growth, on sawah soil hydrophysical condition and rice performance were evaluated under glasshouse conditions in Nara, Japan.The soil for 2010, a sandy loam, was typical of tropical African lowland soils (total carbon, 9.07 g kg^{-1}), whereas that for 2011, a sandy clay loam, was typical of Japanese soils (total carbon, 33.93 g kg^{-1}). Both the dry-season hardened soils (DHS) and all-season moistened soils (AMS) were manually puddled and young seedlings of Japonica transplanted. Each of DHS and AMS was placed under three water regimes namely optimal (WR_o), sub-optimal (WR_s), and poor water regimes (WR_p). Plants were grown without fertilizers to mimic most tropical African farmers. The reduction in soil bulk density 2 h after puddling was greater in DHS than AMS in both years. During rice harvest, soil bulk density and strength were higher in AMS than DHS and under WR-I than WR-II and WR-III in the high-carbon soil of 2011. Water regimeand soil hardening status affected plant height in 2010 (WR_o> WR_s and WR_p)and 2011 (DHS > AMS), respectively. Tillering generally decreased due to soil hardening in 2010; the reverse was observed in 2011. Greater tillering was due to WR_o and WR_s than WR_p towards maturity in 2010. Grain yield, stover yield and root biomass were higher in AMS than DHS in 2010; the reverse was true in 2011. However, these three variables generally decreased with deviation from WR_o in both years. These results suggest an underlying influence of soil carbon status on the effects of lowland soil hardening on sawah systems. In terms of rice yields, low-carbon soils benefit from pre-growing season wetness, whereas high-carbon soils benefit from pre-growing season dryness probably because of soil drying effect.

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[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Suppression of Algae Growth by Phosphorus Removal Using Fly Ash as a Growth Medium of Planted Floats

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Introduction

Phosphorus (P) is one of the essential nutrients for the growth of plants in most ecosystems, and thus it is considered to be the limiting element of primary productivity in most surface water ecosystems (Bunn et al., 1999). Therefore, when P exists in stagnant surface water in excess, it stimulates the growth of aquatic organisms including algae, leading to eutrophication (Jin et al., 2005). Among many physico-chemical technologies are available for the removal of P, biological removal of P using planted floats can be an alternative in-situ P treatment in natural and semi-natural water systems such as lakes, rivers, and constructed wetlands (Xian et al., 2010). Fly ash (FA), a residue of coal combustion in power plants, can strongly adsorb or precipitate P from water (Pengthamkeerati et al., 2008). In spite of the ability of fly ash (FA) to remove water phosphorus (P) via sorption and precipitation, its use as a growth medium of planted float has never been tested (Ugurlu and Salman, 1998). Therefore, this study was conducted to investigate the effect of using FA as a growth medium material of planted floats on the concentrations of P and chlorophyll-a in artificially P contaminated water.

Materials and Methods

Twelve treatments with triplicates were laid out with combination of six different FA mixing rates and two (with or without) rice planting. Growth medium (totally 2 kg) was prepared by mixing sand with different rates (0, 2.5, 5, 10, 25, 50 w/w %), and packed into floats. The floats were placed on baths filled with 8-L of P-contaminated (4 mg L^{-1}) water. Nine rice (Oryza sativa L., cv. Saegyehwa) seedlings were transplanted into the foam for planted treatments and were grown for 32 days until about 90% of added P was removed from the baths. Water samples were analyzed for soluble P (SP) and total P (TP) and chlorophyll-a. The decreasing rate of SP and TP in the solution was fit with the 1st-order kinetics to obtain the rate constant (k). Analysis of variance (two-way ANOVA) was performed using the general linear models procedure of SPSS 18.0 package (SPSS Inc., Chicago. IL, USA) to assess treatment effects. When treatment effects were significant, the means were separated by Duncan's multiple range tests.

Results and Discussion

Both SP and TP decreased ($P<0.05$) with increasing mixing FA rate, and rice planting further enhanced P removal from the bath water. Decreasing pattern of P followed the 1st kinetics and the k ($P<0.05$) increased by rice planting and with increasing FA mixing rates. The k of SP removal ranged from 0.097 to 0.193 day^{-1} for treatment without rice planting and from 0.103 to 0.206

day^{-1} for treatments with rice planting. For TP removal, the k ranged from 0.072 to 0.143 day^{-1} for treatment without rice planting and from 0.090 to 0.192 day^{-1} for treatments with rice planting. Chlorophyll-a concentration significantly decreased ($P<0.05$) with increasing FA mixing rate. Although chlorophyll-a concentration in the treatments mixed with FA at 0 to 10% increased up to 0.65 mg L^{-1}, those in treatments with FA at 25 and 50% resulted in relatively consistent chlorophyll-a concentrations below 0.05 mg L^{-1} throughout the experiment period. Therefore, it was suggested that FA can be used as a plant growth medium in planted floats for enhanced removal of water P and thus for suppression of algae growth.

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Keywords：*Eutrophication, Water contamination, Phosphorus sorption, Coal fly ash*

P2-438

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Characteristics of Isotopic and Elemental Compositions of Potential Water Pollution Sources in Rural Area

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Introduction

Since water quality in rural areas is susceptible to a variety of non-point pollution sources from agricultural, livestock-farming, forest, and residential areas due to the multi-purposes land use characteristics, it is not straightforward to identify pollution sources and thus to implement countermeasure for water quality protection (Choi et al., 2007). In this study, we characterized isotope and elemental compositions of potential pollution sources including agricultural soils, livestock manure, plant residues, and agricultural inputs to explore potential use of isotopic and elemental compositions in estimating water pollution sources.

Materials and Methods

All the samples including agricultural nutrient inputs (synthetic fertilizer, n=8) and livestock manure compost, n=6), agricultural soils (paddy, n=15; upland, n=10; orchard, n=3), plant residues (rice straw, n=9; tree litter, n=18), and materials in livestock farming (formula feed, n=4; livestock manure, n=4) were collected from the Pungyoungjeong river watershed located in Jangsun of Chonnam Province, Korea. The samples were freeze-dried to prevent gases loss of some elements including nitrogen (N). The dried samples were ground to a fine powder and analyzed for concentration and isotope ratio of C ($\delta^{13}C$) and N ($\delta^{15}N$) and metal (Ca, Mg, K, Na, Zn, Cu, and Al) concentrations.

Results and Discussion

The $\delta^{15}N$ (-1.5±0.5‰, n=8) of synthetic fertilizer was lower than that (16.3±0.3‰) of livestock manure compost, reflecting ^{15}N-depleted source (atmospheric N_2 with $\delta^{15}N$ of 0‰) of synthetic fertilizer and ^{15}N-enrichment via gases N loss during composting of livestock manure (Kim et al., 2008). In agricultural soils, the $\delta^{15}N$ of upland (9.6±0.5‰) and orchard soils (10.6±0.4‰) was higher than that (4.9±0.2‰) of paddy due to heavy application of ^{15}N-enriched livestock manure compost in the first two soils. Tree litters have lower $\delta^{15}N$ (-0.7±0.3‰) than rice straw (8.1±0.9‰), reflecting more closed N cycle in forests (Kwak et al., 2009). In agricultural farming sector, although the $\delta^{15}N$ of formula feed was as low as 2.8±0.3‰, manure was more enriched in ^{15}N (10.2±3.5‰) due to faster loss of $^{14}NH_3$ than $^{15}NH_3$ immediately after manure excretion (Lim et al., 2010). The $\delta^{13}C$ of forage was -19.7±0.8‰ and this was higher than C3 plant residues such as rice straw (-28.2±0.1‰) and tree litter (-28.3±0.3‰) due to inclusion of C4 plant maize in the feed. Due to the higher $\delta^{13}C$ of feed, livestock manure (-23.1±1.8‰) and its compost (-24.2±1.4‰) showed relatively higher $\delta^{13}C$ than other organic materials such as rice straw and tree litter. Heavy application of ^{13}C-enriched compost led to a higher $\delta^{13}C$ of upland (-25.4±0.3‰) and orchard (-24.2±0.8‰) than that (-28.0±0.2‰) of paddy. The C/N of rice straw and tree litters was 72.2±5.8 and 32.4±2.2, respectively, and that (14.6±1.7) of livestock manure compost was

lower than that (20.3±2.8) of livestock manure, implying faster loss CO_2 than N during composting. The Al/(Ca+Mg+K+Na) of compost, rice straw, and tree litter was 0.03±0.01, 0.06±0.03, and 0.94±0.27, respectably, which was much lower than those of agricultural soils (5.8±0.2 for paddy, 5.8±0.4 for upland, and 6.4±0.6 for orchard). Meanwhile, (Cu+Zn)/Al of livestock manure compost (0.6±0.4) was higher than other materials. Therefore, our study suggests that the potential water pollution sources have contrasting isotopic and elemental compositions and thus it may be possible to use such characteristics in identifying water pollution sources.

Acknowledgment

This research was financially supported by a grant from the Yeongsan and Sumjin River Watershed Management Committee, Ministry of Environment, Republic of Korea.

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Keywords：*Non-point source pollution, Polluion source, Nitrogen isotope, Carbon isotope, Elemental composition*

P2-439

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Nutrient Sources Affected Concentration and Isotope Ratio of Nitrogen in Ponding Water of Paddy Soils in a Laboratory Incubation Experiment

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Introduction

Surface runoff from flooded paddy during heavy rainfall events is considered to be the primary N delivery path in agricultural area of Korea. In the past up to 1990s, synthetic fertilizer was the primary N sources; thereafter the use of organic inputs has increased due to the environmental-friendly agriculture promotion policy since the early 2000s (Yoo et al., 2012). Since these nutrient sources have different reactive, their impacts on water pollution are likely to be different, and the different reactive may be assessed with N isotope ratio ($\delta^{15}N$). In this study, we investigated changes in concentration and $\delta^{15}N$ of N in ponding water in a laboratory incubation experiment with a paddy soil amended with synthetic fertilizer, green manure, or livestock manure compost to evaluate the potential impacts of nutrient sources on water quality.

Materials and Methods

A total of 12 jars were prepared for the treatments without nutrient input (control) and with nutrient inputs such as synthetic fertilizer (SF, urea), livestock manure compost (LMC, pig manure compost), and green manure (GM, hairy vetch) with triplications. For N treatment, nutrient sources were applied to a jar at 230 mg N, which is equivalent to the standard N fertilization rate (11 g N m^{-2}) for paddy rice in Korea. The jar was received distilled water to the 3 cm above the surface and incubated at 25°C for 30 days. On 1, 2, 4, 7, 10, 15, and 30 days after treatment (DAT), 100-mL of ponding water was sampled and the same distilled water was added to maintain the water depth. The samples were analyzed for pH, N (T-N, Org-N, NH_4^+, and NO_3^-) concentration and the corresponding $\delta^{15}N$. The effects of nutrient sources on N concentration and $\delta^{15}N$ were evaluated with the analysis of variance using the general linear model procedure of the AASW statistics (IBM Corp. Amonk, NY, USA).

Results and Discussion

The concentration of NH_4^+ gradually increased in SF treatment up to 12.2 mg N L^{-1} until 15 DAT followed by a rapid decline to 7.7 mg N L^{-1} on 30 DAT. The GM treatment showed a similar pattern; increases in NH_4^+ concentration up to 10.3 mg N L^{-1} until 15 DAT and decreases to 0.7 mg N L^{-1} on 30 DAT. For SF, the decrease in NH_4^+ concentration coincided with increases in NO_3^- concentration and decreases in pH, indicating the presence of active nitrification. Meanwhile, for GM, there was no substantial increase in NO_3^- and org-N concentration during the NH_4^+ decline period, and this suggests that NH_4^+ was neither oxidized nor immobilized to org-N. Because pH of GM treatment was higher than other treatments and maintained above 7.0 after 7 DAT, NH_4^+ concentration seemed to decrease via NH_3 volatilization. On average across the measurement, T-N concentration was in the order of SF (13.8 mg N L^{-1}) > GM (7.2 mg N L^{-1}) > LMC (5.0 mg N L^{-1}) > control (2.9 mg N L^{-1}) ($P<0.05$), suggesting that application LMC and GM can reduce N concentration in ponding water. The $\delta^{15}N$ reflected both $\delta^{15}N$ of source N (-1.4‰ for SF, 12.5‰ for LMC, and 7.5‰ for GM) and N dynamics such as nitrification and N loss. On 30 DAT, the $\delta^{15}N$ of NH_4^+ was 25.4, 18.7, and

20.7‰ for SF, LMC, and GM, respectively, and the higher $\delta^{15}N$ of NH_4^+ than the $\delta^{15}N$ of N source could be attributed to N isotopic fractionation associated with nitrification (for SF) and NH_3 volatilization (for GM) and to the higher $\delta^{15}N$ of N source (for LMC) (Choi et al., 2005). Meanwhile, the $\delta^{15}N$ of NO_3^- (-3.8, 10.9, and 8.6‰, for SF, LMC, and GM, respectively.) seemed to reflect the $\delta^{15}N$ of sources, suggesting that tracing of N sources using $\delta^{15}N$ of NO_3^- can be possible.

Acknowledgment

This work was supported by the Ag-BMPs development project for water quality improvement in the Saemangeum estuarine reservoir funded by the MIFAFF, Korea

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Keywords：*Nitrogen isotope, Paddy soil, Green manure, Livestock manure, Synthetic fertilizer, Nitrogen contamination*

P2-440

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Zinc Sorption on Coal Mine Drainage Sludge

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Zinc (Zn) is one of essential nutrients for living organisms in natural ecosystem. However, excessive zinc has been paid attention because it can arise adverse effects such as dehydratation, vomiting and respiratory incapacitation. It is known that partition of metals to naturally formed minerals plays an important role in controlling concentration of dissolved metals in different conditions of the near subsurface environments. Nevertheless, development of mechanism(s) of metal uptake by minerals to predict the fate and transport of toxic metals like zinc is not clearly understood yet. In this study, therefore, we investigated zinc sorption on coal mine drainage sludge (CMDS) formed at abandoned mines, Ham-Baek and Ham-Tae mine in Korea over a wide range of physicochemical conditions such as pH, Zn concentration and different ionic strength.

XRF results show that an iron oxide is the major components for both Ham-Baek and Ham-Tae CMDS (hereafter, called HB CMDS and HT CMDS, respectively). However, XRD indicates that HT CMDS is mainly composed of iron (oxy)hydroxides such as goethite whereas HB CMDS is only composed of schwertmannite. At pH 4.0, compared to that sorption of zinc on a synthesized schwertmannite, sorption of Zn on these HB CMDS and HT CMDS increases with increasing zinc concentration without maxima. However, at pH 7.0, the sorption pattern was shown by Langmuir sorption behavior. Our results show that Zn sorption on these two sludges and the synthesized schwertmannite increases with increasing the concentration of a background electrolyte, suggesting that physicochemical properties of these minerals are likely changed by different ionic strengths at the mineral-water interface. Total uptake of zinc by HB CMDS and HT CMDS are almost 80 % at pH 7.0. Desorption experiments show that zinc desorbs on HT CMDS during the first 6 hr, and then is resorbed whereas the sorption on HB CMDS is irreversible at pH 7.0 during the overall desorption period. Therefore, our results show that partition of zinc to naturally formed mineral, CMDS is sensitively influenced by solution conditions and plays an important role in controlling the long-term stability of zinc sorption on naturally formed minerals in natural ecosystems.

Keywords：*zinc, sorption, coal mine drainage sludge, schwertmannite, goethite*

P2-441

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Phosphorus Removal and Diesel Degradation by Bacillus Sp. 3434BRRJ Isolated from Industrial Wastewater

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Soil and water are the important ecosystem in producing the good agricultural products. The agricultural ecosystem is intimidated by the variety of environmental pollutants resulting from the modern industrialization. Therefore, their removal and treatment from the polluted soil and water are the major environmental issues. Compared to the physical and chemical treatment that have been largely used, the biological treatment is considered to be a new attractive treatment, especially, using microorganism in soil and water. Phosphorus(P) is major element causing eutrophication in water system and diesel is one of major toxic xenobiotics in soil and water. This study was initiated to evaluate the P removal and diesel degradation by three strains of bacteria isolated from industrial wastewater. The three strains of bacteria, A1, A2, and A3, isolated were identified as Stenotrophomonas maltophilia strain CUPS 3, Rhodococcus erythropolis strain Sco-C01, Bacillus sp. 3434BRRJ, respectively. The P removal efficiencies by Bacillus sp. 3434BRRJ, Stenotrophomonas maltophilia strain CUPS, and Rhodococcus erythropolis strain Sco-C01 were 99 %, 50 %, 20 %, respectively. The diesel degradation efficiencies by Bacillus sp. 3434BRRJ, Stenotrophomonas maltophilia strain CUPS, and Rhodococcus erythropolis strain Sco-C01 were 86.38%, 23%, 0%, respectively. Lipophilicities by the three strains of bacteria were the highest in the log phase, whereas, they were the lowest in the death phase. The lipophilicity was higher in Bacillus sp. 3434BRRJ than in Stenotrophomonas maltophilia strain CUPS 3, than in Rhodococcus erythropolis strain Sco-C01 in order. As the diesel was used as a carbon source, P removal efficiencies by Bacillus sp. 3434BRRJ and Stenotrophomonas maltophilia strain CUPS 3, were 67.95 % and 44.89 %, respectively. Whereas, P removal by Rhodococcus erythropolis strain Sco-C01 was not accomplished. Therefore, Bacillus sp. 3434BRRJ having both the highest capacity of P removal and diesel degradation was used for further experiment study. The experiment evaluating the effects of temperature, P concentration, aeration, and carbon sources on P removal by Bacillus sp. 3434BRRJ were performed in the following conditions: temperature, 15, 25, and 30 ℃; P concentrations, 20, 30, and 40 mg/l; oxygen condition, aerobic, anaerobic/aerobic conditions; carbon sources, glucose, acetate and mixture of glucose and acetate. As a result, the best optimum conditions for P removal by Bacillus sp. 3434BRRJ were as follows: temperature, 30oC; P concentration, 20 mg/L; carbon sources, mixture of glucose and acetate; oxygen concentration, anaerobic and aerobic conditions. The effect of second carbon sources on the diesel degradation by Bacillus sp. was evaluated in this study. As glucose, acetate, glucose plus acetate as second carbon sources were added, the diesel degradation efficiencies were 69.22%, 65.46%, and 51.46%, respectively. The diesel degradation efficiency was higher in the individual additions of glucose and acetate than in the mixture of glucose and acetate. As P concentration was increased from 20 mg/L to 30 mg/L, the diesel

degradation efficiency was increased by 7%, whereas, as P concentration it was increased from 30 mg/L to 40 mg/L, it was not increased. By using proteomic analysis, total seven proteins spots were specifically and differentially expressed from the culture samples of Bacillus sp. 3434BRRJ treated with diesel at 0.5 %(v/v), compared to those from the diesel 1.5 %(v/v). Through the use of MALDI-TOF/MS and BLAST search of NCBI, the five proteins were identified, one of which may be involved in the degradation of alkane and known as cytochrome P450 system. Also, total twenty two proteins spots were specifically and differentially expressed from the culture samples of Bacillus sp. 3434BRRJ treated with diesel at 1.5 %(v/v), compared to those from the diesel 0.5 %(v/v). By the same procedures as applied in the above experiment, the sixteen proteins were identified, two of which may be involved in the fatty acid transport system and alcohol dehydrogenation, respectively. Further study is needed for the degradation of specific aliphatic and aromatic compounds by the Bacillus sp. 3434BRRJ and the application to the polluted environment.

Keywords：*Sustainability, Ecosystem, Soil, Water, Good Agicultural Products, Contamination, Industrial Wastewa*

P2-442

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Effects of Ca2+ and Mg2+ on the Formation of Trihalomethane(thm) and Haloacetic Acid(haa) during Thechlorination of Drinking Water

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Chlorination is a process widely used to disinfect the water by adding chlorine to it. During this disinfection process, It is frequently reported that THMs(Trihalomethanes) and HAAs(Haloacetic acids) are produced as the two major groups of disinfectant byproducts during the chlorination. Also, the formation of THM and HAA in drinking water are promoted by chlorine after reacting with NOM(Natural Organic Matter) dissolved in drinking water, respectively. The representative disinfection by products observed in many previous studies are chloroform(CHCl3) and dichloroacetic acid(DCAA) which are known to be carcinogens. Recently, it has been reported that the divalent metal ions existing in drinking water promote the formation of such disinfection by products. In this study, we performed a batch experiment on the formation of THMs and HAAs in model solutions following the addition of Ca2+ and Mg2+, which are known to influence the hardness of drinking water during its chlorination. The experimental procedure was carried out as follows. Organic humic acid and citric acid were used as controls. The organic matters used as control were added in 1L of Mill-Q water with the concentration of 1 mgL-1, respectively. The concentrations of Ca2 and Mg2+ added as metal ions in the water solution were 50ppm, respectively. The pH of solution used for the experiment was initially adjusted to 7.0 using NaHCO3. The water solution was separated into brown bottles, injected with sodium hypochlorite(4 mg L-1), and then cultivated for 20~120 hours in a 20℃ of incubator. After this time, the reactions were stopped by the addition of sodium thiosulfate and then the concentrations of THMs and HAAs were analyzed using purge & trap and GC/MC, and GC/ECD, respectively. The chromatographic results for THM and HAA obtained from the instrumental analysis were identified as chloroform and DCAA, respectively. Using the citric acid as control, in the water samples with no metal ions added, after 96 hours, the concentrations of chloroform and DCAA were 26.8 μgL-1 and 19.1 μgL-1, respectively. Whereas, in the same condition with metal ions such as Ca2+ and Mg2+added, those of chloroform and DCAA were 43.7 μgL-1 and 53 μgL-1 and 39.8 μgL-1 and 42.1 μgL-1, respectively. In summary, the concentrations of chloroform and DCAA were approximately two times higher in the water samples treated with the metal ions than in untreated water samples, respectively. Based on the results obtained from the study, it appears that the strength of Lewis acid in the interactions of metal ions with the functional groups of organic matter is involved in the formation of THM. Further study is extensivelly performed for elucidating the factors and mechanism involved in the formation of HAA.

Keywords：*Drinking water, Chlorination, Metal ions, Ca, Mg, Humic acids, Citric acids, THMs, HAAs*

P2-443

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Effect Of Environmental Factors On The Growth Of And Capacity Of Phosphorus(p) Removal By Bacillus Sp. 3434brrj In The Biological Reactor

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This study was initiated to isolate and characterize the pure bacterial cultures from the mixed culture capable of removing Phosphorus(P) from the wastewater and to evaluate the environmental factors inovlved in their P removal. In the all experiments, the initial P concentration was 20 mg/L, except the growth curve of bacteria and P removal efficiency as a function of P concentration. The P removal efficiency by the mixed bacterial culture isolated from the wastewater was 67.5%, of which Bacillus lichenifomis was selected and grown and its growth and P removal efficiency were measured as affected by the environmnetla factors. Its P removal efficiency was 100.0% as the initial P concentration was 10 mg/L and P was removed as the bacteria was grown. The temperature showing the highest P removal efficiency was at 30oC, and the pH showing the best growth and P removal efficiency was at 7. The carbon source showing the maximum P removal efficiency and growth was glucose and 80.9%. Therefore, based on the results in the 1st year of the study, the best optimum conditions for the growth and P removal of Bacillus lichenifomis were 10 mg/L of initial P concnetration, pH 7, 30oC of temperature. In the 2nd year of the study, Bacillus sp. 3434 BRRJ in the 5L biological reactor was inoculated rather than Bacillus lichenifomis which was used in the 1st year of the study for the best optimum conditions in the removal of P, because Bacillus sp. 3434BRRJ isolated from the industrial wastewater showed hither P removal efficiency than Bacillus lichenifomis. The same methodology as used in the isolation and charactetrization of Bacillus lichenifomis was used in those of Bacillus sp. 3434BRRJ used in the 2nd of the year of the study. The P removal efficiency by Bacillus sp. 3434BRJ was higher in the alternating anaerobic and aerobic conditions than the only aerobic condition in the all experiments performed. In the anaerobic and aerobic conditions, the growth and P removal efficiency of Bacillus sp. 3434BRRJ were the best at 30oC of temperature. P removal efficiency was the highest in the use of the mixture of glucose plus acetate as carbon sources, which was 61.3%. Fom this experiment, the best optimum conditions for the maximum P removal efficiency by Bacillus sp. 3434BRRJ were as follows: the initial P concentration was 20 mg/L, pH 7, 30oC of temperature, the mixture of glucose plus acetate as carbon sources, and in the anaerobic and aerobic conditions. The 3rd of the year of the study was performed based on the 2nd year of the study. The domestic wastewater rather than the synthetic wastewater was filled and used as the liquid media of 5L of biological reactor for the evaluation of P removal efficiency by Bacillus sp. 3434BRRJ on site wastewater treatment plant. The initial P concentration and pH of domestic wastewater used in the study was 3.991 mg/L, and 7.2, respectively. Therefore, the study was performed as these conditions were initially maintained. The study was performed in the condition that the best results were obtained from the 2nd year of the study, Extra additional carbon sources were not provided in the study. After the study was performed, the bacterial growth was the fastest grown at 30oC of temperature compared to 35oC of temperature. the P removal efficiency was 95.53% at 30oC of temperature. Based on the experimental results obtained from the study, it appears that the best optimum conditions for the growth of Bacillus sp. 3434BRRJ and its P removal capacity from the wastewater were at temperature of 30oC with alternating anaerobic and aerobic condtions.

Keywords: *Wastewater, Bacillus sp. 3434BRRJ, Best Optimum Condition, Biological Reactor*

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[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Characterization of the Proteins Involved in the Inhibitory Effect of Copper(cu) on the Growth and Phosphorus(p) Removal Efficiency of Bacillus Sp. 3434BRRJ

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Proteome indicates the combination of proteins with "-ome" and the whole proteins expressed in the specific condition of the cell. Proteins are major cellular components controlling the life and their analyses are needed in the understanding of biological activity in living organisms including microorganisms. Recently, proteomics is used as a experimental tool to analyze the function of gene and identify the proteins and modified proteins. The goal of proteomics is to systematically study the amount, function, structure, cellular distribution, interaction of proteins. In addition, since the various physiological responses of the living organism to the internal and external changes at the specific moment can be detected through the use of proteomics, it can capture the different expression patterns under the same genome and detect the molecular changes under some condition. The heavy metals flowed into the biological wastewater treatment process frequently inhibit the efficiency of the process. In our previous study, it was found that, as the concentrations of heavy metals used were gradually increased, the growth and P removal efficiency of Bacillus sp. 3434BRRJ isolated from the industrial wastewater were correspondingly decreased. Therefore, this study was initiated to evaluate the proteins involved in the inhibitory effect of the various concentrations of Cu on the growth and P removal efficiency of Bacillus sp. 3434BRRJ through the proteomic analysis.

Keywords：*Bacillus sp. 3434BRRJ, Copper(Cu), Inhibition, Growth, Phosphorus Removal, Proteome Analysis,*

P2-445

[C3.5-1] Water Conservation Technologies and Impacts on Sustainable Dry Land Agriculture

Effects of Selected Heavy Metals on the Growth of and Phosphorus(p) Removal Capacity by the Three Bacteria, Bacillus Sp. 3434 BRRJ, Pseudomonas Aeruginosa, Bacillus Subtilis

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Phosphorus accumulating microorganisms (PAOs) are influenced by various environmental factors and heavy metals. This study was performed to evaluate the effects of the selected heavy metals on the growth and phosphorus removal capacity of Bacillus sp. 3434BRRJ, Pseudomonas aerunogisa, and Bacillus Subtilis, well known as PAOs. The heavy metals used in this study included Cu, Cd, Zn, and As. The IC50 (median inhibition concentration) values of Bacillus sp. 3434BRRJ for the Cu, Cd, Zn, and As were 8.07 mg L-1, 0.18 mg L-1, 0.25 mg L-1 and 73.62 mg L-1, respectively. The IC50 values of Pseudomonas aerunogisa for the Cu, Cd, Zn, and As were 4.45 mg L-1, 0.48 mg L-1, 2.34 mg L-1 and 18.51 mg L-1. The IC50 values of Bacillus subtilis for the Cu, Cd, Zn, and As were 3.81 mg L-1, 0.53 mg L-1, 0.47 mg L-1 and 11.31 mg L-1. The phosphorus removal efficiencies of the three bacteria, Bacillus sp. 3434 BRRJ, Pseudomonas aerunogisa, and Bacillus subtilis were 93.12%, 71.81%, and 65.31%, respectively. Of the three PAOs, Bacillus sp. 3434BRRJ had the best results in terms of their growth rate and P removal efficiencies. Based on the experimental results from this study, it appears that as the concentrations of four heavy metals were increased, the growth rate and P removal efficiencies of the three bacteria were correspondingly decreased.

Keywords：*Phosphorus Accumulating Microorganisms, Heavy metals, Growth, IC50, P removal efficiency*

P2-446

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Temporal Analysis of Bioremediation of Crude Oil Contaminated Soil Using Remediation by Enhanced Natural Attenuation (rena) Technique in Mbodo Community, Port Harcourt, Nigeria

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The study evaluates the soil properties response to crude oil pollution using remediation by enhanced natural attenuation (RENA) technique. 600g of uncontaminated soil was collected from the top soil (0-15cm) depth around Agbada 1 Flow Station, Mbodo Community, Aluu, Port Harcourt City, Nigeria. This site was chosen because of the possibility of soil in the area to be polluted with crude oil in future. The soil sample was air-dried and carefully sieved with 2mm diameter mesh. 200g of the soil remained uncontaminated with crude oil and this is called sample A which was the control while the remaining 400g of soil was contaminated with 1ml of Bonny Light type of crude oil and left for a week. Thereafter, the contaminated soil (Sample B) was subdivided into two equal parts (200g) namely sample B1 and sample B2. Sample B2 was fertilized with 1g of NPK 15-15-15 fertilizer while sample B1 remained contaminated but unfertilized. The experiment was left for another week in the laboratory under room temperature. Laboratory analysis was then carried out on the soil samples (A,B1 and B2) every week for a total period of five (4) weeks on the concentrations of soil pH, total organic carbon, nitrate, sulphate, available phosphorous, cadmium, chromium, sodium, lead, iron, potassium, total petroleum hydrocarbon (TPH), moisture content and water holding capacity. Descriptive statistics was used to explain the concentrations of the soil properties in response to crude oil contamination in both fertilized and unfertilized contaminated soil samples. A TPH concentration of 6820 mg/kg was achieved after spiking and tilling of contaminated soil. There was a reduction in the TPH level from 7150mg/kg on the first day of application of fertilizer to 2550 mg/kg after 28th day. The water holding capacity and moisture content increased with time from 35.6% and 59.4% on the first day to 47.7% and 65.3% on the 28th day respectively. Finally, Cd reduced with time after the application of fertilizer from 0.09 mg/kg to 0.04 mg/kg. The study recommended among others that there should be a periodic monitoring and management of oil spill sites in oil producing communities to sustainably manage soil for food production and prevent loss of biodiversity.

Keywords：*RENA, Crude oil, Sustainable management*

P2-447

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Heavy Metal Transport and Accumulation in Maize Crop Grown on Battery Wastes Contaminated Site in Response to Compost and Inorganic Fertilizer

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Excessive heavy metal accumulation in agricultural soils and the consequent contamination of crops pose serious risk to human health through food chain. Approach for the removal of the contaminants from contaminated site must be considered to prevent or reduce bioaccumulation of heavy metals in plant tissues. Immobilization of heavy metals in the contaminated media through the use of organic amendments is said to be cost-effective and environment friendly.

In this study, effect of organic materials (Mexican sunflower compost; MSC) and Cassava peel compost; CPC) applied at 0, 20 and 40t/ha and inorganic fertilizer (NPK; 20:10:10) at 100kgN/ha on heavy metal (Zn, Pb, Cd and Cr) uptake by maize crop grown on abandoned battery waste contaminated site at different growing stages; one and two month(s) after planting (i.e 1MAP, 2MAP) and at harvesting were assessed. The soil on this site has been reported to contain high level of heavy metals especially lead (Pb: 138,000 mg/kg, Cu: 482 mg/kg, Zn: 1510 mg/kg, Cr: 12.3 mg/kg and Cd: 41.3 mg/kg) which made it unproductive and phytotoxic. The treatments were MSC40, MSC20, CPC40, CPC20, F1 and Control (0t/ha) using Randomized Complete Block design with four replications. At each sampling period, the plants were separated into different parts, and analysed for Zn, Pb, Cd and Cr concentrations following standard procedure. Transfer factor (TF) to the edible parts (leaf at 1 MAP, 2 MAP and seed at harvesting) was determined for each metal and expressed in percentage (i.e. TF (%) = concentration of metal in edible part divided by concentration of metal in soil multiplied by 100). Percentage Pb concentrations in the root and shoot, Bioaccumulation and translocation factors were also calculated to determine the effectiveness of compost and inorganic fertilizer in the immobilization and upward movement of Pb in maize plant. Similarly, correlation coefficient of soil Pb and those of the plant tissue was also determined to understand the relationship between Pb concentration in the soil and plant uptake.

Result showed that maize plant accumulated more Pb than other metals with Cr being the least and was below the detection limit at harvesting. Generally, heavy metal concentrations were higher at 1MAP than 2MAP in all the treatments ($P < 0.05$). Pb concentration was reduced in all the compost treated plants from the initial values that ranged between 22100-26700 mg/kg at 1MAP to 10,400-13,200 mg/kg at 2MAP. At both periods, the highest concentration of Pb was recorded in the inorganic fertilizer treatment followed by control. The plants in these treatments were stunted and later withered. Higher compost rate performed better than lower rate and mean Pb concentrations in maize plant tissue from MSC40 (7636.3 mg/kg) and CPC40 (10712 mg/kg) treatments were lower than those of MSC20 (12501.8 mg/kg) and CPC20 (12668.04 mg/kg). The concentrations of these metals (most especially Pb) in the root was generally higher than in other plant parts except Cu. At harvesting, the lowest Pb concentration was recorded in the seeds from MSC20 (152mg/kg) followed by MSC40 (174mg/kg). The transfer factors of all the metals were

also reduced starting from 1MAP to harvesting with more in the control and F1 than in compost treatments. On the percentage distribution in root and shoot, at 1MAP, the percentage Pb in the maize shoot (59 -73%) was higher than that of the root (26?41%) in all the treatments. The trend was however, reversed at 2MAP and at harvesting. At 2MAP, the percentage Pb concentration in the shoot (5.4 - 61%) was lower than that of the root (47-94%) especially in all the compost treatments. Similarly, at harvesting, the highest percentage was found in the root (66-91%). Bioaccumulation and Transfer factors were also reduced in all the compost treatments at every growing stage. There was also strong correlation between total Pb concentration in the maize plant and soil Pb (0.84***).

Heavy metal concentration and distribution in plant was found to depend on the maize growth stage. Amendment with compost reduced heavy metal accumulation by maize crop and was more effective on Cr than other heavy metals.

Keywords：*Soil contamination, Food poisoning, Heavy metals, lead (Pb), Nutrient, Mexican sunflower, Cassava*

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Oil Tea (*camellia Oleifera*abel.), an Aluminum Hyperaccumulator, Adapts to Acid Soils Ingeniously

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Oil tea (*Camellia oleifera* Abel.), an oil tree species, is cultivated in the southern provinces of China and Southeast Asia, where allitic acid soils are the main soil types. Aluminum (Al) is regarded as a serious factor limiting crop production in acid soils. Nevertheless, a wide range of native plant species and genotypes including oil tea, Al hyperaccumulator, could grow well and evolve ingenious adaptive mechanisms, which deserve further investigation.

Al accumulation in oil tea:

More than 13,000 mg kg^{-1} Al could be accumulated in old leaves of oil tea, which is much higher than those famous Al accumulators such as tea (*Camellia sinensis* (L.) O. Kuntze) and buckwheat (*Fagopyrum esculentum* Moench) grown in the same region. In a year, Al accumulation in the new leaves of oil tea increased gradually and significantly. What's more, the average Al concentration in the embryo of oil tea seeds was 389 mg Al kg^{-1} DW, much higher than in other Al accumulators. Al in seed oil was 2.78 mg L^{-1}, about 2 times of that in peanut oil, another cooking oil usually used in China.

Positive effects of Al to growth of oil tea:

Although Al is recognized as toxic to most plants, to some Al accumulators, it seems that Al is even necessary or beneficial. A series of hydroponic experiments showed that Al could improve root architecture, enhance root activity, increase biomass, while if Al was deficient in nutrient solution for a relative long term, root growth was abnormal. It's also observed that Al was vital for flowering and lifecyle completion. All these results showed that Al played the role of nutrition during oil tea growth.

Al uptake and transport in oil tea:

How oil tea could accumulate so much of Al? Our recent results showed that Al^{3+} and Al-F (1:1), ubiquitous in acid soils, could influx into oil tea roots. The kinetics of Al^{3+} cumulative uptake in excised roots and intact plants, also suggested the efficient Al influx into roots helped oil tea to accumulate huge amounts of Al. Do the transportation processes account for the plentiful Al accumulation in oil tea? The leaf transpiration suppression experiment clarified the importance of xylem transport to Al accumulation in leaves. However, xylem transport alone could not sufficiently explain the high Al accumulation in the seasons when the leaf transpiration is weak. The results of a series of lab experiments demonstrated that Al could be redistributed between leaves, from seeds to leaves, leaves to roots, and leaves to seeds, which indicates that Al can be transported via the phloem in oil tea. The diverse transport mechanisms of Al, the combined action of xylem and phloem transport in specific seasons, are presumed to account for the plentiful Al accumulation in oil tea.

Relationship between Al and Phosphorus in oil tea:

Al toxicity and Phosphorus (P) deficiency coexist as the main constraints for plant growth in acid soils. It would be worth investigating further the relationship between Al and P in oil tea. Our preliminary field investigation provided an exciting phenomenon on Al and P in oil tea: the higher of the Al contents in the organs is, the lower of P contents would be, which was more obvious during April to May. More interestingly, during April to May Al accumulation in leaves was depressed, while P accumulation was increased under partial suppression of leaf transpiration. These findings led us to hypothesize: is Al and P synergistic? or might Al substitute some roles of P in part in oil tea? Using hydroponic experiment, it was found that appropriate amount of Al application stimulated plant growth and P uptake. In addition, oil tea could also utilize the insoluble Al-P source. In conclusion, these results suggested that Al played an important role in facilitating P uptake in oil tea, Al and P are in harmony in coping with acid soils for oil tea.

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The Cost Benefit Analysis of Using Contaminated Agricultural Land to Planting Energy Crops

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In Taiwan, the government has been developing a green energy plan to promote biofuels production and consumption since 2006. After successfully introducing the 1 percent biodiesel (domestic diesel fuel now adds 1% biodiesel, referred to as B1) in 2008, Taiwan has accomplished the goal to implement B2 mandate for motor fuel by 2010 and set the goal of B5 mandate by 2016. With policy requirements, the demand for biodiesel will increase, and the energy crop planting is one of the options. In order to avoid the problem that the biofuel mandating may lead to some displacement and crowding out effect in food production, this study suggests the use of listed contaminated agricultural lands for energy crop cultivation and adopting phytoextraction as the remediation method.

After yearly verifications and pollutions reductions by Taiwan EPA, these contaminated agricultural sites are now around 720 on the list, approximately 108 hectares. Since the main function of agricultural land is production and food supply, the regulatory standards are more stringent than other types of contaminated sites. Common remediation methods for agricultural land include: soil acid washing, thermal desorption, soil turnover and dilution technologies, etc. Those remediation methods may cause changes in soil properties, soil aggregate structural damage, and microbe disappearance in environment, affecting agricultural lands' function, which need to restore their fertility to continue farming.

Phytoremediation is the least harmful method. Through the use of appropriate plants, contaminated soils and groundwater are mitigated and remediated, without the need of various equipments and machineries to excavate the contaminants and deal with disposal problems, but this may need long-term maintenance and monitoring at a brownfield site.

In order to avoid idle agricultural land becoming a burden on country's economy, using listed contaminated agricultural lands for energy crops cultivation provides an opportunity to produce carbon-neutral biomass fuels without impacting on food production. The long-term growth has the potential to achieve cost-effective reduction of contamination level. In this study, one of the listed sites using phytoextraction is evaluated for the benefits analysis of energy crops production, in terms of environmental, economic, and social benefits, as well as cost analysis comparison with other remediation technologies.

Keywords：*Contaminated Agricultural Land , Energy Crops, Cost Benefit Analysis, Phytoremediation*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Evaluation of Biological Nitrate Degradation Rate by Indigenous Microorganism in Column Packed With Nitrate-Contaminated Soils Under Various Conditions

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In Korea, approximately 31% of groundwater wells installed in agricultural area was exceeded a quality standard for drinking water due to groundwater contamination by agricultural activity or inappropriate management of manure. Thus, nitrate management in the groundwater is required to provide safe-groundwater.

Known-typical nitrate-treatment technologies include ion exchange, reverse osmosis, and biological denitrification. Of the treatment methods, biological denitrification process by indigenous microorganism has environmental and economic advantages for the complete elimination of nitrate because of lower operating costs compared to other methods. Major mechanism of the process is microbial reduction of nitrate to nitrite and nitrogen gas by three functional genes(noeZ, nirK, nirS) that encode for the enzyme involved in the pathway.

In this work, we sampled nitrate-contaminated soils from four sites with different nitrate concentration and set up anaerobic soil-columns with the soils. We compared denitrification rate by natural microorganism in each column, and evaluated influence of injection concentration of fumarate and hydraulic retention time (HRT) on the rate.

The experiments were performed as following, 1) transport test of Nitrate, fumarate, and bromide, 2) Activity test with/without fumarate without nitrate-contaminated groundwater source, 3) Activity test with fumarate and nitrate-contaminated groundwater. In the result of transport test, bromide and nitrate recovery was 80~99%, but fumarate recovery(40~60%) was lower than other compounds as, possibly due to fermentation of fumarate. Through following activity tests, we also evaluated a possibility of natural attenuation without carbon source, appropriate amount of carbon source and HRT to keep high denitrification efficiency for a long-term.

Keywords：*Biological Denitrification, Natural Attenuation, Nitrate, Fumarate, Soil-Column*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Phytoremediation of Soil Contaminated with Petroleum Hydrocarbon Using Different Amendments

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Increasing industrial and urban areas in the developing countries would contaminate vital natural resources like soil and water. Adding amendments such as organic carbon and clay minerals help soil for faster and better remediation. In this research study, the use of low-cost and environmentally safe amendments for the in situ remediation of hydrocarbons is investigated as a promising method. for soil remediation. A previously polluted soil (Isfahan refinery complex, Isfahan, Iran) was selected for the incubation experiments. Theand three soil amendments (natural bentonite, cationic surfactant modified bentonite and activated carbon) were applied at the rates of 40 and 80gr/kg of (amendment/soil) and incubated weight to the polluted soil for 50 days. After the incubation period, the hydrocarbon concentrations were gravimetrically determined and corn (Zey maize) was grown in the pots and the yield was determined. The results showed that soil with amendments significantly decreased the amount of hydrocarbons from 5% in polluted soil to 3.7% in the activated carbon treatment, accompanied by increased plant yield. Activated carbon showed the most effectiveness on reducing the pollutant concentrations. All amendments applied at 40 gr/kg of soil weight were effective as amendments applied at 80gr/kg. The effects of these amendments on reducing hydrocarbon in soil were also confirmed by greater yield compared to the untreated soil.

Keywords：*minerals, cation modification, activated carbon, adsorption, hydrocarbon.*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Phytostimulation of Maize (zea Mays L.) in an Aged Petroleum Contaminated Calcareous Soil Incorporated with Sewage Sludge

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Phytostimulation, is an important mechanism involved in degradation of petroleum hydrocarbons via stimulating microorganisms in the root zone. In this study, the effects of sewage sludge application on degradation of petroleum hydrocarbons contaminated soil was investigated. Maize (Zea mays L.) was grown in three levels of sewage sludge (0, 2, and 5% w/w) under controlled conditions. At the end of the experiment, total petroleum hydrocarbons (TPH), microbial respiration and dry weight of roots and shoots were measured. The results demonstrated that maize grow better in the presence of sewage sludge and thus more roots and shoots dry weight were observed at the presence of the highest level of sewage sludge application. The study observed that application Application of sewage sludge improved microbial respiration and resulted in faster TPH dissipation especially in the presence of the plants.

Keywords：*petroleum-contaminated soils, phytostimulation, maize (Zea mays L.), sewage sludge.*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Soil Water Management to Decrease the Arsenic Content and Arsenic Speciation of Brown Rice Grown in Arsenic Contaminated Soils

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Rice (Oryza sativa L.) is efficient in arsenic translocation to the grain. In the arsenic (As) contaminated paddy field, arsenic is reduced and mobilized in the submerged condition. Thus, the potential risk of food safety increased when rice grown in the As-contaminated paddy soil. The solubility of arsenic is decreased in the aerobic soil conditio. The objectives of this study are (1) to mitigate the As concentration in the brown rice grown in two As contaminated soils with 5 soil water managements, and (2) to investigate the As species of brown rice under different soil water managements.

The pot experiments were conducted with 3 arsenic levels soils and 5 different soil water managements to validate the hypothesis of soil drainage treatments to reduce the As concentration of the brown rice. The rice (Oryza sativa L. cv Tainan 11) was grown in the greenhouse. The two volcanic soils (silt clay) were sampled in paddy soil (Gd-pd, total As 375 mg/kg) and upland soil (Gd-up, total As 550 mg/kg) from Guandu plain located at northern Taiwan. The other one soil (silty loam) was collected from the main agricultural area in Taiwan (Er soil) and spiked with As to 35 mg/kg. Different soil water management treatments are designed as: (1) convention treatment, drainage for one week at the rice maximum tiller number stage and keep water head at 3-5 cm depth in the resting cultivation; (2) aerobic before heading treatment (A/F), keep drainage condition for 6 weeks before “heading”, and then keep water head at 3-5 cm depth in the resting cultivation; (3) aerobic after heading treatment (F/A), keep water head at 3-5 cm depth before “heading” and then drainage condition for 6 weeks in the resting cultivation; (4) water saturated treatment, maintain the soil pore saturated with water and no water head at the soil surface; and (5) flooding treatment (as control), keep the water head at 3-5 cm depth during the whole cultivation period. The pot experiments were conducted by 4 duplicates. The As concentration and As species of brown rice were analyzed by ICP/MS and HPLC/ICP/MS. ANOVA was conducted with SAS 8.0, and significant level was set at $p=0.05$.

In flooding treatments, the total As content of the brown rice is 0.5-0.8 mg/kg among three soils. The A/F and water saturated treatment significantly decrease the As content to the level of 0.3-0.5 mg/kg ($p<0.05$). The convention and F/A treatments are unable to decrease the As content of the brown rice grown in the Er soil with As level of 0.5-0.6 mg/kg, but As in brown rice of Gd soils 0.3-0.4 mg/kg. The inconsistency is attributed to the effect of soil drainage between Er and Gd soils. Gd soils are rich in organic carbon (2.0-3.6%) and higher amorphous iron (16-18 g/kg) and in addition of fine soil texture, which leads to soil aggregates formation in the Gd soils rather than in Er soil during the drainage.

In the convention, F/A and flooding treatment, the DMA (dimethylarsenic acid) content significantly increases with the As content of the brown rice ranged from ND to 0.8 mg/kg, while the inorganic arsenic content remains always keep around 0.1-0.3 mg/kg. The concentration of DMA and total As of the brown rice of these 3 treatments are significantly increased with As concentration in the pore water and are also parallel distribution of DMA and total As.

Keeping the soil flooded during the vegetative period of the paddy rice leads to organic arsenic accumulation in the brown rice. In two A/F and saturated treatments, the arsenic content ranged from 0.25 to 0.55 mg/kg and over 80% of total arsenic of the brown rice is inorganic arsenite (As(III)). Maintaining the soil in aerobic before the heading stage significantly decreases the As content of the brown rice and also increases the % of arsenite (As(III) of total As in brown rice. Total As intake of the brown rice of the A/F treatment is 50-60% of As compared to the flooding treatment. Aerobic treatment before heading period (A/F) is strongly recommended to reduce arsenic of brown rice and to mitigate arsenic pollution in this study.

Keywords：*soil water management; arsenic speciation; brown rice; Arsenic contamination soils.*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Soil Water Management Effect on as Concentration of Brown Rice Grown in Two Different Soil Properties of Arsenic-Contaminated Soils

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Soil arsenic (As) contamination is highly concerned in the world since As was listed as the class I carcinogen by WHO and paddy rice is widely cultivated on As-contaminated lands in Asian countries. Soil water management during rice heading period was supposed to decrease As uptake by brown rice in some previous studies. However, very few studies had compared the soil water managements effecting on the soils with different physical and chemical properties. The objective of this study was to evaluate the effects of different soil water managements on lowering As level of brown soils in two typical soils with different content of clay and free iron, because these two soil characteristics control the As solubility of soils.

Two typical agricultural surface soils of Taiwan was collected. The Pichen clayey soil (Pc soil) was red soil and classified as Hapludox, but the Erlin silty soil (En soil) was grey soil and classified as Eutrudept. Soil pH of Pc and Eh soils are 6.4 and 7.6, respectively. After soil spiked with two levels of As (spiked 10 and 20 mg/kg for En soil, shown as En+10 and En+20 soil; and spiked 20 and 40 mg/kg for Pc soil, shown as Pc+20 and Pc+40 soil) followed by 4 months soil aging of wet-dry cycling. The rice seeding (Oryza sativa L. cv. Tainan 11) was transplanted into each 3.5 kg of the spiked soils in 1/5000 a Wagner's pot in phytotron (30/25 degree C in day and night). Four soil water managements were designed to evaluate the effects on lowering As level of brown rice to compare with the conventional soil water management in Taiwan. Four soil water managements were listed as the followings: (1) conventional treatment, which had 10 days soil aerobic treatment after maximum rice tilling and flooding in the rest stage (35 days after rice transplanting, as CK), (2) 3 weeks soil aerobic treatment before rice heading stage (as A), (3) 3 weeks soil aerobic treatment after rice heading (as B), and (4) 3 weeks soil aerobic treatment before rice heading, and another 3 weeks treatment continued after rice heading (as C). The samples were digested by HNO3/H2O2 in heating block. The straw As concentration was determined by HGAAS and ICP-MS was used to analysis As content in husk and brown rice.

The content of clay or free iron of En soil (205 g/kg of clay and 9.3 g/kg of free iron) was much lower than those of Pc soil (444 g/kg of clay and 43 g/kg of free iron). This is the reason why to explain the As concentration of soil pore water in Pc soil of all the treatments (0.01-0.02 mg As/L) are significantly much lower than those of En soil (0.2-0.8 mg As/L) ($p<0.01$). Therefore, the As concentration of brown rice growing in Pc soil of all the treatments (0.25-0.45 mg As/kg rice) are also significantly much lower than those of En soil (0.35-0.75 mg As/kg rice) ($p<0.05$). The high content of clay and free iron significantly control the solubility of As in soil pore water, As uptake of brown rice, and also on the grain yield of As-contaminated soils.

The As concentration of brown rice cultivated in En+20 soil was lower than that of Eh+10 soil. In addition, the productivity of rice in Eh+20 was only 65?87% of that of Eh+10. The As concentration of soil pore water of Eh+20 soil (0.3-0.6 mg/L) was near 2 times of Eh+10 soil (0.1-0.3 mg/L), which indicated the As toxicity and restriction on rice growing and consequent inhibition on arsenic uptake for Eh+20 soil.

The effect of soil aerobic treatments before rice heading (A and C) on the reduction of As uptake by brown rice, husk and shoot were observed in Pc soils, especially for Pc+40 soil, compared with CK treatment ($p<0.05$). but there is no any effect on the As uptake by brown rice, husk and shoot of rice grown in Erlin soil because there are much higher As uptake of brown rice, husk and shoot in Erlin soil.

Keywords：*soil water management, clay, free iron, brown rice, As-contaminated soil*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Reactions of Nonylphenol with Humic Acid in Sediment at Different Ph

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Nonylphenol (NP) is one kind of environmental hormones and regarded as highly potential endocrine disruptor due to its chemical structure close to that of estrogen. The aim of this study was to investigate the kinetics and equilibrium adsorption of nonylphenol by humic acid (HA) in sediment at different pH. Composite sediment was collected from Tali brook (120.680°E, 24.108°N) in Taichung City area, Taiwan. Commercialized K^+-humate was purified to obtain low ash content HA (MW > 1000). After the extraction of NP with methanol, six portions of air dried sediment were spiked with NP concentrations of 50, 100, 150, 200, 250, and 300 mg kg^{-1}. The sediment with NP concentration of 200 mg kg^{-1} was selected for kinetics study. Suspension containing sediment spiked with NP and amended with HA was taken in an 125 mL Erlenmeyer flask and pH was adjusted to 4.00, 6.00, or 8.00 and agitated at 25°C for 0, 5, 10, 15, 20, 25, or 30 d reaction periods. Correspondingly, suspensions containing sediments spiked with NP at concentrations of 50, 100, 150, 200, and 300 mg kg^{-1} and amended with HA were agitated at 25°C for 25 d. All the experiment including controls of quartz sand was carried out in four replicates. The results showed that no significant difference in methanol extractable amounts of NP from quartz sand spiked with NP (QNP) at pH 4.00, 6.00, and 8.00 for 5, 10, 15, 20, 25, and 30 d reaction periods. The extractable amount of NP from QNP slightly decreased with increasing reaction period. However, there were significant differences in extractable amounts of NP from quartz sand spiked with NP and amended with HA (QNP+HA) at pH 4.00, 6.00, and 8.00 for 15, 20, 25, and 30 d reaction periods. The extractable amount of NP from QNP+HA drastically decreased with reaction period at pH 4.00, 6.00, and 8.00. The sequence of the extractable amount of NP from QNP+HA was at pH 4.00 > 6.00 > 8.00 for 15, 20, 25, and 30 d reaction periods. This indicates that HA played a role in reacting with QNP leading to less extraction of NP at higher pH. The extractable amounts of NP from sediment spiked with NP (SNP) and from SNP amended with HA (SNP+HA) reaction systems were significantly lower than those from QNP and QNP+HA systems, respectively. The significant differences among the extractable amounts of NP from QNP, QNP+HA, SNP, and SNP+HA reaction systems may thus be attributed to the synergistic effect of sediment and HA in reacting with NP. The results indicated that the adsorption kinetic data were best described by pseudo-second-order model. The plot of the amounts of adsorbed NP against spiked NP concentrations at 50, 100, 150, 200, 250, and 300 mg kg^{-1} of SNP and SNP+HA reaction systems at 25°C depicted that the adsorbed amounts of NP were significantly higher in SNP+HA reaction system than in SNP system at the sequence of pH 8.00 > 6.00 > 4.00. This indicates that higher pH affects the deprotonation of HA which in turn promotes the adsorption of NP in SNP+HA system. Dubinin-Radushkevich (D-R) adsorption isotherm model provided a better fit than the other three tested models with experimental results of adsorbed NP against methanol extractable NP for the SNP and SNP+HA reaction systems at the three pH values. After 20 d reaction period, the reaction of NP with HA in SNP+HA reaction system at different pH was evidenced by the presence of characteristic absorption bands in Fourier transform infrared spectra (FTIR). The potential adsorption of NP by river sediment in the presence of humic substances in river water-sediment equilibrium system affected by pH thus merits close attention.

Keywords：*Nonylphenol, Endocrine disruptor, Humic acid, Sediment, Kinetic, Adsorption*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

High Background Levels of Cr And Ni in Serpentinitic Soil and their Uptake by Paddy Rice in Taiwan

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The background levels of Cr and Ni generally ranged from 22.9 to 98.9 mg/kg and from 18.6 to 66.7 mg/kg respectively in the surface soils of rural lands in Taiwan. Additionally, the soil pollution control standards are 250 mg/kg for Cr and 200 mg/kg for Ni by the Environmental Protection Administration (EPA) of Taiwan. However, high background levels of Cr and Ni were demonstrated in the rural soils derived from serpentinites in eastern Taiwan. The source of Cr and Ni was from geochemical anomaly reasons, and thus was not anthropogenic. Regarding parent material types, three sites of serpentinitic soil with agricultural production were chosen for this study, they are colluvial, alluvial, residual. These soils are very diverse, which covered loam, sandy loam, and clay soils in texture and Entisols, Inceptisols, and Vertisols in Soil Taxonomy. The metal concentration, in declining order, was residual (Cr: 288-2,090 mg/kg, Ni: 1,200-6,720 mg/kg) > colluvial (Cr: 88.4-647 mg/kg, Ni: 62.6-773 mg/kg) > alluvial (Cr: 190-430 mg/kg, Ni: 97.1-243 mg/kg). A total of 39 soil samples corresponding to paddy rice was performed to determine Cr and Ni contents at these sites from two growing seasons of rice in 2012. The experimental results indicated that total Cr concentration in the soil was in the range of 41.8-1,140 mg/kg, while Ni was of 43.8-2,670 mg/kg. The extractable concentration of Cr with 0.1 N HCl ranged from ND to 3.32 mg/kg (mean=1.55 mg/kg) and that of Ni was from 0.30 to 131 mg/kg (mean=22.7 mg/kg). These extractable concentrations of Cr and Ni were much higher than the averages of 10,813 surface soil samples in eastern Taiwan (Cr: mean = 0.40 mg/kg, mean + 3std = 1.53 mg/kg; Ni: mean = 1.96 mg/kg, mean + 3std = 9.75 mg/kg). Nevertheless, the 0.1 N HCl extractable Cr and Ni were only 3% and 10% of their total contents. The concentrations of Cr and Ni in the brown rice were not significantly different among sites. The concentrations of Cr in all brown rice samples were lower than 1.5 mg/kg, and those of Ni were lower than 4.5 mg/kg (dry weight base). However, they were higher than those of general rice in Taiwan (Cr: 0.1-0.2 mg/kg; Ni: 0.3-0.5 mg/kg), revealing that the bioavailability of Cr and Ni in the serpentinitic soils is still higher than in other soils. The concentration of metal in the rice organ was in the order: root > stem and leaf > grain, but the metal content in the organ was not corresponding to the change of metal in the soil. Because the regulated food standards of Cr and Ni were not available in the world, we calculated the tolerable upper intake level of Cr and Ni of rice according to WHO's tolerable daily intake (TDI) of Ni and USEPA's dietary reference dose of Cr(III). After the computing, rice produced from these sites was safe to be eaten because the intake of Cr and Ni was lower than above mentioned reference values.

Keywords：*serpentine soil; chromium; nickel; paddy rice*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Lead Immobilization in a Contaminated Soil by Phosphate Enriched Chitosan Beads

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Contamination of soil with lead (Pb) has occurred on a global scale. Exposure to Pb may cause adverse effects to human health and the environment. The adverse health effects caused by low-level exposure to Pb include neurological impairment and deficits in the functioning of the central nervous system. This paper investigates the role of phosphate enriched chitosan beads in lead immobilization of contaminated soil from South Australia. The aim of immobilization is to reduce the leachability of the Pb to ground water and translocation to plants. Chitosan-phosphate (CH-P) products were synthesized using single super phosphate (SSP), mono-calcium phosphate (MCP), di-ammonium phosphate (DAP) and di-potassium hydrogen phosphate (DPP), respectively, and their physicochemical properties characterized. Total P contents of CH-SSP, CH-MCP, CH-DAP and CH-DPP were 56750±840, 75000±1140, 3500±20 and 8500±120 mg kg-1, respectively. Water soluble and citrate soluble P contents of CH-SSP, CH-MCP, CH-DAP and CH-DPP were 5.8 and 58.8 %, 11.9 and 49.6 %, 84.3 and 99.6 %, and 91.5 and 98.8 % of total P, respectively. Rock phosphate (RP-10 % P) and single super phosphate (SSP - 9.3 % P) were used as reference phosphate materials to compare the Pb immobilization potential of phosphate enriched chitosan beads. Surface (0-15cm) soil, from Kapunda, South Australia, was collected. The soil was sandy loam with pH 6.7 and 160 mg Pb kg-1 soil. Transparent round plastic pots with 700 ml capacity filled with 500 g of soil were used for plant growth study. All the phosphatic materials were thoroughly mixed with soils at the rate of 1000 mg P kg-1 soil. Rhizon samplers (one per pot) were placed horizontally at 1 cm from the bottom of the pot to allow sampling of soil pore water at various periods during the experiment. Eight treatments were applied in triplicate. Indian mustard (Brassica juncea var. Varuna) was grown as test crop. The soils were moistened to field capacity before the sowing of seed. Approximately 8-10 seeds of mustard were sown directly into the soil at 5 mm depth and the pots were covered loosely with lids for 3 days to maintain the moisture content and thereby achieving germination. Each treatment was carried out in triplicate and the experiment was performed in a temperature-controlled greenhouse environment (25±3°C; 16 h light). The pots were watered twice with deionized water every day during the germination period. The plants were thinned to 4 per pot after one week of germination and plants were harvested after 5 weeks of growth period. Harvested plant (shoots) samples were washed with MQ-water, oven dried to a constant weight at 60°C, and dry matter yields (DMY) were recorded. The shoots samples were ground to a fine powder and digested in di-acid mixture (HNO3: HClO4 - 5:1). The digests were diluted with MQ-water and analyzed for Pb using ICP-MS and phosphorus spectrophotometrically. After harvesting of plants, soil samples were collected from each pot and analyzed for bioavailable Pb (1 M NH4NO3 extractable) and P (0.5 M NaHCO3, pH 8.5). The pore water samples collected using the rhizon samplers were analyzed for Pb and P concentration. Free Pb2+ and H2PO4- concentrations in 1 M NH4NO3 and 0.5M NaHCO3, pH 8.5, respectively and in pore water were used to predict the bioavailability of Pb and P, respectively. Results showed that DMY increased significantly in different phosphatic material treatments as compared to control (no P) treatments and highest DMY was recorded in CH-SSP treatment. Uptake of Pb by mustard shoot was significantly reduced in different phosphates treatments in comparison to control and reverse was found to true in case of P uptake by mustard shoot. Lowest Pb uptake and highest P uptake by mustard shoot was observed in SSP treatment. Results from pore water and bioavailable P and Pb indicated that their significant increase in bioavailability of P and simultaneously significant reduction in Pb bioavailability by different phosphate enriched chitosan materials increased immobilization of Pb in contaminated soil. Further results from this study showed that phosphate enriched chitosan material could be used as an ecofriendly nontoxic material for lead immobilization in contaminated soils.

Keywords：*Chitosan, Lead, Phosphorus, Soil*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

The Impact of Greenhouse Vegetable Farming Duration and Soil Types on Phytoavailability of Heavy Metals and Their Health Risk in Eastern China

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Heavy metal contamination in vegetables from greenhouse vegetable production (GVP) in China requires major attention. For GVP sustainability at a large regional level, 441 surface GVP soil and 132 corresponding greenhouse vegetable samples were collected from six typical GVP bases in eastern China to systematically evaluate the impact of GVP duration and soil types (Anthrosols and Cambosols) on phytoavailability of four major metals, Cd, Cu, Zn, and Pb, and their health risk. The results revealed high Cd accumulation in leaf vegetables grown in Anthrosols, which might pose potential health risk. Regardless of soil types in the study region, greenhouse farming lowered soil pH and enhanced metal availability with rising GVP duration, which might exacerbate Cd phytoavailability and vegetable Cd contamination as well as potential health risk. Also, increased GVP soil organic matter contents over time, found in some locations, increased crop-depending Cu and Zn uptakes. Furthermore, due to GVP, the annual decrease rate of soil pH and increase rates of soil available metal concentrations were generally much greater in Anthrosols than those in Cambosols, which contributed a lot to high Cd uptake by leaf vegetables grown in Anthrosols and their potential health risk. From sustainable GVP perspective, fertilization strategy with reduced frequency and rate is especially important and effective for abating soil and vegetable contamination by heavy metals under greenhouse farming.

Keywords：*Soil pH; Anthosols; Cambosols; Available heavy metals; Heavy metal uptake by crops*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Accounting for Changes in the Water Retention Properties of Mine Landform Cover Material over Time

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Rapid physical weathering of waste rock covers can lead to changed soil water retention and transmission properties. Evaluating rapid temporal changes from direct physical measurements is costly and often inconclusive. Indirect monitoring of water retention relations offers an alternative. The objective was to apply indirect, continuous monitoring of soil water content and water potential to evaluate temporal changes in plant water extraction and soil water retention in a store-and-release cover constructed from waste rock.

A constructed cover at Ranger uranium mine, in the seasonally dry monsoon tropics in Northern Australia was characterized and monitored between 2001 and 2005. The cover comprised a drainage limiting layer of weathered rock overlain by 0.5-1 metre unweathered rock. Particle size distribution, hydraulic conductivity and bulk density over four depth ranges were characterized from core samples. Infiltration through the surface was measured and rainfall and evapotranspiration were continuously monitored. The cover was partially revegetated with endemic species planted in 100 m2 islands covering 10% of the area.

A monitoring system was installed at four depths in revegetated and bare patches to 2.0 m to monitor the soil water content (θv) and soil water potential (Ψ) profiles. The log-linear Campbell function was fitted to draining cycles in each season's data using least squares regression. A statistical test of the homogeneity of slopes, b, of the lines fitted each year was made using analysis of variance. A one dimensional saturated-unsaturated water balance model (SWIM) was run to assess the temporal effect of changing water retention parameters on deep drainage.

Vegetation generated a stable porosity, in contrast with bare areas, reflected in higher maximum water contents. Increasing slope, b, of the water retention characteristic with plant cover indicated increased fine porosity over time. Although, the drainage flux estimate was insensitive to changes in the water retention characteristics.

Vegetation produces water stable porosity ? transforming an infiltration limited desert to a soil water storage limited woodland ecosystem. Rapid and complete control of resources by selected species enhances ecosystem development. Ensuring that ecological endpoints can be met in a landscape restoration will rely on cover designs that account for natural levels of plant available water storage.

Keywords：*water retention, mine rehabilitation, mine soils, ecosystem restoration*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

The System for Evaluation and Management of Contaminated Agricultural Soils Proposed in the Czech Republic

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The limit values of risky elements (RE) and persistent organic pollutants (POPs) are defined in current Czech legislation in Direction No. 13/1994 Sb. These limit values have a status of maximally tolerable values in agricultural soils. Nevertheless, the criteria were derived from available data in the beginning of 90th in the Czech Republic and present more compromise of statistically derived values from data corresponding with the load of Czech agricultural soils and the data of some European countries than scientifically supported limit values. The final version of limit values can be defined as variously increased background values of risky elements of soil (pseudototal content in extract of Aqua regia). The current version of limit values in Czech legislation can be considered as behind the time. New version of limit values is based on the principle of hierarchical limit values and three individual limit values present specific risks.

Prevention limit is the first level of limit values and is derived from background values of RE and POPs (total contents) in Czech agricultural soils. The exceeding of prevention limit values is the indication of increased anthropogenic soil load. The application of materials with possible increased RE and POPs contents (sludge, dredged sediments and biosolids) will be forbidden.

Indication limit values of food chain contamination and plant growth inhibition were proposed only for RE on the base of research of RE transfer from the soil into selected plants. The limit values compare the (pseudo)total contents of RE and their mobile contents (1mol/L NH4NO3 extract).

Indication limit values of human health protection were derived from the direct risk of POPs and RE (As, Cd, Hg and Pb) increased contents on human health by their inhalation, dermal and oral intake on contaminated fields.

The exceeding of indication limit values will be followed by the testing of RE transfer into individual plant species on the field (food chain contamination) or risk assessment realization (human health protection).

The inputs of RE and POPs by sludge and dredged sediments application into agricultural soils (the most important inputs) are regulated by legislative tools in the Czech Republic.

The system of management of contaminated agricultural soils follows two principles: the land exclusion from agricultural soil fund (heavy contamination) and the application of practices decreasing the risks. The change of plant production can decrease the risk of food chain contamination (technical plants or plants with low transfer factors) and the application of soft remediation methods can decrease contaminant mobility in environment. The change of soil properties (pH, Cox) and application of selected organic and inorganic amendments was studied as well as phytoremediation techniques in our conditions. The results confirmed higher efficiency of amendment and change of soil properties application in comparison with phytoremediation techniques as the tools of management of contaminated agricultural soils.

Keywords：*risk elements, persistent organic pollutants, legislative tools, soil remediation*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Safety Evaluation of Vegetables Grown on the Highly Arsenic-Contaminated Soils in Northern Taiwan

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Arsenic (As) is an environmental contaminant due to its widespread in many fields and its toxicity to plants, animals, and humans. In 2006, large areas of As-contaminated cropland were confirmed in the Guandu Plain of northern Taiwan, but studies focused on effects of the highly As-contaminated soils on crop production in Taiwan are not yet available. This study was to examine the growth and As levels of the crops grown on highly As-contaminated soils and to assess vegetables safety. Earlier study reported that the rural soils were contaminated by irrigation water which was mixed from stream water and hot spring water from the nearby geothermal areas.

In this study, soils involving four different As levels (CK: 20 mg/kg, L: 120 mg/kg, M: 200 mg/kg, H: 270 mg/kg) were collected from the Guandu Plain for pot experiments. An extra soil sample with higher level of total-As (2H: 450 mg/kg) was also collected for planting the loose head lettuce. The soil samples for the pot experiments were slightly acidic (pH 4.45-6.43) with high organic content (2-5%), and were mostly fine-textured soils. Regardless of various As levels in soils, no toxicity syndrome was found in all cultivated carrot, garland chrysanthemum, and loose head lettuce in pot experiments during the growing period. There was no significant difference among the biomass of edible part of carrot grown in soils with different total-As levels. Same results were also found in the cases of garland chrysanthemum and loose head lettuce. As concentrations of carrot roots were all lower than 0.2 mg/kg DW (equals to 0.034 mg/kg FW, based on the average water content, 83%) and there was no significant difference among As levels in carrot roots harvested from soils with different As concentrations.

Among the 4 vegetables cultivated in this study, As concentration in the edible part of carrot is the lowest. Arsenic concentrations in the edible parts of garland chrysanthemum and loose head lettuce increased with increasing total-As concentration in soils. The highest average As concentrations in garland chrysanthemum and loose head lettuce were 0.825 mg/kg DW (equals to 0.074 mg/kg FW, based on the average water content, 91%) and 0.515 mg/kg DW (equals to 0.021 mg/kg FW, based on the average water content, 96%), respectively. The European Food Safety Authority (ESFA) reported that the provisional tolerance weekly intake (PTWI) of inorganic As is 15 μg/kg body weight. Assuming the average body weight of Taiwanese adult is 60 kg, the tolerance daily intake of As for an adult will be 128 μg. According to Taiwan's government official statistics in 2010, the average amount of daily vegetable consumption per person is 286 g fresh weight. Assuming the average water content of vegetable crops is 90%, from the values above we can calculate and find that if the levels of As in vegetable is higher than 4.48 mg/kg DW, the intake of As via vegetable will be higher than the PTWI. In Taiwan, U.S. and WHO, the established standard of inorganic As in drinking water is 10 μg/L. Under the assumption mentioned above and assuming the amount of water an adult drinks every day is 2 L, we calculated and found that if the level of As in vegetable reached 0.697 mg/kg DW, the intake of As via vegetable consumption will be the same as the intake of As via drinking the water contained As at the concentration of 10 μg/L.

In summary, the phytotoxic effects of As in soils was not shown in our pot experiments growing vegetable crops in different As levels of intrinsic As-contaminated (120-450 mg/kg) Guandu Plian soils. Although As levels in vegetable crops grown in As-contaminated fields on the Guandu Plain were low, long-term consumption may result in higher intake of As in the human body.

Keywords：*Arsenic; Pot experiment; Safety evaluation of vegetables; Provisional tolerance weekly intake (PTWI)*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Root Uptake of Cs 134 Early After Radioactive Fallout

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Our investigation is focused on the dynamism of Cs 134 increase in the plant tissues after soil contamination by radioactive fallout. We assume that the harvesting early after fallout could reduce the quantity of the contaminated biomass.

Our experiments were carried out with 3 weeks old sunflowers as a model plants in a phytotrone. The 200 ml of the Cs 134 solution with the activity 3 kBq/L was spilt on the top-soil.

The first group was harvested after 1 day. The plants were washed. Roots, stems and leaves were separated, dried and finaly, their activity was determined by gamma spectrometry.

The main finding is that the harvesting in the first two days could be effective in reduction of the quantity of contaminated biomass. However, the Cs 134 activity in the green biomass was low even at the end of experiment.

The leaves of the plants from the first group contained the 5 Bq/kg (dw) or less.

From fifth to tenth day the Cs 134 activity concentration in plant tissues still slightly increases but after ten days it remains almost constant. Twenty days after contamination the Cs 134 activity concentration in leaves was 26 Bq/kg (dw). Contrary to leaves, the activity in the roots permanently increased untill the end of the experiment when it reached 430 Bq/kg (dw). It corresponds well with the ability of sunflower roots to adsorb a high quantity of cesium from contaminated water.

The lowest activity was catched in the stems.

This approach is applicable in the case when the negligable quantity of radionuclides is retained on plants during rain.

Keywords：*radioactivity, sunflower, cesium, uptake,soil*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Horse Paddocks - A Source of Water Pollution Via Excess Phosphorus (p) and Nitrogen (n) Leaching and Possible Counter Measures

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The Baltic Sea is one of the most eutrified water bodies in northern Europe in which more than 50% of the total anthropogenic waterborne phosphorus (P) and nitrogen (N) are coming from agricultural sources. Swedish reduction goals for nutrient load to the Baltic Sea by 2021 are 530 tons P and 9,240 tons N. Horse farms, which cover almost 10% of Swedish arable lands, are so far not included in the national nutrient reduction plans or in the Baltic Sea Action Plan. Previous studies have pointed out that horse paddocks with high animal densities are rich in nutrients, and thus can be a potential source of high P and N leakage threatening both surface and ground water quality. In our studies, we made a survey of the enrichment of paddock soils with P and N on a number of horse farms and measured leaching losses of different forms of P and N from paddock soils compared to adjacent reference sites. We divided paddocks into grazing, feeding, and excretion areas showing significant differences. Soils in feeding and excretion areas were found to be enriched with P (973-1034 mg total P kg-1) and N (2768-3036 mg total N kg-1) compared to reference area (642 mg total P kg-1 and 2226 mg total N kg-1). Soil columns of topsoils (0-20 cm) from the different paddock areas were used for leaching studies and exposed to artificial rain (40 mm four rain events, 72h intervals) and forms and concentrations of P, N and dissolved organic C (DOC) in leachate water were measured. Concentrations and losses of P were almost 3 fold and total N were 15 fold higher than from reference areas. Highest losses were measured from feeding and excretion areas dominated by inorganic fractions. Dissolved reactive P and nitrate N accounting for 68% and 80% of total losses were significantly correlated with dissolved organic C leached. Comparing mean losses from paddock soils with national means for Swedish agricultural soils showed that leaching of P was twice as high (1.10 kg total P ha-1 yr-1) and of N almost 5 times as high (93.90 kg total N ha-1 yr-1) as mean values. However, losses from excretion areas could amount to 7.5 kg total P and 484 kg total N ha-1 yr-1. Relating mean concentrations to environmental threshold values revealed that dissolved P from paddock soils was almost 10 fold higher (0.29 mg L-1) than the maximum threshold value (0.03 mg L-1). Similarly, mean nitrate (NO3-) concentrations in the leachate from paddock soils (98 mg L-1) was almost two fold higher than the threshold value (50 mg NO3- L-1) for water quality and the concentrations in leachate from feeding and excretion areas were far above. We conclude that horse paddocks need to be considered as pollution sources being a potential threat to the quality of nearby surface waters and ground water. Feeding and excretion areas within paddocks are nutrient hotspots in the agricultural landscape. Horse paddocks in general need to be considered in national mitigation plans to reduce losses to water bodies. Possible counter measures currently investigated include – (i) limiting the horse density in paddocks; (ii) using bedding materials on excretion areas together with chemical amendments for nutrient adsorption.

Keywords: *eutrophication, water pollution, P & N loads, nutrient leaching, water quality*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Effect of Inorganic and Organic Amendments on the Bioavailability of Chromium in Contaminated Soils: A Sequential Study

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Contamination due to metals often associated with the urban and peri-urban soils intensively irrigated with raw city effluents. Many techniques like use of organic and inorganic amendments have been using to reduce the risks associated with metal contamination. In the current study different amendments were used modify availability, concentration, and uptake of chromium by rice crop grown in two soils differing in texture. Rice was irrigated with water containing chromium at 20 mg kg-1. Amendments include calcium carbonate at 6 or 12%, gypsum at 50 and 100% soil gypsum requirement, farm manure at 7.5 or 15 g kg-1 soil and a control without amendment. Both organic and inorganic amendments decreased the ammonium bicarbonate diethylene triamine penta acetic acid (AB-DTPA) extractable fraction of chromium in soils and uptake by rice. Dry matter, concentration, uptake, and extractability of chromium were greater in sandy loam soils compared with sandy clay loam soils irrespective of amendments. Sequential extraction showed that maximum chromium concentration was extracted from the organic fraction and increasing application rate of gypsum and lime decreased Cr concentration. From the results of this study it could be inferred that amendments at suitable rates could be employed to decrease the accumulation of Cr in food crops grown on soils irrigated with polluted water.

Keywords：*amendments; bioavailability; chromium; rice*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

The Effect of Deltametrin Application on Microbial Degradation of Organic Matter and Soil Fertility

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Availability of potential natural resources of microorganism for pesticide degradation does not guarantee the environment would be free from pesticide. This is caused by evolution and growth of degraders microorganism hindered by biotic and abiotic factors. Bioremediation for this environment problem could be overcamed by using indegenous degraders microorganism. Deltametrine is one of pesticides (insecticides), that is commonly used by farmers in Indonesia. Deltametrine is a piretroid with a highly toxicity and has a long time effect on environment. This research was done in the pots scale, using 2 types of soil ie., Latosol and Grumosol, dosages of Deltametrine application were 50 kg ha-1, 100 kg ha-1 and 150 kg ha-1. The results of research showed that Deltametrin highly decreased population of soil microorganism (bacteria and fungi) within 14 to 21 days. Deltametrin did not have direct effect on C and N ratio, P2O5-availability, pH, EC and plant growth.

Keywords：*Deltametrin, Bioremediation, Latosol, Grumosol*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Foliar Application of Zinc at Booting Stage can Modify Plant Growth and Decrease Cd Concentration in Bread Wheat

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Cadmium is one of the toxic pollutants that may pose serious threat to the soil-plant-water-environment. Accumulation of Cd in wheat grains is a major rout of Cd entry into food chain in many Asian countries. Strategies such as breeding to produce Cd hypo-accumulators and application of amendments (immobilizing agents) to minimize Cd accumulation in cereal grains are gaining attraction of the scientific communities. Zinc is an essential nutrient that can interact with Cd both in soil as well as plant. However, Zn availability and uptake is very low in calcareous soils. Therefore strategies that can effectively increase the plant Zn content in Cd contaminated calcareous soils would offer solution for minimizing Cd in grains. In present study, Zn was directly sprayed (at different growth stages) on leaves of wheat grown with and without Cd in calcareous soil. There were 3 levels of Cd (0. 2.5, 5 mg kg-1 soil) and Zn was foliar applied (0.05 % solution of ZnSO4.7H2O) at five different growth stages (mid Tillering, jointing, booting, heading and grain filling). Cadmium in soil at all levels (without Zn) dramatically decreased plant growth, increased Cd accumulation in wheat roots, flag leaves, shoots and grains and decreased the uptake of Cu, Fe, Mn and Zn. Foliar spray at booting stage, significantly increased Zn concentration in leaves, shoot and grain compared to control and Zn application at other stages of wheat. When plants were exposed to Cd at 2.5 mg kg-1, the foliar applied Zn at booting stage decreased the grain Cd concentration from 0.83 mg kg-1 in the control treatment to 0.0.09 mg kg-1. When Cd level was increased to 5.0 mg kg-1, the same treatment decreased the grain Cd concentration from 0.88 to 0.14 mg kg-1. These data suggest that under Cd stress, foliar application Zn at booting stage than other stages of plant growth could be viable option to improve plant growth through increased uptake of micro-nutrients and decrease Cd concentration in grains of wheat.

Keywords：*Cadmium, wheat, Zn, foliar spray*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Application of Lherzolite on the Plant Growth and on Chemical Fractionation of Lead in Contaminated Soil

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A green house pot experiment was conducted to investigate the effect of 5% application of lherzolite to a contaminated soil on the growth of radish (Raphanus sativus L.) and Japanese mustard spinach (Brassica rapa L. var. perviridis) and on chemical fractionation of lead (Pb). Both plants were grown in a sandy loam soil contaminated with lead (302 mg kg-1 Total Pb). The source of Pb contamination in soil was surface water which was previously mixed with contaminants discharged from industrial and mining operations located in Tohoku district, Japan. Plants were grown consecutively three times in the same pots. After the third harvest, soil samples were collected and analysed by sequential extraction procedure into five operationally defined fractions (F1-exchangeable, F2-carbonate bound, F3-oxides bound, F4-organically bound and F5-residual). Application of lherzolite to soil increased plant growth three folds over the control. Lherzolite addition to soil decreased 75% of exchangeable (F1), 50% carbonate bound (F2), but it increased in the oxide bound (F3) fractions of Pb. This result indicates that the reduction of Pb in exchangeable and carbonate fractions by addition of lherzolite to the soil resulted in higher growth and decreased concentrations of Pb (82 to 94%) of plant tissues.

Keywords：*contaminated soil, lead, lherzolite, chemical fractionation*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Effect of Rare Metals on Uptake Characteristics and Growth Response of Leafy Vegetables

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The uptake of rare metals such as gallium (Ga), germanium (Ge), antimony (Sb) and bismuth (Bi) by komatsuna (Brassica rapa L. var. peruvidis bailey), chinese cabbage (Brassica rapa, var. chinesis) and leaf lettuce (Lactuca sativa, var. crispa) grown in hydroponics was investigated in order to get a comprehensive aspects of these metals on plants. For this, the seeds of each of komatsuna, chinese cabbage and leaf lettuce were first sown on urethane mat and were placed in an incubator with a proper diluted nutrient solution (Otsuka nutrient solution A shoho). Ten days after germination, seedlings were transplanted into hydroponics equipment and were grown with the similar nutrient solution. After 14 days, gallium (III) chloride and germanium (IV) oxide each at a rate of 0.00, 0.05, 0.25 and 0.50 mg L-1 as Ga and Ge, respectively and Bis(+)-tartrato〕diantimonate (III) dipotassium, 3-hydrate and bismuth (III) nitrate each at a rate of 0, 2, 5, 10 and 20 mg L-1 as Sb and Bi, respectively, were added to the hydroponics equipment. Plants were harvested eight days after addition of rare metals. Ga and Ge contents in shoots of each plant were determined by the wet digestion method with a mixture of nitric and perchloric acids while Sb and Bi contents were determined by the wet digestion method with a mixture of nitric, perchloric and hydrofluoric acids. The biconcentration factor (BCF) of these metals for plants was measured by dividing the contents of each of these metals in plant with its concentration in nutrient solution. No clear growth differences were observed in komatsuna, chinese cabbage and leaf lettuce with the different concentrations of Ga and Ge in solution. However, the growth of komatsuna and chinese cabbage decreased with increase in Sb concentration in solution whereas the growth of leaf lettuce did not show any response with Sb concentrations. In case of Bi, no clear growth difference was observed in komatsuna while the growth of chinese cabbage decreased with Bi concentrations and it was reversed in leaf lettuce. Although it found that the contents of rare metals in plants increased with an increase in rare metal concentrations in solution, the growth responses of plants varied with the contents of rare metals in plants. The BCF for plants was much higher than 1.0 indicating that the cultivation of plants in hydroponics may pose health risk to human.

Keywords：*rare metals, uptake, growth, leafy vegetables, hydroponics*

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

The Potential of Legume Trees for Phytostabilization of Mercury Polluted Soils

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Candidate plants for phytostabilization of mercury (Hg) should have an extensive root system and have a tolerance to Hg and capability to accumulate bioavailable Hg in its root system and thereby reduce the bioavailable Hg concentration in the rhizosphere. Some species of legume trees, such as sengon buto (Enterolobium cyclocarpum), sengon laut (Paraserianthes falcataria), and weru (Albizia procera) have an extensive root system and high biomass. A semi-hydroponical experiment was carried out to determine the tolerance to Hg exposure of these species based on physiological response. Two-weeks-old plants were grown in perlite as substrate in nutrient solution treated with 0 (control), 3 and 30 μM Hg for 7 days. Hg did not cause growth inhibition in roots and shoots, with high tolerance index (> 95%) to Hg exposure. Three legume species accumulated Hg in roots, but its translocation to the shoots was very restricted. Total Hg concentration in roots of sengon buto is 69- to 431 fold, sengon laut 34- to 177 fold and weru 14- to 77 fold by total Hg concentration in shoots. These species show typically excluder behavior where root is a main organ for Hg retention. Total Hg concentration up to 2,275 μg g-1 dry weight; 1,851 μg g-1 dry weight; and 636 μg g-1 dry weight in roots of sengon buto, sengon laut, and weru, respectively, did not cause oxidative stress in seedlings. Hg treatments did not reduce chlorophyll concentration and did not increase malondialdehyde (MDA) concentration but caused different effect of biothiols (cysteine and glutathione) concentration in seedlings of three legume species. The tolerance to Hg and the capability to retain Hg in roots make three legume species as good candidates for phytostabilization of Hg-polluted soils.

Keywords：*phytostabilization, mercury, sengon buto, sengon laut, weru*

P2-470

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Phytoextraction of Lead Contaminated Soils with Fagopyrum Esculentum: A Field and Laboratory Scale Study

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Soil contamination has been widely studied and the development of more sustainable and cheaper remediation techniques such as phytoextraction is increasingly gaining interest, especially for diffuse contamination of trace elements such as in agricultural contaminated soils. Numerous studies have already tested Pb removal from soils using phytoextraction and several hyperaccumulators have been identified such as buckwheat (Fagopyrum esculentum Moench) (CHAUDHRY et al., 1998; TAMURA et al., 2005) whose interest relies on its hardiness and its low consumption of fertilizers. Despite the high amount of papers about Pb phytoextraction, very few studies have tested in the field the efficiency of the selected plants (VANGRONSVELD et al., 2009).

Our research project is part of a national program for monitoring urban garden soils (JASSUR) taking place in seven French cities. Concentrations of Pb exceeding the threshold value for human consumption have been found in vegetables, and resulted in the closure of several garden plots by the city council, (Jean Soro et al., submitted). A costly rehabilitation management (ca. 60k€ for 2000 m²) was undertaken by bringing clean arable soil, not to mention the consumption of soil, a non-sustainable resource. As an alternative in situ phytoextraction with buckwheat, combined with a 5 mmol/kg citric acid application was tested to enhance the phytoextraction rate. Yet the first results showed that Pb uptake by buckwheat was far below our expectations with a bioconcentration factor (BCF) of 0.008 while Tamura et al. showed a BCF of 0.63 with the same plant, obtained in laboratory conditions. To explain these results, several tests have been started: (i) characterization of Pb mobility and speciation in naturally-contaminated (situation of the garden plots here studied) vs. anthropogenic-contaminated soils, (ii) selection of different extractants (including bacterial siderophores) at different concentrations to enhance the phytoextraction rate, (iii) comparison of different buckwheat species.

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Keywords：*phytoextraction, lead, Fagopyrum esculentum, garden soils*

P2-471

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Rhizo-Phytoextraction of Metal Contaminated Soils: An Innovative Selection Tool for Rhizobacteria

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Remediation of arable soils contaminated by metals is in need of adapted low-cost techniques that can be applied in situ such as phytoextraction. Unlike physico-chemical techniques, phytoextraction preserves the agronomical value of the land allowing its reuse for other crops after the treatment. Yet such a treatment is quite long which constitutes its main drawback (LEWANDOWSKI et al., 2006). In order to increase the phytoextraction rate, soil inoculation with microorganisms allowing metal mobilization in the soil is an innovative approach to increase plant biomass and metal uptake by the plant (KUIPER et al., 2004). The selected microorganisms, mostly Plant Growth Promoting Rhizobacteria (PGPR), may act on the metal phytoextraction either indirectly by increasing the plant growth (as a result of a higher P and K solubilization rate, production of phytohormons (e.g., IAA), ACC deaminase and siderophores) or directly by increasing metal mobility with microbial metabolites such as organic acids, surfactants and siderophores (GLICK, 2003). According to the literature, coupling bioaugmentation and phytoextraction increases, in 60% of the studies, the biomass of plants grown on a contaminated soil by max. 4 times and/or increase metal concentration within the shoots up to 3.1 times (GLICK, 2010; LEBEAU et al., 2008). Most of the studies conducted to date select plants and microorganisms independently which prevent to suggest the more relevant plant/microorganisms associations while interactions between these two actors are a determinant factor for the success of phytoextraction

Our “phytoextraction-assisted bioaugmentation” project aimed at selecting a relevant plant/microorganisms couple, from an existing bacterial collection, as a function of different parameters and was developed in miniaturized microwell plates. A decision tree will allow choosing the best bacterial species depending upon the soil parameters included i) the bacterial tolerance to metals, , ii) their ability to grow and mobilize metals in growth media closely related to the soil composition, through the production of metabolites known for their solubilization activity (siderophores, organic acids). Then the ability of bacterial strains to colonize the soil is assessed as well as their rhizocompetence by measuring IAA production, ACC deaminase and their ability to grow with plant root exudates. Eventually, our bacterial selection tool will be validated by testing the selected strains soil microcosms in laboratory conditions and then in greenhouse before an in situ application to arable soils.

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Keywords：*phytoextraction, rhizobacteria, selection, bioaugmentation*

P2-472

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Cu Extractability and Uptake By Maize (zea Mays L.) and Ryegrass (lolium Perenne L.) Plants In a Contaminated Soil Amended with Manure, Compost and Compost-Derived Humic Acids

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Usually, organic amendments, i.e compost and manure, have been applied on the soil row in solid state, but in the last years liquid organic products (humic extracts) are being used. These amendments are basically a mixture of concentrated humic substances, i.e. humic (HA) and fulvic acids (FA). Humic substances has a strong affinity for Cu, thus they can affect the fate of this element in soils. In some fertile soils of central Chile the available Cu concentration in the arable layer is highly elevated, leading to plant toxicity. In this scenario, organic matter (OM) applications could be used to reduce Cu availability for plants, improving plant growth. The main objective of this study was to evaluate the effect of the application of two solid and one liquid organic amendments: turkey manure, vineyard compost, and compost-derived HA, on the soil Cu extractability and growth and aerial dry matter (DM) yield of maize and ryegrass plants grown in pots (5L and 2L) using a contaminated Mollisol (DTPA-Cu = 90 ppm). Maize and ryegrass plants were consecutively cultivated during the experimental period (140 days) using a complete random design with 4 replications. Amendments were applied 10 days before the first crop (maize), and both plant species were chemically fertilized (NPK). Application rates of manure and compost were equivalent to 6.6, 13.3 and 17,7 ton C/ha, while the application rate of HA was equivalent to the FA+HA-C of the manure. Control treatments with and without chemical fertilization were also included. Total DM production of maize and ryegrass was quantified, and root samples were taken as well to perform the malondialdehyde (MDA) test to determine possible damage at a membranes level. At the end of the experiment, analyzed soil properties included among others: pH, OM, water soluble C (Cws), HA-C, FA-C, and extractable Cu. The extractability of Cu was determined using the 0.005 M DTPA and 0.01 M CaCl2 methods. The analyses were performed by AAS, and also the free CaCl2-Cu+2 concentration was analyzed by ion selective potentiometry.

Aerial DM yield of maize was enhance by manure and compost addition in comparison to the fertilized control, while HA reduced DM production ($p<0.05$) by 50% due to increased soil EC. Dry matter yield of ryegrass was proportionally increased by the C rate for the three amendments, with few significant differences ($p<0.05$) among them at the two higher application rates. Significant modifications of Cu extractability ($p<0.01$) was attained by the application of the amendments. Manure applied at the highest C rate was the most efficient reducing DTPA-Cu, while HA also at the highest C rate was the most efficient for CaCl2-Cu. However, soil Cu concentrations determined by both extractants were negatively correlated ($r=-0.413$, $p=0.005$) each other. The DTPA-Cu was positively correlated with MDA values ($r=-0.43$ - -0.47, $p<0,001$) and negatively with total DM production ($r=-0,633$, $p<0,001$) and total Cu uptake ($r=-0,552$, $p<0,001$) of both plants species, indicating that higher soil Cu concentration induced a higher damage of root membranes and affected plant growth. CaCl2-Cu represented a very small fraction of the DTPA-Cu, was not correlated with MDA test and was positively correlated with total DM yield ($r=-0,771$, $p<0,001$) and total Cu uptake ($r=-0,722$, $p<0,001$). This results suggest that under the experimental conditions DTPA-Cu was a better indicator of potential Cu toxicity as compared to CaCl2-Cu in this Mollisol affected by an excess of Cu. CaCl2 solution, commonly associated with soluble+exchangeable metal fraction, was not able to extract Cu from all the soil solid phases that contain bio-accessible Cu for plants. The soil properties that better explained DTPA-Cu concentration were FA-C, HA-C and pH, while CaCl2-Cu concentration was related to OM and FA-C. In the CaCl2 extract, the complexed Cu-to-free Cu+2 ratio was also modified ($p<0.01$) by the application of the organic materials. The leaching of Cu and its relation with Cu complexation in the soil and leachates being analyzed. Acknowledgments: FONDECYT Project N°11110509, Chile, granted to Dr. Mauricio Molina-Roco.

Keywords：*Cu availability, Cu contamination, humic substances, Cu sequestration*

P2-473

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Phytoextraction-Assisted Bioaugmentation of Soils Contaminated by Cu and Cd: Role of the Bacterial Siderophore Pyoverdine

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Phytoextraction-assisted bioaugmentation of soils has gained interest this last decade (Lebeau et al. 2008) in order to reduce the processing time, as the major constraint of phytoremediation. Among microorganisms, siderophore-producing bacteria (SPB) are able to bind a wide range of metals other than iron (Braud et al. 2009) and seem to be involved in the enhancement of phytoextraction performances. Yet impact of bacterial siderophores, as part of the metabolite mixture synthesized by SPB is not fully elucidated, as underlined by the sometimes contradictory effect of bioaugmentation associated to phytoextraction (Lebeau et al. 2008, Sessitsch et al. 2013).

Our study focuses on the well-known pyoverdine (Pvd), produced by Pseudomonas aeruginosa. Pvd whose coordination properties for Cd(II) and Cu(II) were determined, was supply to a calcareous soil. The mobility (CaCl2 extractions), the phytoavailability (DGT measurements) and the metal phytoextraction were assessed (Cornu et al. in press). The stability constant of Pvd-Cu (KL'Cu = 1020.1) was found much higher than that of Pvd-Cd (KL'Cd = 108.2). Metal phytoextraction was closely related to Pvd coordination properties: At 250 µmol kg-1, Pvd enhanced the mobility, the phytoavailability and the phytoextraction of Cu, not Cd. All these results were compared to those reported for phytoextraction-assisted chelates. Based on some additional experiments obtained in hydroponic conditions and modeling, pH was shown to be involved in the metal-Pvd complexation-decomplexation (Cornu et al. submitted). Besides the uptake of metals by plant seems to predominantly involve a decomplexation of metal-Pvd. The role of biofilms that cover the root surfaces is supposed to be of major importance in this phenomenon.

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Keywords: *phytoremediation, metals, siderophore, bacteria, soil*

P2-474

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Use an Aryl Hydrocarbon Receptor (ahr) Reporter Gene Assay with the Improved Cleanup Procedure to Survey Dioxin Levels of Taiwanese Soil

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The aim of the present study was to investigate dioxin levels in 800 soil samples collected from four local regions of Taiwan (northern, middle, southern, and eastern Taiwan). Combination of a fast cleanup column and an in-vitro bioassay was carried out in the present study. Initially, dioxin sampling areas was selected based on the dioxin dispersion model from the stationary sources. Each local region had at least a potential dioxin-contaminated area and a reference site. Soil samples were obtained from the potential dioxin-contaminated areas and the reference sites. The extracts were cleanuped by a CAPE coupled carbon-acid silica column set after extraction. The final analytes was examined by an in-vitro ary hydrocarbon receptor (AhR) reporter gene assay, such as DR-CALUX® assay, to determine soil dioxin levels. The mean dioxin level of 800 soil samples was 36.0 pg-bioanalytical equivalency (BEQ)/g dry weight (d.w.) with the standard deviation (SD) of 56.7 pg-BEQ/g d.w.. The mean ratio of dioxin values with HRGC/HRMS v.s. DR-CALUX® was 3.83 (SD=1.40) with a linear correlation (adjusted R2=0.893, $p<0.001$). Soil dioxin-BEQ levels had the higher magnitude in northern Taiwan (61.8 pg-BEQ/g d.w.) than the other three local regions (22.2, 24.9, and 7.80 pg-BEQ/g d.w. in middle, southern, and eastern Taiwan, respectively). Bade city located at northern Taiwan had the distinctly highest mean dioxin-BEQs among the ten sampling areas. After examining multiple linear regression models, dioxin-BEQ levels could be predicted by three major variables including soil sampling location ($\beta=0.097$, $p<0.001$), soil with the purpose of land use ($\beta=0.065$, $p<0.001$), and soil brightness ($\beta=0.170$, $p<0.001$) with adjusted R2=0.947 (the minor component of soil moisture with $\beta=0.051$, $p=0.020$) ($p<0.001$). The significant odds ratios (OR) were soil sampling location (OR=2.43, $p<0.001$), soil with the purpose of land use (OR=1.47, $p<0.001$), and soil brightness (OR=2.83, $p=0.009$) in testing univariate logistic regression when the 3rd quartile was as the cutting point (33.4 pg BEQ/g d.w.). In conclusion, four variables (soil sampling location, soil with the purpose of land use, soil brightness, and soil moisture) could predict 94.7% of dioxin contamination in 662 soil samples. Higher dioxin-BEQ levels may be linked to soil collected in northern Taiwan particularly for Bade city, soil near the industrial area, and the darkness soil. It is still unknown whether soil brightness is associated with dioxins distribution in soil. The future studies are encouraged and needed. AhR reporter gene assays are excellent tool to investigate soil dioxins contamination with the large-scale numbers. We combined the CAPE-coupled carbon-acid silica column sets and the DR-CALUX® assay to accelerate soil dioxins survey. The univariate logistic regression model indicated that high levels of dioxins were correlated with soil collected from northern Taiwan, the darkness soil, and soil near the industrial area. However, based on the current evidence, we still did not conclude that soil brightness affects dioxins contamination in soil.

Keywords：*polychlorinated dibenzo-p-dioxins/furans, aryl hydrocarbon receptor (AhR), bioassay, dioxin survey*

P2-475

[C3.5-2] Techniques to Manage Contaminated Arable Soils

The Potentiality of Arabidopsis Halleri Ssp. Gemmifera to Accumulate Cd, Zn and Pb Grown in Nutrient Solution

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Arabidopsis (A.) halleri ssp. gemmifera is a plant recently found to be grown vigorously in heavy metal contaminated areas of Japan. It contained remarkably high amount of Cd and Zn in its shoots. In this study, the potential of A. halleri ssp. gemmifera for accumulation Cd, Zn and Pb was investigated in hydroponics. The plants were grown for 21 days after Cd (0, 10, 100 and 400 μM), Zn (0.2, 10, 100, 500, 1000, 1500 and 2000 μM) and Pb treatments (0, 50, 100, 250, 500, and 1000 μM). Cadmium, Zn and Pb concentrations in the plant parts increased significantly with increasing their rates. Cadmium concentrations reached a maximum of about 5,640 and 15,967 mg kg-1 in the shoots and roots, respectively, at 400 μM Cd in the nutrient solution. The highest Zn concentration of 26 400 mg kg-1 at 1000 μM was measured in the shoots, while in the roots, it reached to 71, 000 mg kg-1 at 2000 μM Zn in the nutrient solution. In the case of Pb, the highest concentration was of 5100 mg kg-1 obtained in the shoot while in the root, it was about 20 folds of shoot (10.6%) at 1000 μM Pb in the solution. These results indicate that A. halleri ssp. gemmifera has an extraordinary ability to tolerate and accumulate Cd, Zn and Pb and hence may be used to clean up heavy metal polluted soil and water.

Keywords：*hyperaccumulator, hydroponics, phytoremediation, tolerance*

P2-476

[C3.5-2] Techniques to Manage Contaminated Arable Soils

One-Pot Synthesized Zerovalent Iron/activated Carbon Composite Degrades Trichloroethylene

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Zerovalent iron (ZVI) in activated carbon (AC) was prepared from one agricultural waste, coir, immersed in iron salts and then activated through one-step pyrolysis. The activation of AC by iron salts significantly increased surface area of AC and distributed elemental iron over the AC. The X-ray diffraction and X-ray absorption near edge structure spectra revealed that zerovalent iron was present. As compared to AC without iron salt activation, ZVI/AC increased the trichloroethylene (TCE) removal rate constant by 8 times and dechlorinated about 74% TCE. The dechlorination ability of ZVI/AC was dominated by the zerovalent iron content.

Keywords：*Adsorption, Dechlorination, Zerovalent iron, Activated carbon, Trichloroethylene.*

P2-477

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Cadmium Accumulation and Antioxidant Response of Wheat Cultivars to Silicon Application in Hydroponics

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The effect of Si application on growth, antioxidant activity and Cd concentration in two each of high and low shoot Cd (HSCd and LSCd) cultivars was evaluated in glass house hydroponics experiment. Based upon initial screening study, the LSCd cultivars Iqbal-2000 and Lasani-2008 and HSCd cultivars Inqlab-91 and Sehar-2006 were grown in Jonson's nutrient solution without and with 15 uM Cd. The Cd stress (15 μM Cd as CdCl2.H2O) was imposed 15 days after seedling transplanting in hydroponics without and with three levels of Si (2, 4 and 6 mM) as mono silisic acid (SiO2. nH2O. Silicon supply to Cd stressed plants enhanced root and shoot biomass of HSCd cultivars. In LSCd cultivars, Si enhanced biomass was either non-significant or increase was very low compared to HSCd cultivars. Silicon did not improve the SDB of HSCd cultivar Inqlab-91 which had proved SDB tolerant under applied Cd stress level during initial screening study. Silicon treated sensitive HSCd wheat cultivars showed higher improvement in chlorophyll contents and photosynthesis while decrease in stomatal conductance and transpiration rate. Reversely, Cd stress had higher negative effect on chlorophyll contents and photosynthesis in sensitive HSCd cultivars compared to tolerant LSCd cultivars. Thus, Si improved chlorophyll contents and photosynthesis could be regarded as the alleviation of Cd toxicity in Cd stressed plants. Improvement or reduction in gas exchange attributes of Si treated plants was limited to 2 or 4mM Si application. The Si treatment enhanced the activities of CAT, APX, GPX and SOD antioxidant enzymes and depressed MDA contents in Cd stressed wheat cultivars. Generally, the increase (Antioxidants) or decrease (MDA) was higher in LSCd cultivars compared to HSCd cultivars. Increase in antioxidant activity with Si treatment alleviated lipid peroxidation only in HSCd sensitive cultivars as indicated by decreased MDA concentration in leaves. Application of Si significantly decreased RCd concentration only in LSCd cultivars while that of SCd in both the HSCd and LSCd cultivars. The decrease in SCd concentration was due to both the decrease uptake and less translocation from roots to shoots. Similar to root and shoot biomass, 4mM remained the optimum level (except 2mM for RCd in Lasani-2008) reducing Cd concentration in wheat cultivars beyond which no further decrease in Cd concentration was observed. Overall, optimum level of Si enhancing growth, gas exchange attributes and antioxidant activity was either 4 mM or 2 mM in fewer parameters indicating that the optimum level of Si for wheat cultivars lied between these treatments.

Keywords: *Antioxidants, Cadmium, Gas Exchange, Silicon, Wheat*

P2-478

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Calcium Application Alleviates Nickel Phytoxicity in Rice (Oryza Sative L.)

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Urbanization and industrialization have resulted in contamination of ground water and soil with heavy metals and other potential toxicants. Nickel (Ni) is toxic not only for humans but also for plants as it can affect many metabolic processes of plants causing reduction in growth and yield. However, mineral nutrition management can improve growth and alleviate the ill effects of heavy metal toxicity. The study was conducted to investigate the role of calcium (Ca) in alleviation of Ni toxicity in rice using two levels of Ni viz 20 and 40 mg kg-1 using Ni(NO3)2.6H2O and two levels of Ca viz. 80 and 160 mg kg-1. The experiment was laid out in completely randomized design (CDR) with three replications. Ni significantly decreased shoot and root dry weights of rice, chlorophyll contents, photosynthetic rate, transpiration rate and stomatal conductance. Calcium application ameliorated the toxic effect of Ni on growth and other physiological parameters. The lower values of remediation factor and phytotoxicity index of plants growth with Ca indicated the beneficial effects of Ca in plants grown in Ni contaminated soils.

Keywords：*Nickel, Calcium, Phytotoxicity*

P2-479

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Arbuscular Mycorrhizal Fungi in Bioremediation of Co-Contaminated Soil

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Arbuscular mycorrhizal fungi have proved ability to enhance biodegradation of organic pollutants in the greenhouse. Thus, a pot experiment was carried out to investigate the effect of the arbuscular mycorrhizal fungi Glomus mosseae and Glomus versiforme on the uptake of cadmium (Cd) and pentachlorophenol (PCP) and from co-contaminated soil by maize (Zea mays L.). The results indicated that symbiotic associations were effectively established between AMF and maize in mixed pollution. An increase in Cd accumulation by maize roots was observed when PCP was also present. After harvest, the residual PCP concentation in the soil decreased significantly ($p < 0.05$). With mycorrhizal inoculation the amount of residual PCP decreased more in the bulk soil but minus in the rhizosphere soil compared to the uninoculated controls.

Keywords：*Arbuscular mycorrhizal fungi, Metal, Organic contaminant, co-contamination*

P2-480

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Remediation of Crude Oil Polluted Soils: Effect of Organic and Inorganic Nutrient Source on the Growth of Sweet Potato (ipomea Batata)

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Experiment to remediate crude oil polluted soil using sweet potato as a test crop was conducted in the Faculty of Agriculture Teaching and Research Farm of Ambrose Alli University, Ekpoma, southwestern Nigeria. The soil was polluted with crude oil prior to planting. The treatments consisted of three levels of NPK 15:15:15 fertilizer (0, 50 and 100 kg/ha) and three levels of poultry manure (0, 4 and 8 tons/ha). The experiment was a 3 x 3 factorial with nine treatment combinations and was fitted into randomized complete block design, replicated three times. Results showed that application of 100 kg/ha plus 8 t/ha PM increased vine length, vine girth and leaf area significantly at all the weeks after planting. Separate application of 100 kg/ha NPK fertilizer increased sweet potato leaf area significantly compared to the control. Combination of 100 kg/ha plus 8 t/ha PM It also increased phosphorus, potassium and nitrogen uptake, shoot and leaf dry matter yield significantly when compared to the control. However, single application of 50 kg NPK/ha increased P uptake compared to the control and fertilizer alone. Applying poultry manure alone significantly increased Mg and total N contents, P was significant with NPK fertilizer. Inorganic and organic fertilizer mixtures are effective in the restoration of crude oil contaminated soils and are therefore recommended.

Keywords：*crude oil, poultry manure, NPK fertilizer, remediation, sweet potato.*

P2-481

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Biosolid-Based Co-Composts With Lime, Bentonite and Biochar Reduce the Bioavailability of Cadmium in Contaminated Soil

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Cadmium (Cd) is a common trace element in air, water and soil; soil serves as both source (geogenic) and sink (anthropogenic) of both elemental and bioavailable Cd. The major factors governing cadmium speciation, adsorption and distribution in soils are pH, soluble organic matter content, hydrous metal oxide content, clay content and type, presence of organic and inorganic ligands, and competition from other metal ions.

In this experiment, biosolid samples from Wastewater Treatment Plant (Bangkok, Thailand) were mixed with lime, biochar and bentonite (30%; w/w basis) to study their effects on Cd (im)mobilization in contaminated soil from gold mine. The amendments were incubated with a neutral pH soil under aerobic conditions at room temperature for five months so that the effects of various additives on transformation of heavy metals in contaminated soil could be examined. The specific objectives were to study, (i) the redistribution of metal in the biosolid amended soil; and (ii) the mobilization of metal and their subsequent release to soil pore water. Both the NH4NO3 extractable concentration of Cd (CdNN) from contaminated soil and the concentration of these metals in soil pore water were investigated.

Co-composting biosolids using alkaline material, biochar and clay mineral have been shown to immobilize Cd in contaminated soil. The pH and dissolved organic carbon (DOC) of both soil and soil pore water increased. The NH4NO3 extractable Cd (CdNN) from soil and the total Cd concentrations in soil pore water were lower in all amendments than soil alone. While biosolids blended with lime was most effective in the immobilization of Cd in the biosolids amended soil and their subsequent release to soil pore water. Therefore, the amendments used along with biosolids have been effective in immobilizing Cd in contaminated soil.

Keywords：*biosolids, lime, biochar, bentonite, co-compost, heavy metal, dissolved organic carbon, contaminated soil and bioavailability*

P2-482

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Feasibility Study of Using Earthworm and Agricultural Waste as Bio-Adsorbent for Copper Contamination in Soil

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The aim of this study was to study feasibility of using earthworm and agricultural waste as bio-adsorbent for copper contamination in soil. The survival and the growth of earthworms affected by copper with agricultural wastes materials were monitored. Two earthworm species, Eudrillus eugeniae (African night crawler) and Eisenia foetida (Tiger) were used for this study. The experimental design was Factorial in Completely Randomized Design with two factors: 1. Absorbs organic material (cassava peel and eucalyptus bark) and 2. Concentrations of copper (500 , 1,000 and 2,000 ppm) with three replications at the 28 - day study, During the study period, data was collected for the surviving earthworms, the number of cocoon and weighed of earthworm. The results found that agricultural wastes materials could adsorb copper and reduce copper toxicity to earthworms. Eucalyptus bark was a good bio adsorbent better than cassava peel. Earthworms could survive under concentrations of copper at rates of 500 ? 2000 ppm under amendment with eucalyptus bark but earthworms could survive under concentrations of copper at rates of 500 ? 1000 ppm under cassava peel. The earthworm species Eisenia foetida when cultured in the presence of natural organic adsorbents of copper tends to survive in heavy metals contaminated soil more than Eudrillus eugeniae.

Keywords：*copper, agricultural waste material, earthworm, bio-adsorbent*

P2-483

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Manage Different Agro-Industrial Wastes by Using Vermicomposting with Chicken Manure

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The agro-industrial waste has been increasing every year. Without proper management, it would cause problems to soil as well as water and air pollution to the environment. Thus, the objective of this study was to investigate the use of chicken manure in vermicompost of different agro-industrial waste. The vermicompost experiment was conducted by using different agro-industrial wastes (cassava pulp, cassava peel, eucalyptus peel and oil palm) and different rates of chicken manure. The qualities and quantity of each mixture and vermicomposting and the growth of earthworm in different treatments before and after 30 days were analyzed. The best proportion of agro industrial waste for vermicomposting was in the treatment composted with cassava pulp 33%, cassava peel 33%, eucalyptus bark 33% and oil palm 5% with chicken manure 2.5%. Earthworms (Eudrilus eugeniae) could survive 100% in this treatment and could produce the high number of cocoon. Moreover, the quality of vermicomposting was the best in this treatment. Heavy metals (As, Cd, Cr, Cu and Pb) were also reduced 25-100% after vermicomposting process. Therefore, chicken manure can be used to increase the growth of earthworms in vermicompost using industrial wastes (cassava peel, cassava pulp, and eucalyptus peel) to produce biofertiliser and reduce environmental pollution problem.

Keywords：*chicken manure, earthworm, vermicomposting, agro industrial waste*

P2-484

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Potential of Elephant Grass in the Phytoremediation of Zinc and Cadmium Contaminated Soil

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The soil contamination by heavy metals is a constant risk to human health and other living organisms, for their toxicity and persistence in the environment. The phytoremediation is a promising technique for the remediation of soils, and its low cost and lower environmental impact. The objective was to evaluate the effect of cultivation of Pennisetum purpurem Schum. in the distribution of chemical fractions of zinc and cadmium in soil contaminated with industrial waste containing high levels of these elements. An experiment was conducted with a sample of Bt horizon a Argisol Yellow, contaminated and not contaminated with residue that shows high levels of Zn and Cd, cultivated and not cultivated with Pennisetum purpurea Schum. and receiving the application of three doses of CaCO3. The cultivation of Pennisetum purpureum Schum. promoted reduction of soil pH of all treatments, and favored the zinc solubility of contaminated substrates. The application of CaCO3 decreased the soluble fraction of Zn and Cd contaminated soil, without cultivation.

Keywords：*Pennisetum purpurem Schum, industrial waste, heavy metals, Argisol*

P2-485

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Organic and Microbial Evaluation of Biodegradation Capacity of Soils to Degrade Petrogenic Hydrocarbons

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The extensive use of petroleum products represents a constant threat of oil spills to onshore and offshore environments. By properly evaluating the indigenous bioremediation potential of soils we can gauge the efficacy of using such a remediation option and look at further avenues to augment biodegradation rates. Using a biologically active model sandy soil (thus offering lower probability of PHC compounds becoming less available on reactive with charged surfaces) we tested the microbial potential of soils to degrade suite of petroleum hydrocarbons (PHC) and evaluated if straight chain hydrocarbons are more prone to biodegrade than cyclic compounds. The soils were spiked with specific PHC belonging to a set of aliphatic, aromatic and polar compounds thus giving the ability to study biodegradation of a range of petrogenic compounds covering easily, moderate and recalcitrant biodegradable compounds. A modified Microresp based multiple substrate-induced respiration method was used to study respiration response of the soil exposed to a range of hydrocarbon substrates. Apart from this, microcosms were studied to identify variations between CO2 respiration between spiked and unspiked treatments which would be the first step in identifying involvement of an organic and/or microbial transformation pathway for the substrate of interest. Based on a community level physiological microbial functional profiling, an initial screening was carried out for understanding the ability to biodegrade selected compounds. Using a suite of microbial and organic geochemical techniques (respirometery, high resolution organic geochemistry and metagenomic analysis) the ability of indigenous soil microbial population to degrade a set of petrogenic hydrocarbon was evaluated.

Keywords：*Multi SIR, Diesel biremediation*

P2-486

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Immobilization of Copper in Brown Soil Using Different Amendments

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Background: In China soil contamination by heavy metals is becoming more and more serious, how to immobilize heavy metals in soils and reduce their transport to edibles of plants is the focus of public attention. Some amendments such as phosphate, clay and lime have been widely used to immobilize heavy metals in soils. However, not enough work on the immobilization of copper which is one of main pollutants in China's soils has been performed. Objectives: The aims in this study are (1) to compare the ability of six amendments to immobilize Cu in brown soil and (2) to optimize in-situ remediation of Cu-contaminated soils using agricultural amendments. Methods: By single chemical extraction and greenhouse pot experiment, available Cu and Cu uptake by turnip rape (Brassica campestris, L.) were analyzed in Cu-contaminated brown soil under the addition of six amendments (red mud, boron mud, phosphate rock, hydroxyapatite, calcium magnesium phosphate and diammonium phosphate) with different rates. Results: After adding six amendments EDTA-extracted copper (EDTA-Cu) all significantly decreased. The treatments with high rate of red mud and phosphate rock were the most effective in high-contaminated brown soil (100 mg Cu kg-1), where EDTA-Cu decreased by 43.6% and 38.6% as compared to the control respectively. While in low-contaminated soil (50 mg Cu kg-1), it was the treatment with high rate of calcium magnesium phosphate, where EDTA-Cu decreased by 35.0%. All amendments except hydroxyapatite could stimulate the growth of turnip rape and reduce its uptake of Cu. In high-contaminated soil the leaf biomass and Cu content treated with high rate of red mud and calcium magnesium phosphate were enhanced by 796% and 593%, and reduced by 57.3% and 51.6%, respectively, as compared to the controls respectively. While in low-contaminated soil the biomass and Cu content of rape leaf treated with high rate of red mud was enhanced by 929% and reduced by 47.9%, respectively. Conclusions: The several amendments especially red mud and calcium magnesium phosphate could be efficiently used to remediate Cu-contaminated soils, which would be shooting two birds with one stone. In our experiments the optimized rate was 45000 kg ha-1 for red mud and 2475 kg ha-1 for calcium magnesium phosphate, respectively.

Keywords: *Amendment; Cu-contaminated brown soil; Phytoavailability; Immobilization; Remediation*

P2-487

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Phyto-Extraction of Heavy Metals from Municipal Sewage Loaded Soils of Calciorthents

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The present study was conducted to study the influence of sewage effluent on depth-wise distribution of micro nutrients (Zn, Cu, Fe, Mn & B) and pollutant elements (Pb, Cd, Ni and Co) and ascertain the concentration, relationship between soil properties and plant and their translocation index to know the phtoextraction capacity of different plant species.

Sewage effluents from the Muzaffarpur Municipal Area of Bihar, India had been used as the source of irrigation for the last two and a half decades by the farmers alongside the sewage channel. Five nurseries were selected within 1 km in which one of the nurseries had terminated irrigating with the sewage effluent eight years ago and had started using the water from the hand pump. Three vegetables of Brassica species namely (B. oleracea var.botrytis (cauliflower) , B. oleracea L.capitata (cabbage) and B. caulorapa L.(knol khol) alongwith three other vegetables, namely, tomato (Lycopersicum esculentum Mill), spinach (Spiniceae oleracea L.) and Brinjal (Solanum melongena L.) were grown in these nurseries and harvested at the physiological maturity. The Zn, Fe, Cu, Mn, Pb, Ni, Cd, Co and B in the sewage effluent were 4.7, 5.4, 9.7, 9.7, 5.0, 3.6, 1.7, 5.9, and 6.1 times more than the water from hand water. Application of sewage effluent decreased the pH and increased the EC of the surface soil but exhibited no definite trend with increasing depth. However, accumulation of OC, available P2O5 and K2O to the extent of 2.34 per cent, 630 and 400kg ha-1, respectively was observed which decreased with depth. All the eight heavy metals Zn, Cu, Fe, Mn, Co, Ni, Pb and Cd along with B were accumulated on the surface soil having a differential movement to lower depths. Maximum phytoaccumulation of micronutrients and pollutant were observed in the roots followed by leaf and stem of both, receiving sewage effluent and that which is presently not using it. The step down multiple regressions was also calculated. The relative accumulation of elements the six different plant species could be arranged as: Root: knol khol > brinjal > tomato > cabbage > cauliflower > spinach. Stem: spinach > brinjal > tomato > cabbage > cauliflower > knol khol. Leaf: tomato > spinach >brinjal >cabbage > cauliflower > knol khol. Overall: knol khol > brinjal > tomato > spinach > cabbage > cauliflower. From the foregoing results it appears that knol khol is the better phytoremediator than cauliflower indicating that it could be used to mine out the elements from the soil. Similar results were reported for different plants, including canola (Brassica napus L.), oat (Avena sativa), and barley (Hordeum vulgare) which could tolerate and accumulate metals such as selenium, copper, cadmium and zinc (Banuelos et al., 1997; Ebbs et al., 1997). Moreover based on relative accumulation they could be arranged as: Fe >Zn >Cu >Mn >B >Pb >Ni >Co >Cd

The relative translocation of elements in different plant parts of crop species was worked out by transport index (TI) (Elemental concentration in stem or leaf /elemental concentration in root) X 100, for different elements in different crops. This was 39 per cent to 93 per cent in stem and from 39 to 154 per cent in leaves including all the elements. This indicates that elements mostly accumulated in roots and translocation to stem is comparatively difficult as compared to that from stem to leaf. The TI values more than 100 indicate higher translocation and accumulation in upper plant parts. Different elements could be arranged for TIS as: Cu >

Pb >Ni > Zn > B > Mn > Fe > Co >Cd. Moreover the TIL was in the order of: Mn >Zn >Cu > Cd > Ni >Co >Pb > Fe >B .Different crop species also differed widely in their capacity to translocate elements from underground part to aerial part. The TIS of different crops with respect to elements is as: Cauliflower > spinach >cabbage > brinjal > tomato >knol khol. Moreover the TIL of different crop followed the order of: Cabbage > tomato >knol khol >cauliflower > brinjal > spinach. It could be concluded that by continuous use of contaminated sewage water surface soils are enriched with elements which could be toxic to different plant species.

P2-488

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Determination of Chemical Availability of Nickel and Copper in Soil

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The vast increase in environmental pollution by heavy Metals puts public health at risk because they tend to bio-accumulate. Determination of the different ways of binding gives more information on trace metal mobility as well as on their availability or toxicity, in comparison with the total element content. The result obtained from the extractable elements are dependent on the extraction procedure applied. This procedures are simply the BCR three step extraction and that of exchangeable extraction using 0.01 CaCl2. This study demonstrate the usefulness of this extraction techniques within the bioavailability contexts and their extraction efficiency.

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[C3.5-2] Techniques to Manage Contaminated Arable Soils

Improvement of Remediated Soils by Applying Different Agricultural Soils

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Soil has self-decontamination ability, but if the ability is exceeded, it goes to contamination. Remediation for contaminated soils is very complex, difficult, cost expensive, and time-consuming work. Also, remediated soils are changed in different properties and have secondary contamination problems depending on what remediation technologies are applied, so that the remediated soils has been reused mainly in landfills, waste landfill reclamation, and road construction. Because of these reasons, ecological safety is ensured for the reuse of remediated soils. Thus, the continuous and proper management is needed for improving the quality of remediated soils. Hence, this study was conducted to investigate the improvement of remediated soil quality as affected by the application of normal agricultural soils. Two different remediated soil samples, RSA and RSB, were selected, which were previously petroleum contaminated soils remediated by land-farming technique. The agricultural soils, ASA and ASB, applied were sandy clay loam and clay, respectively, with different properties. The remediated soil samples were both sandy loam and the chemical properties of RSA and RSB were as follows; soil pHs of 8.5 and 8.7, soil organic matter contents of 7.4 and 5.5 g kg-1, available phosphorus concentrations of 7.2 and 4.4 mg kg-1, and exchangeable calcium contents of 14.8 and 11.7 cmolc kg-1, respectively. The properties of both RSA and RSB were not fitted to the optimal values for cultivating corps recommended by National Academy of Agricultural Science at Rural Development Administration in Korea. After incubating the mixtures of remediated soils with agricultural soils (3:1 ratio, w/w) for 8 months, soil pH of RSA and RSB was lowered, whereas total nitrogen and available phosphorus contents increased. Also, DTPA-extractable Cu, Ni, and Zn contents were raised with the applications of ASA and ASB. For these reasons, applying some portions of agricultural soils might improve the quality of remediated soils.

Keywords：*remediated soil, agricultural soil, soil chemical properties, plant available chemicals*

P2-490

[C3.5-2] Techniques to Manage Contaminated Arable Soils

Ethylenediamine-Zeolite Hybrid for a New Approach to Phytoremediation

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Phytoremediation, clean-up heavy metal contaminated soil, has received a lot of attention during the few decades because it is well known a cost effectiveness and environmental friendly process. However, its performance is hindered by difficulty in mobility and toxicity of target metal ions in soils. Recently we found the potential of ethylenediamine-zeolite hybrid (En-ze hybrid) as chelating agent as well as nitrogen source for phytoremediation. The objective of this study was to evaluate the effect of En-ze hybrid on phytoremediation in heavily Cu-contaminated soil. En-ze hybrid was synthesized by saturating zeolite 4A with ethylenediamine (En). Ethylendiaime (pH 7.0 adjusted by HCl solution), zeolite and En-ze hybrid were mixed with soil at a rate of 1.5 g, 10.0 g and 11.5 g kg-1 soil respectively. Cu extractability and soluble N were monitored. En-ze hybrid released most of adsorbed En, and enhanced Cu mobility in soil. Therefore, our results supported that En-ze hybrid could offer a new approach to phytoremediation in heavily metal contaminated soils.

Keywords：*Phytoremediation, Ethylenediamine, Zeolite, Metal-contaminated soil, Chelating agent*

P2-491

[C3.5-3] Management and Reclamation of Mining Site Soils

Visible and Near Infrared Spectroscopy of Anthropogenic Soils on a Brown Coal Mining Dumpsite

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Large-scale open-cast mining of brown coal is a commonly used method of mining in many parts of the world. This mining practice leads to the formation of permanent dumps of sterile rock which are typically heavy with clay, with little or no organic matter content. Even if soils of reclaimed dumpsites can develop a high similarity to natural soils in the close vicinity to mines, after a period of time, some of their properties, even the unfavourable ones can remain unchanged. These soils are at the beginning of their development and have certain specific characteristics, and the specific conditions for this type of soils development can be achieved only after their reclamation. For planning the future exploitation of these soils, for their conservation and the protection of other associated natural resources, it is very important to obtain and process detailed information about soils of mining regions. For the purpose of reclamation, the measurement of soil characteristics of these areas after open-cast brown coal mining is a classical approach to start the landscape restoration. Therefore, fast and accurate prediction of these soil attributes is necessary. Visible-Near Infrared (Vis-NIR) reflection spectroscopy is rapid, non-destructive, reproducible and cost-effective analytical method which, due to the relatively simple sample preparation procedures as well as the fast delivery of results, has been very popular in soil science. This study was performed to predict properties of anthropogenic soils in dumpsites in order to evaluate the soil condition and apply suitable reclamation practices. The aim is to make use of visible-near infrared spectroscopy with different pre-treatment, calibration and validation techniques for the evaluation of reclaimed dumpsite soils and to predict the future development of soils under study. Partial Least Square Regression (PLSR) and Support Vector Machine Regression (SVMR) models were constructed to relate soil properties (pH, P, K, Ca, Mg, clay, silt and sand) data to the reflectance spectral data by applying first and second derivatives preprocessing strategies. Then, the performance of Vis-NIR calibration models was evaluated by Root Mean Square Error (RMSE) and coefficients of determination in cross-validation (R2 cv). According to the criteria of minimal RMSE and maximal R2 cv, the first derivative and SVMR models provided more accurate prediction models than PLSR models which were more feasible to predict soil attributes in Anthropogenic soils. Overall, this study indicated that the Vis-NIR reflectance spectroscopy technique combined with a continuously enriched soil spectral library as well as a suitable chemometric indicator could be a nondestructive alternative for monitoring of the soil environment. Such development could prove to be useful for long-term planning and site-specific management activities in brown coal mining dumpsites. Hence, this could be a valuable contribution to the determination of anthropogenic soil properties and the initial quality of the developing soils.

Keywords：*Open-cast mining, Reclamation, Visible-Near Infrared, Anthropogenic soil, Partial Least Square Regre*

P2-492

[C3.5-4] Physical Restoration of Soils

Heavy Metals Concentrations in Soil and Factors Controlling their Behavior during an Application of Raw and Composted Recycled Paper Mill Sludge

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Increasing amount of paper mill sludge that need to be disposed off by industries has recently raised concern for an alternative environmentally sustainable application. Recycled paper mill sludge (RPMS) is an active organic material and has potential to supply nutrients for crops growth. However, the limitation to its usage is the presence of heavy metals. Hence it is important to understand the heavy metal accumulation in the soil systems as well as plant uptake due to RPMS application. Therefore, glasshouse and field study were conducted to investigate the heavy metals concentrations in soil and plant and factors controlling heavy metals behavior during one year application of raw and composted RPMS.

Glasshouse study was conducted in the glasshouse unit of the Faculty of Agriculture, Universiti Putra Malaysia. Orthosiphon stamineus was used as the test crop in 20 kg pots with 4 treatments and 4 replications arranged in a complete randomized design (CRD). The field study was located at the University Agricultural Park, Selangor, Malaysia. Twelve plots were established and each plot consisted of 15 plants of Orthosiphon stamineus with 4 treatments and 4 replications arranged in a randomized complete block design (RCBD). The treatments for both the glasshouse and field were control, 100 kg N ha^{-1} of inorganic fertilizer (recommended rate) and 200 kg N ha^{-1} of raw and RPMS compost, respectively. Treatments were applied once at the beginning of the experiment during transplanting of seedlings. This study was carried out of for 4-crop cuttings of Orthosiphon stamineus with harvesting period of every 3 months.

In the glasshouse experiment, application of composted and raw RPMS gave higher concentration of heavy metals compared to the control. The heavy metals content do not exceed the heavy metals investigation levels for Malaysian soils which is the level taken at the 95^{th} percentile of the heavy metals data for agricultural soils, with the exception of cadmium. After application of raw and composted RPMS for all treatments, the levels of heavy metals in plant foliar tissues were below the Maximum Permitted Concentration (MPC) as stated in the Malaysian Food Act (1983) and Food Regulations (1985) which was established on `as consumed` weight basis. An elevated heavy metals concentration in Orthosiphon stamineus is of great concern to the herbal tea quality. Results of the field study followed the same trend as the laboratory study but resulted in lower concentrations of heavy metals, presumably due to environmental conditions such as rainfall, temperature and leaching, which may have resulted in less accumulation of heavy metals in the soil and plant uptake. The results show relationship between soil pH with total Cd in soil, total carbon in soil with total and available Cu in soil and available P in soil with total Cd and Pb in soil.

This study indicates that raw and RPMS compost can be a supplementary N fertilizer and safe to be utilized for edible plants. Recycled paper mill sludge has not been utilized in Malaysia due to lack of information on the suitability of this waste for land application. Therefore, the results of both glasshouse and field experiments can contribute to better understanding of recycling this waste on land.

Keywords：*Heavy Metals, Paper Mill Sludge, Organic Fertilizer, Soil Properties, Correlation Analysis*

P2-493

[C3.5-4] Physical Restoration of Soils

Soil Assessment at Degrading Mangrove Forests: A Case Study in Lawas, Sarawak

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Mangrove ecosystems provide multiple benefits such as protection and income to the surrounding communities. The ecosystems are fragile and little shift in environmental parameters can cause severe degradation to the health of mangrove stand. In Lawas, Sarawak, planting of Rhizophora spp. was conducted to further enhance protective function of existing mangrove forests. High mortality was recorded in Kampung Awat-Awat and Kuala Lawas, thus soil and site monitoring was initiated. Soil profiles examination was carried out at a depth of up to 120 cm using standard Jarret/Dutch Edelmen auger. Augering was executed during the low tide. Sand accretion was the reason for high mortality in Kampung Awat-Awat. The change in substrates from clay mud to sandy beach depressed the growth of Rhizophora spp. Sand accretion between 2 cm to 7 cm was recorded on top of massive sand mixed with clay mud. Below 81 cm soil depth, we discover the original mangrove soil which consisted of clay mud mix with organic hemic. At Kuala Lawas, similar phenomenon was observed but with thicker layer of clay mud and sand mixture up to 120 cm soil layers. Sand accretion had depressed growth of Rhizophora spp. to the extent of killing the saplings.

Keywords：*mangrove forest, Rhizophora planting, sand accretion*

P2-494

[C3.5-4] Physical Restoration of Soils

Role of Arbuscular Mycorrhizal Fungi to the Phytoremediation of Metal Polluted Soils

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Human activities such as mining, agriculture, and domestic residues generate wastes, some of which contain large amounts of heavy metals/metalloids (metal(loid)s) that could enter natural ecosystems. These toxic heavy metal(loid)s cause irreversible soil degradation, affecting its physical, chemical and biological properties, which limit the vegetation establishment and their use in agriculture, thus reducing the activities and functioning of soil micro- and macro-organisms.

A number of environmental remediation systems using physical, chemical, or biological treatments have been developed in the last decades. The physicochemical treatments include soil washing, vitrification, thermal treatment, and excavation and confinement of the soil in special dumps or landfill sites besides being expensive may alter the soil's physicochemical and biological properties. For these reasons, physicochemical treatments are not applicable on the scale at which mining activities usually pollute soils.

Recently, the potential role of higher plants in the remediation of metal(loid)-polluted soils has gained momentum, because in contrast to physical and chemical remediation techniques the use of plants do no require the removal of polluted soils and therefore the costs involved and the impact on the ecosystem are correspondingly low. Phytoremediation refers to a suite of technologies that use plants (and their associated microorganisms) to remove, transfer, stabilize, decrease, and/or decompose pollutants in the environment. The principal disadvantage of phytoremediation is that it is a slow process which requires several years or decades to reduce metal(loid) concentrations in soil to levels that are harmless to humans and other organisms. This slowness is due to the limited growth and biomass production of hyperaccumulator plants and the lack of knowledge about the interactions among plants, soils and microbial communities that could limit the metal(loid) availability.

However, some microorganisms can adapt/resist to metal(loid) stress, and some of them are able to promote the plants establishment and therefore promoting phytoremediation processes. In this context, the use of arbuscular mycorrhizal fungi (AMF), and their role in phytoremediation, has emerged as a new and interesting choice. In addition to AMF's well-known contribution to plant nutrient acquisition and growth, these fungi have developed diverse mechanisms that encourage plants to grow in soils with high toxic metal(loid) concentrations. These AMF-induced mechanisms include immobilization of metal(loid)s by chelating substances secreted to soil, binding of metal(loid)s to biopolymers in the cell wall, immobilization in the plasmatic membrane once it crosses the cell wall, intracellular chelation through metallothioneins, and transportation of metal(loid)s through fungal hyphae to their reproductive structures (spores) for storage.

Nevertheless, there are still debate about field application of AMF in the phytoremediation of metal(loid) polluted soils.

The information generated in the last years has enhanced our understanding of mycorrhizal biology and of the metal(loid) tolerance of plants and fungi; however, more studies are necessary in this area for improving and implementing the use of AMF in phytoremediation programs. This paper examines the AMF metal(loid) tolerance mechanisms and its role in the promotion of in phytoremediation processes.

Keywords: *metal tolerance mechanisms*

P2-495

[C3.5-4] Physical Restoration of Soils

Chicken Manure and Water Dispersible Clay of Brazilian Soils

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Brazil becomes the third producer and the first exporter of chicken meat in the world. So, generation of chicken manure has been growing at the same rate, which can cause many environmental problems, if not destined correctly. The major use for chicken manure, in Brazil, is as organic fertilizer, helping on nutrients supply and increasing soil organic matter content. Farmers rarely consider soil physical attributes when fertilize their crops, believing the addition of organic fertilizers always improves soil physical properties. This belief can cause many problems, such as the increase of water dispersible clay, which can be the reason of many physical problems. The objective of this work was to evaluate the effects of chicken manure in water dispersible clay of soil. The upper layers (0-20 cm) of two soils were collected. The first was situated under native rainforest and the second under pasture. They have 68% and 11% of clay content, respectively, and will be called clayed and sandy soil. Pots were completely randomized and filled with 1 dm^3 of soil, mixed with chicken manure. The relative doses were 0, 4, 8, 16 and 32 metric tons ha^{-1}. Each treatment had ten replications and were irrigated up to 80% and 60% of saturation humidity, thrice per week, for clayed and sandy soil, respectively. After 75 days, soils were air-dried and sieved (2 mm). The evaluate was based on analysis of exchangeable basic cations (Ca^{2+}, Mg^{2+} and K^{+}) and potential acidity (Al^{3+} + H), which were used to calculate cation exchange capacity in pH-7,00 (CEC) and basic cations saturation (V). The pH-H2O and pH-KCl (1 mol L-1) were used to calculate point of zero charge (PZC) and ΔpH. Soil organic matter (SOM) and water dispersible clay (WDC) content were also evaluated. Data were statistically treated with ANOVA and the best regression curves were plotted. SOM slightly changed in sandy soil and no difference was found in the clayed one, maybe because of the small C/N ratio in this chicken manure. The stability of soil colloidal constituents is influenced by diffuse double layer thickness and surface potential, which depends on the difference between pH and PZC. The pH-H2O raised up only in sandy soil, because of its smaller buffering capacity. PZC increased in both soils, but much more pronounced in sandy soil. PZC increase can be caused by cations specific adsorption. The absence of response in clayed soil could have happened because of the buffering capacity or because of higher phosphate fixation. ΔpH, which correlates with the difference between pH-H2O and PZC, changed only in sandy soil. Therewith, just sandy soil's surface potential had reduced with application of chicken manure, helping flocculation forces to dominate. The sum of bases (Ca^{2+}, Mg^{2+} and K^{+}) had been increased in both soils. The increase of ion concentration induces diffuse double layer compression, which would reduce repulsive forces between colloids and increase soil flocculation. But when cations proportions were evaluated, there was an increase of dispersible cations, like K^{+} and Mg^{2+}, over flocculants ones, as Ca^{2+}. This tends to thicken diffuse double layer more efficiently than the thinning caused by the increase of cations concentration, repulsing colloids. No response was found in WDC contents, in both soils, which were already highly dispersed. Maybe K^{+} and Mg^{2+} increment was more efficient dispersing the soil, than the flocculation induced by ΔpH reduction and ionic concentration increment. This shows the importance of soil physical and effluent chemical analysis on organic fertilizers management. Chicken manures with high dispersible cations contents can cause no physical benefit for soil or even increase WDC content, causing many problems.

Keywords：*Soil Flocculation, Effluents Management*

P2-496

[C3.5-4] Physical Restoration of Soils

Interactions of Food Waste Compost with Metals and Metal-Chelant Complexes during Soil Remediation

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Food waste compost has received extensive interest in recent studies as an organic amendment for promoting metal immobilization and plant growth in contaminated soils. On the other hand, chelant-enhanced phytoextraction is an emerging soil remediation technology that offers advantages of low treatment cost and green image for widespread application, which can potentially be augmented by the addition of food waste compost. Thus, this study investigated the interactions of food waste compost with the newly extracted metals and metal-chelant complexes during soil remediation enhanced by EDDS ([S,S]-ethylenediaminedisuccinic acid, biodegradable chelant) and EDTA (ethylenediaminetetraacetic acid, conventional chelant), respectively. The locally available food waste compost proved to be an efficient sorbent for both metals and their chelant complexes, especially for metal-EDDS complexes. Nearly complete sorption was observed for Cu, Zn, Pb, Zn-EDDS, and Pb-EDDS, whereas a smaller amount of Cu-EDDS, Cu-EDTA, Zn-EDTA, and Pb-EDTA were sorbed, probably due to their different chemical structure. Moreover, the co-presence of food waste compost was shown to improve the EDDS-enhanced metal extraction from the contaminated soil, which may be ascribed to the release of dissolved organic matter that also formed soluble metal complexes. However, this effect was negligible in the case of EDTA-enhanced metal extraction because of a relatively high efficiency by EDTA itself. These results suggested that the field deployment of food waste compost may be more beneficial to EDDS-enhanced than EDTA-enhanced soil remediation.

Keywords：*Chelating agents; Food waste compost; Metal extraction; Phytoremediation; Soil amendment.*

P2-497

[C3.5-4] Physical Restoration of Soils

A New Method for Selective Extraction of Trace Elements Occluded in Mn Oxides from Soils with a Focus on Applicability to Andisols

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Introduction

It is well known that Mn oxides are capable of affecting dynamics of trace elements through oxidizing As (III) and Cr (III) and holding (adsorption and occlusion) wide variety of elements (e.g. Cd and Co). Over recent decades, Chao's method (extraction with 0.1 mol L^{-1} NH_2OH-HCl at pH 2.0 for 30 min; Chao 1972) has been commonly used to extract Mn oxides and occluded trace elements from soil samples. However, our previous study showed that Chao's method is not suitable for Andisols because of extremely low solubility of Mn oxides (Suda et al. 2011). Therefore, an alternative method is developed and evaluated here, to extract Mn oxides and occluded trace elements from Andisols, along with Entisols and Inceptisols which are widely distributed in Japan.

Materials and Methods

Twelve samples (Entisols, Inceptisols and Andisols) were collected from agricultural fields and forests in Japan. The new method consists of three steps (for 1 g of air-dried soil sample, < 2mm): (1) reduction of Mn oxides with 0.01 mol L^{-1} NH_2OH-HCl (pH 5.0, 20 mL) for 16 h, (2) recovery of re-adsorbed elements by extraction with 0.5 mol L^{-1} NH_4Cl in 0.02 mol L^{-1} HCl for 10 min (20 mL), and (3) washing with ultrapure water (10 mL). The method was compared its applicability with Chao's method in terms of extractability and selectivity. Standard addition experiment was also carried out to estimate the extent of re-adsorption of released elements (Cd, Co, Cu, Ni, Zn, Pb) from Mn oxides during the extractions.

Results and Discussion

The amount of Mn extracted with the new method was larger than Chao's method, especially from Andisols samples. The new method also extracted larger amounts of Fe than Chao's method; however, the average rates of extraction of Fe oxides were only less than 2%. Thus, the new method could extract Mn oxides from soil samples with limited extraction of Fe oxides. Only slight difference was observed between the amounts of Al and Si extracted with the two methods. Moreover, the extraction ratio of Al/Mn and Si/Mn obtained with the new method were less than with Chao's method. Thus, the extraction selectivity of the new method is comparable to that of Chao's method. The new method extracted larger amounts of Cd, Co, Cu, Pb, and Zn from most samples than Chao's method. The increase in the amounts of extracted trace elements was attributed to an increase in the release of occluded elements from the Mn and Fe oxides. The results of standard addition experiments strongly indicated that the new method successfully extracted Cd, Co, Ni, and Zn, which were released from Mn oxides. However, re-adsorption of Cu and Pb could not be prevented with both methods, indicating that neither the new method nor Chao's method is suitable for fractionation studies of

Cu and Pb in soil, due to their high affinity to solid phases such as organic matter and Fe oxides. Therefore, it should be concluded that the new method is applicable to soil samples, even to Andisols samples, for extraction of Mn oxides and some occluded elements (Cd, Co, Ni, Zn).

Acknowledgement

The research was funded by Ministry of Agriculture, Forestry and Fisheries through Research project for improving food safety and animal health As-210.

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Keywords：*Mn oxide, Selective extraction, Trace element*

P2-498

[C3.5-4] Physical Restoration of Soils

Immobilization of Arsenic and Cadmium by Oil Palm Empty Fruit Bunch Biochar

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The presence of functional groups, porous structure and alkalinity of biochar are suitable characteristics as a potential amendment to immobilize the trace elements. A laboratory incubation study was carried out to evaluate the effect of biochar on water-soluble arsenic (As) and cadmium (Cd). Muck soil used for the study was collected from Johor, Peninsular Malaysia. The soil with pH 4.8 contained approximately 140.18 and 2.54 mg/kg of As and Cd respectively, which are higher than 95th percentile of these trace elements in Malaysian soil. Due to the high production of empty fruit bunch (EFB) from oil palm mill, this waste was used as biochar feedstock. EFB biochar was produced at 350oC with 55% of carbon content through pyrolysis process. The contaminated soil was separately amended with 20 t C ha-1 of EFB with moisture maintained at field capacity. Water sample was extracted by using rhizon soil moisture sampler on a weekly basis for eight weeks. Water-soluble arsenic and cadmium amended with biochars showed 73% and 93% lower concentration, respectively, compared to the control at the end of the incubation period. The decreased in concentration was possibly due to higher pH of the biochar amended soil (pH 5.3 to 5.6) than the non-amended soil. The As concentration in soil solution water from EFB biochar amended soil were significantly different than non-amended soil throughout the incubation period. This was proven from the glasshouse study which shown the significant decreased of As and Cd uptake by plant grown with biochar application. The results highlight the potential of EFB to remediate As and Cd contaminated soil.

Keywords：*Immobilization, EFB biochar, arsenic, cadmium, soil solution*

P2-499

[C3.5-4] Physical Restoration of Soils

Agroforest System Implantation for Gully Erosion Control in Pindorama Reserve, Brazil

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The Polo Centro Norte is a research center located in Pindorama, Sao Paulo State, Brazil (21º 13' S; 48º 55' W). The soils of Polo Centro Norte are classified as Kandiustalf. The difference in the texture of soil horizons make them highly susceptible to erosion processes due to differentiation on water infiltration velocity in the different horizons. The area had a gully 700 meters extension and in some places up to 15 meters deep as a result of improper management along the years. As an action plan, in 1997, four ponds were built in fall intending leading the water to a controllable speed, this way stabilizing the installed erosive process.To ensure the sustainability process were installed soil conservation practices throughout the drainage divide contribution area. The following step to control erosion process and establish environmental sustainability was to restore the vegetation cover what was done with the implantation of a Agroforestry System. Part of the total area of the research center is occupied by native forest remainders with great diversity of regional endemic species. The plantation started in April 2011 and is under preliminary evaluation where it is observed that the native species are sprouting in the area.Each dam edge received a different plantation treatment so tillage, weed control methods and water parameters can be observed differently. The management system adopted in each dam was: Treatment- Dam 1: Plantation of native species, interspersed with rubber tree (Hevea brasiliensis Muell. Arg), Malpighia punicifolia L and Bixa orellana L without tilling the soil. The planting was done in hollows with approximately 0.30 cm x 0.30 cm x 0.60 cm deep, spaced 3 x 2m, with control of weeds using lines coupled to the tractor and mower without planting annual crops between rows.

Treatment 2 - Dam 2: Planting of forest trees species, interspersed with rubber tree (Hevea brasiliensis Muell. Arg), Malpighia punicifolia L and Bixa orellana L, without soil disturbance. The planting of tree species was made in pits in the dimensions of treatment 1, spaced 3.5 x 2m. To weed control was made appling herbicide Roundup WG and subsequently held the planting of annual crops (corn) between rows of corn planting tree species in no-tillage system.

Treatment 3 - Dam 3: Planting of forest trees species, interspersed with rubber tree (Hevea brasiliensis Muell. Arg), Malpighia punicifolia L and Bixa orellana L with soil tillage and furrow opening. For the preparation of soil disk and trencher were used. The planting of tree species was done in furrows after plowing and disking the area, spaced 3.5 x 2m. There was the annual corn crop planting under conventional tillage, using grid lines and conventional planter planting of tree species.

Treatment 4 - Dam 4: Planting of forest trees, interspersed with rubber tree (Hevea brasiliensis Muell. Arg), Malpighia punicifolia L and Bixa orellana L with soil tillage and furrow opening. For the preparation of soil disk and trencher were used. The planting of tree species was done in furrows after plowing and disking the area, spaced 3.5 x 2m. There was no planting of annual crops between rows of corn planting tree species.

The native species, the rubber tree and Bixa orellana L developed well in the field. The seedlings of Malpighia punicifolia L grew committed in an area subject to flooding. In treatment 4, tree species had higher liana infestation that hampered its development and a higher incidence of invasive weeds in general.

The rubber suffered attack in the beginning of the experiment by capybaras. After planting corn capybaras attacked maize plants which allowed recovery of rubber seedlings. The spacing of 1 meter resulted in three corn rows\ between lines that should be changed two rows in the following years as the trees have grown since then. In July-October 2011 ponds' water evaluation had statistical difference for determined in situ (pH, dissolved oxygen, electric conductivity and temperature). These data confirm the expectations of management of each influences the water quality of the adjacent pond and native species of flora and flora are sprouting in the area.

Keywords：*erosion control, agroforestry system, watershed monitoring*

P2-500

[C3.5-4] Physical Restoration of Soils

Effect of Subsurface Drainage Pumping Station System on Soil Salinity and Drainage in the Reclaimed Tidal Flat Land

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In the reclaimed tidal flat land, drainage and soil salinity are the main factors that can affect the upland crops cultivation. Upland crops can be damaged by either excess water or capillary rise of the salts caused by soil water evaporation. This study was undertaken to determine the effect of subsurface drainage pumping station system on soil salinity and drainage in the reclaimed tidal flat land. Field experiment was conducted at Yeongsangang reclaimed tidal flat land(34°38′N, 126°30′E) in Korea. The dominant soil series at this experimental site was Yeosu series(fine, nonacid, mixed, mesic family of Typic Fluvaquents). Drainage plots were treated with three drainage methods namely: (1)control(CL), (2) subsurface drainage combined with pumping station(SDP), (3) open ditch drainage combined with pumping station(ODP). During the experimental period, the average of gravitational soil water content within surface soil(0~20cm) was 22.7 % for CL, 19.4 % for SDP, 21.0 % for ODP and the electrical conductivity was 2.6 dSm-1 for CL, 2.5 dSm-1 for SDP, 3.5 dSm-1 for ODP, respectively. This results implies that subsurface drainage can improved the salts leaching with vertical water flow and the salts existed in surface soil run off into the drainage pumping station with the several rainfall. Conclusively, subsurface drainage combined with pumping station can be very effective strategy for drainage and desalinization in the reclaimed tidal flat land.

Keywords：*Reclaimed tidal flat land, Subsurface drainage pumping station system, Soil salinity*

P2-501

[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Change in Soil Organic Matter Composition and C Transfered Pathways after Afforestation of Farmland in Northeastern China

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In China, substantial areas of cropland have been afforested since the 1970s. However, information regarding the effects of this practice on soil organic matter (SOM) composition and the pathways of forest-derived C incorporation into different density fractions are not well known. We compared the bulk composition of soil samples (0-5 cm and 5-10 cm) and fractionated soil samples (0-5 cm) from three sites under continuous cultivation and adjacent afforested lands converted from croplands 5, 12 and 25 years ago, in northeastern China. The results showed: (i) the greatest differences in SOM composition between the subsoil (5-10 cm) from the 12-year forest and the topsoil (0-5 cm) of the 5-year forest, with more leaf material in the SOM of the newly afforested topsoil than in the subsoil of the relatively old forest; (ii) compared with the arable soils, which contain substantial recalcitrant material and microbiallyderived material, the SOM from the old afforested soil had a larger fraction of less-decomposed SOM; (iii) the decline of C/N and increase of $\delta^{13}C$ run across fractions with a density from 1.8 g cm^{-3} to 2.5 g cm^{-3} in both sites. The denser fraction 2.5-2.8 g cm^{-3} and > 2.5 g cm^{-3} did not follow this trend in both sites; (iv) most of forest litter-derived C transfered from plant residue to aggregates of low density and gradually to aggregates of higher density with highly microbially decomposed SOM; and (v) a small proportation of forest litter-derived C diffused quickly and absorbed by denser fractions.

Keywords：*Afforestation; SOM composition; Density fracitons*

P2-502

[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Study of Purine Alkaloids and Phenolic Substances if Cocoa Beans Grown in Different Soils in Southeastern Bahia, Brazil

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The cocoa tree (Theobroma cacao L.) presents levels of secondary metabolites in their fermented and dried beans around 10% of the dry weight, among which the purine alkaloids (methylxanthines) and phenolic substances has been the most studied. This study was conducted in 13 areas (soils) of southeastern Bahia, northeastern region Brazil. The content of phenolic compounds (catechin, epicatechin and polyphenol) were determined by spectrophotometry and the levels of purine alkaloids (theobromine and caffeine) were determined by chromatography. The levels of these substances are very similar to levels found in cocoa common at the same region. Except the theobromine, no variables showed significant differences between the soils. The descriptive statistical techniques and exploratory study allowed the characterization of phenolic compounds and purine alkaloids of cocoa beans (clone PH 16) including the exploration of relationships between them. This work provides a viable path for the study of other genotypes of cacao, and investigating different soil management and cropping systems and fosters the possibility of defining a Denomination of Origin for cocoa produced in the region.

Keywords：*Theobroma cacao L., Theobromine, Caffeine, Catechin, Epicatechin, Polyphenol.*

P2-503

[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Nutrient Cycling in Japanese Agro-Ecosystem in 1980 And 2010

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Introduction

Chemical fertilizer and manure application are essential for crop production and maintain soil fertility. However, inappropriate management of them causes negative environmental impacts such as increase damage to water environment, greenhouse gas emission etc. Estimation of application of chemical fertilizers and manures, namely activity data is needed as the first step for quantitative assessment of negative environmental effects. For example, soil surface nutrient (especially nitrogen (N) and phosphorus (P)) balance is an index for total negative environmental impact in national or regional scales on Organization of Economic Co-operative Development (2003). Nitrogen and P input as chemical fertilizers and manures are important factor to evaluate the losses of N and P from farmland to water environment by N and P index (Schroder et al. 2011). To evaluate negative impacts, we established nutrients flow model to evaluate potential negative impacts to environment and sustainability of agro-ecosystem. Along with this model, we calculated N, P, and K flow associated with livestock production in 1980 and 2010 at first.

Materials and Methods

To estimate livestock waste production per kinds of livestock in 1980 and 2010, we used a software developed by Tsuiki and Harada (1997) for N and P and formula developed by Ikumo (2001) for K. Feed consumption was obtained from statistics in those years and N, P and K concentration at those years.

Results

Values were indicated as 1980/2010 in Japanese national scale. Livestock ate 140/145GgN, 33/22GgP and 337/260GgK of feed produced in Japan and 840/844GgN, 165/136GgP and 100/10GgK of imported feed. As the result, 96/146GgN, 12/15GgP and 16/19GgK of products and 690/785GgN, 131/108GgP and 234/210GgK of waste was produced. During this process, 194/61GgN, 56/36GgP and 187/40GgK were lost as bone and internal organs and so on. Before composting of livestock wastes, 15/5GgN, 2/1GgP and 41/18GgK of co-products (saw dust, rice straw, rice husk, etc) was added, then produced 217/176GgN, 119/100GgP and 170/161GgK of livestock manure could be produced as potential. During composting, 488/615GgN, 13/8GgP and 105/67GgK were lose. On our estimate, 220GgN and 120GgP of livestock waste manure was applied in 1980. Therefore, almost all livestock waste was utilized as manure.

At the conference, a pre-announcement

We wish to estimates chemical fertilizer application for crops, N, P and K withdrawal by crop yielding. Then complete nutrient flows for calculation of soil surface N, P and K balance in Japanese agriculture will be indicated at the conference.

Keywords：*Nitrogen, Phosphorus, Potassium, Nutrient cycling, food production*

P2-504

[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Belowground Carbon and Nitrogen Status in a Fire-Damaged Urban Forest Landscape

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The change of soil property after forest fires in forest ecosystems holds considerable interest because the fire can change physical, chemical and biological properties of forest soils. The degree of change in the soil property depends on soil characteristics, topography, fuel type, fire intensity, amount of ash accumulation, time after fire, and climatic factors. Urban forests can play an important role in enhancing ecosystem service with many demands such as recreational service, esthetics and biodiversity. However, many urban forests are faced with challenging natural and anthropogenic influences, such as forest fire and air pollutions. Although several studies have investigated the change of soil properties after forest fire in forest ecosystems, limited information is available on urban forest landscapes. In addition, quantification of nutrient status following forest fire is critical for the actual and potential vegetation restoration of urban forests. This study was conducted to examine carbon (C) and nitrogen (N) status of belowground (forest floor and soil) in restored plots by tree planting and unrestored plots after forest fires, and unburned plots in urban forest areas. The study site was located in BongDae (Mt.) of the Ulsan Metropolitan city, located in southeastern Korea. This mountain was one of the frequent urban forest fire areas (37 times from 2003 to 2011) which were mostly caused by arson. The dominant forest soils are eroded soils (Entisols) originated from granite parent rocks. The soil sampling plots were established on restored plots by tree planting, unrestored plots, and unburned plots. A soil pit was dug near the center of each sampling plot and bulk soil composites of about 1 kg were taken from soil at a depth of 0～15 cm with bulk density samples using a 100cm3 stainless steel cylinder. The forest floor samplings were sampled by a 900cm3 aluminum frame. The forest floor and soil samples were ground in a Wiley mill to pass a 40-mesh stainless steel sieve. Carbon and N concentrations from the ground materials were determined on an elemental analyzer (Thermo Scientific, Flash 2000, Italy). Carbon concentration of forest floor was significantly lower in the unrestored (38.1%) and restored (39.23%) than in the unburned (48.9%) plots, while C concentration at 15 cm of soil depth was not significantly different among the treatments. However, N concentration of forest floor and soil were not significantly among the treatment plots. Carbon storage of forest floor was significantly lower in the unrestored (3.69 Mg C/ha) or restored (3.11 Mg C/ha) than in the unburned (9.39 Mg C/ha) plots, while soil C storage was not significantly different among the treatments (soil: 4.7-10.8 Mg C/ha). Similarly, N storage of forest floor was significantly lower in the unrestored (118 kg N/ha) or restored (78 kg N/ha) than in the unburned (167 kg N/ha) plots, while soil N storage was not significantly different among the treatments (220-465 kg N/ha). Total C storage of belowground (forest floor and soil) was also significantly higher in the unburned (20.2 Mg C/ha) than in the unrestored (8.7 Mg C/ha) plots due to the difference of C storage in forest floor. The results indicate that belowground C and N reduction after forest fires in urban forests was due to decreased C storage of forest floor.

Keywords：*Urban soil, Forest fire, Forest fertilization, Carbon, Nitrogen, Vegetation restoration*

P2-505

[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Carbon and Nitrogen Status of Organic Horizon by an Age Sequence of Pinus Radiata Plantations in South Australia

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The organic horizon strongly affects the biogeochemistry of forest ecosystems because turnover of litter is a major pathway by which C and nutrients are transferred to underlying soils. However, the amount of C and nutrient content in the organic horizon depends on several ecological factors and forest management activities, such as tree species, climate, site quality, stand increment, stand age, stand density, fertilization, and thinning. Understanding changes in the quality and quantity of organic horizon components over time is important as it will provide insights into the dynamics of organic matter and nutrients. Generally, C and nutrient content of organic horizons increased with increased stands age. However the mass of organic horizon component also tends to decrease in response to the degree of disturbance intensity such as thinning and harvesting.

Radiata pine (Pinus radiata D.Don) is a common plantation species in Australasia. Although the characteristics of organic horizons have received a considerable attention in radiata pine plantations, little is known about the underlying changes of C and N in organic horizons over time. The objective of this study was to measure the C and N status of organic horizon in an age sequence of radiata pine plantations.

The study was conducted in the Kuitpo radiata pine plantation in the Mount Lofty Range, South Australia. Experimental plots were located in various stand age sequences of radiata pine plantations (longitude 138°41'-42' E, latitude 35°11'-14' S) on site quality I-VII, which encompasses the range from site quality I on the highest productivity land to site quality VII on the poorest sites.

The experimental design consisted of three age sequences (13-year-old; 27-year-old; 41-year-old) with various levels of tree density and site quality in each plantation, each divided into three randomly assigned 20 m × 20 m plots. The entire organic horizon (Oi, Oe, Oa) including small branches < 2cm diameter was collected from three random points of each plot using a 900 cm^2 aluminum template (30 × 30 cm) in September 2012. The samples were transported to a laboratory and then oven-dried at 65^oC for 48 h. All dried samples were separated into foliage, branch, bark, cone, and miscellaneous components, and each portion was weighed. Each component of the sample was ground in a Wiley mill to pass through a 40-mesh (0.425 mm) stainless steel sieve, and the C and N in the ground materials were determined using an elemental analyzer (Thermo Scientific, Flash 2000, Italy). Carbon concentrations of leaf, branch, and bark were significantly higher in the 41-year-old (foliage: 49.3%; branch: 48.1%; bark: 48.0%) than in the 13-year-old (foliage: 48.2%; branch: 46.6%; bark: 43.7%) plantations, while N concentrations was significantly lower in 41-year-old (branch: 0.79%; bark: 0.39%; cone: 0.37%) than in those of the 13-year-old (branch: 0.35%; bark: 0.21%; cone: 0.26%) plantations except for foliage. Carbon and N concentrations in organic horizon were generally lower in nutrient deficient conditions (V-VII site quality) compared with trees grown in better nutrient conditions (III-V site quality). Carbon content of foliage was significantly higher in the 13-year-old (3,036 kg C ha^{-1}) than in the 41-year-old (l,630 kg C ha^{-1}) plantations, while woody materials such as branch and bark were significantly lower in the 13-year-old compared with the 41-year-old plantations. Similarly, N content of foliage was significantly lower in 41-year-old (15.60 kg N ha^{-1}) than that of the 13-year-old (32.86 kg N ha^{-1}) plantations. However, total C content of the organic horizon was not significantly different among the age sequences, although N content was significantly higher in the 13-year-old than in the 41-year-old plantations. The results indicate that there are major change in C and N status in both trees, and soil organic horizons in response to stand age characteristics and site quality in radiata pine plantations.

Keywords：*Organic horizon, Radiata pine plantation, Carbon storage, Nitrogen storage, Stand age, Forest floor*

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[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Annual Variation of Soil Respiration Rates Following Fertilizer Applications in Red Pine Stands

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The quantitative evaluation of soil respiration following fertilizer application is a key process for understanding carbon dynamics in forest ecosystems. However, soil respiration was increased following nitrogen fertilization, while soil respiration was significantly lower for fertilized than for unfertilized plots due to reduced root and microbial respiration. Since soil respiration results from two main sources, root respiration (autotrophic respiration) and the microbial decomposition of organic matter (heterotrophic respiration), heterotrophic respiration was reduced after nitrogen applications in pine forests, while root respiration would be expected to increase along with an increase in forest production after fertilizer application. However, soil and heterotrophic respiration responded differently to the changes of nutrient availability following fertilizer application. Although the nutrient availability is potentially important regulators of soil and heterotrophic respiration, experimental data in relation to fertilizer application are limited in Korea forest ecosystems. Red pine (Pinus densiflora S. et Z.) forests are the most important type of coniferous tree species and occupy more than 23.5% (1.5 million ha) of Korean forest land. The objective of this study was to determine the effects of fertilizer application on total soil and heterotrophic respiration in red pine stands.

This study was conducted in approximately 40-year-old natural red pine stands in the Wola National Experimental Forest, which is administered by the Korea Forest Research Institute. The experimental design consisted of a completely randomized block design with 2 blocks (35° 12' N, 128°10' E, 180 m) involving 18 plots (plot size = 10×10 m): 3 treatments (NPK, PK fertilized, control) ×2 blocks×3 replicated plots] in mature red pine stands. Fertilizer (NPK=113:150:37 kg/ha ; PK=150:37 kg/ha) was applied for two years (April 2011 and 2012). A root exclusion collar with a trenching was used to separate heterotrophic respiration from soil respiration. Trenching was performed by excavating the outside edges of a columnar soil of 50 cm diameter and 30 cm deep about one month (24 March 2011) prior to fertilizer application. In this study, we assumed that soil respiration was regarded as soil CO_2 efflux omitted from outside of the trenched location, while heterotrophic respiration was regarded as soil CO_2 efflux omitted inside of the PVC collars in each plot. Four replicate measurements (2 inside PVC collars and 2 outside the trenched locations) of each plot were performed monthly between 10:00 and 12:30 h for during the study period by using an infrared gas analyzer system (Model EGM-4 environmental gas monitor systems, PP systems, Hitchin, UK) equipped with a flow-through closed soil respiration chamber (Model SRC-2, same manufacturer). Soil temperature from each plot was measured at 12cm depth adjacent to the soil respiration chamber, using a digital soil temperature probe. Soil and heterotrophic respiration rates were monitored monthly from April 2011 to March 2013. Monthly variation of soil and heterotrophic respiration was similar between the fertilizer and the control treatments. Annual mean total soil respiration rates (g CO_2 m^{-2} h^{-1}) in fertilizer applications were similar between April 2011-March 2012 (NPK: 0.50; PK: 0.49) and April 2012-March 2013 (NPK: 0.51; PK: 0.48), but the respiration rates in the control was slightly lower in April 2012-March 2013 (0.45) than in April 2011-March 2012 (0.50). In contrast, heterotrophic respiration was lower in April 2012-March 2013 (NPK: 0.27; PK: 0.29; control 0.30) than in April 2011-March 2012 (NPK: 0.39; PK: 0.35; control 0.31). These results suggest that fertilizer application induced the decrease of heterotrophic respiration, while annual variation of soil respiration rates was not affected by fertilizer application.

Keywords：*Soil respiration, Carbon cycling, Fertilization, Autotrophic respiration, Heterotrophic respiration*

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[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Evaluation of Alluvial and Upland Soils of Obubra Local Government Area of Cross River State, Nigeria for Okra (Abelmoschus Esculentus) Production

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This experiment was carried out at the green house of Agronomy Department, Faculty of Agriculture and Forestry, Obubra Campus, Cross River University of Technology (06051N, 8o201E) , with the aim of evaluating upland and alluvial soils for Okra production. Samples were obtained from the riverine areas of Obubra in Cross River State, Nigeria and research farm of Cross River State University of Technology. The soils of Obubra are formed from Shale, reddish Brown and gravelly and have been described as Lithic Dystropept (Dystric Cambisol) and the okra variety planted was the Clemson Spineless. Six random samples were bulked together for both chemical and physical analysis. The physical properties had values of 76.3% and 86.1% for sand for alluvial and upland soils, 12.7% and 6.5% silt for alluvial and upland soils and 11.0% and 7.4% clay for alluvial and upland soils respectively. The two soils had pH values of 4.7 and 5.6 for alluvial and upland soils respectively. The result of both physical and chemical properties of the investigated soil samples revealed that, the alluvial soil is more acidic than the upland soil. The organic matter of the alluvial soil was 2.69gkg-1 compared to that of upland soil that had 0.46gkg-1. Total nitrogen of both soils were 0.14gkg-1 for alluvial and a lower value of 0.03gkg-1 for upland soil. The alluvial soil with a higher level of organic matter as a result of accumulation of alluvial deposit, gave a significant yield of 2.42kg compared to the upland soil with a yield of 1.39kg at harvest. Finally, the difference observed in the yield of the okra variety was due to the fertility status of these soils.

Keywords：*Alluvial and Upland soils, Okra Variety and Yield*

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[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

How Does Litter Cover, Litter Diversity and Fauna Affect Sediment Discharge and Runoff?

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In forests, the litter cover protects the soil from being eroded to a large extend by reducing erosivity of raindrops, decreasing sediment discharge and lowering runoff volume. However, the role of litter diversity has not been investigated so far. Further, only little is known about the interrelationship between litter cover, litter diversity and litter decomposition by soil macro fauna and their effect on sediment discharge and runoff. To quantify these effects and to get a better understanding of the mechanisms and processes involved, we conducted a new integrated litter experiment (NILEx) within the research unit "Biodiversity and Ecosystem Functioning" under subtropical climate conditions in China (BEF China, funded by the German Research Foundation, DFG).

Within NILEx, we installed 96 runoff plots sized 40cm x 40cm on two hill slopes inside a castanea molissima forest plantation. Plots were filled with seven different litter species, i.e. 16 one-species plots, 24 two-species plots, 4 four-species plots and 4 bare ground plots, and replicated once. 48 plots were prepared with soil macro fauna traps (Renner solution) while the other half was accessible for diplopods and collembola. To initiate soil erosion, rainfall was generated artificially by using a rainfall simulator with a continuous intensity of 60 mm/h. Our experiments included two runs (dry and wet) of 20 minutes duration each, both conducted at two time steps in summer and autumn 2012. Linear mixed effect models were used to analyze the data.

Our results show that litter diversity and soil macro fauna play an important part in initial soil erosion processes. A significant diversity effect appears in time step 1 when the plots were fully covered by litter. Soil macro fauna plays an important role in sediment discharge at both time steps. Sediment discharge at time step 1 was mainly driven by litter diversity, soil macro fauna, dry or wet run, hill slope and soil moisture (model R^2=0.92). However, considering runoff volume, the effect of litter diversity and soil macro fauna is less important at both time steps. The effect of litter diversity is negative as with increasing diversity level we found decreasing sediment discharge and runoff volume. If soil fauna was present in our plots, erosion rates were higher.

The biodiversity effect can be explained as a function of litter coverage. We assume that in higher divers litter mixtures, leafs do better overlap and fill gaps and, thus, prevent overland flow or rain splash better than single species mixtures. This effect can also explain why we did not found a significant diversity effect at time step 2 when the runoff plots were less covered and gaps were larger anyway. Since we found out that soil macro fauna is not a present factor in litter decomposition, we believe that the effect of soil macro fauna arises from loosening the soil surface and making it easier to be detached and washed away rather than from contributing to litter decomposition and providing a less covered ground.

Keywords：*Soil erosion, litter cover, litter diversity, sediment discharge, runoff, soil macro fauna,, rainfall simulation*

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[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Paw-Paw Leaf Biopesticide and Pennisetum-Grassenhanced Soil Properties and Moringa Oleifera Growth

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Moringa oleifera (MOR), a fast growing tree native to the tropical 3rd World Region is globally acclaimed nutritionally and medicinally as a source of high quality protein, minerals and vitamins. In industry (MOR) is a source of effective decontaminant and exceptionally non drying and non sticky oil particularly appropriate for fine machine lubrication. Fortunately (MOR) production rate is fast growing among 3rd World Farmers. There is however, urgent need to sustain and promote (MOR) production both for home consumption and international export by developing effective strategy to facilitate production such strategy necessitates the development of healthy biopesticide and bio-fertilizer using renewable resources within the reach of 3rd World Farmers in order to address production problems particularly nematodes and termites pests, the number one enemy of (MOR) during early growth. This strategy will also contribute to frustrate the ongoing dumping of harzardous pesticides banned from USA and Europe in the 3rd World Region. This paper on the effects of pawpaw leaf biopesticide (Pawpst) and goat droppings-treated Pennisetum bio-fertilizer (Penbio) on Moringa oleifera growth and soil properties highlighted the positive impact of both the biofert (Penbio) and the Biopesticide (Pawpst) on (MOR) growth and soil properties. Particularly outstanding is the enhanced soil biological activities mediated by (Pawpst) and (Penbio) biofert, which enhanced (MOR) early growth as was evident from increased (MOR) germination rate. (Pawpst) induced a (80%), (Penbio) (99%) while combined Biopesticide + Biofert treatment induced a (120%) relative increase in (MOR) germination rate. Mor-Leaf production rate and total biomass production followed similar trend. (MOR) total biomass production increased 2-fold, 6.5-fold and 7-fold with (Pawpst) biopesticde, (Penbio) biofert and combined (Pawpst) + (Penbio) treatment. Soil analysis at (MOR) final harvest indicated the positive impact of both biofert and biopesticide treatments on soil pH and nutrient availability. (MOR) growth on control soil with no treatment induced a 60%, while (Pawpst) and combined biofert + (Pawpst) treatment mediated a 130% and 150% relative increase in soil available cations. (Pawpst) bio-pesticide impacted soil conservation positively by reducing soil erodibility by 7%. In contrast (Penbio) biofert exerted a dispersion effect rendering the soil highly erodible. Combined (Pawpst) biopesticide + (Penbio) biofert treatment however decreased soil dispersion by 11% relatively, indicating thereby the mitigation effect of (Pawpst) biopesticide. The foregoing evidence indicates a need for optimizing the quality of (Penbio) biofert in order to address its dispersion effect. It is obvious that the sources of both Biopesticide and the Biofertilizer are renewable, abundantly available and environmental friendly. Production is simple and within the reach of 3rd World Farmers. Both Biopesticide and Biofertilizer could therefore contribute positively to promote food security, Environmental Health and Mitigation of climatic crises.

Keywords：*Moringa oleifera; Pawpaw Leaf; Biopesticide, Biofertilizer pennisetum grass; soil propertie*

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[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Soil Carbon Cycle in Subtropical Afforestation in Taiwan

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Introduction

FAO reported that the world's total net loss of forest area was 7.3 million hectares per year in the period 2000-2005. Afforestation and reforestation to enhance sequestration of atmospheric CO2 is one possible method to mitigation of climate warming. Carbon (C) pools in terrestrial ecosystems are increasing attention because of their potential sequester C capacity. Taiwan plant domestic broadleaves trees in fallow farmland are over 10,000 ha from 2002 to 2008. Recently, carbon cycle assessment of forest ecosystem is paid more attention on soil carbon cycle investigation. Impact of forest soil carbon cycle factors, in addition to texture, temperature, moisture and other environmental factors, different tree species will also affect soil carbon cycle. To understand soil carbon cycle after afforestation is helpful to assess overall forest ecosystem carbon cycle. Little was known that sequester C capacity and soil carbon cycle of broadleaves plantation in subtropical area. The objective of this study is to understand soil carbon cycle, such as soil carbon distribution and soil respiration, after different tree species afforestation in subtropical Taiwan.

Materials and methods

The Pingdong long-term ecosystem research site (PD, 22o31', 120o36'E) incluing CO2 flux tower was also established in 2008 by the Experimental Forest, National Taiwan University (EXFO, NTU), Taiwan. This evergreen broadleaved forest of subtropical and tropical site is located in southern Taiwan at an altitude of 60 m a.s.l. The research site was sugarcane farm before 2002. The sugarcane was removed and fourteen broadleaved species were planted in 2002-2005. The soil belongs to Entisol with over 60% of sandstone. The soil pH is 5.5 with low base cations because of high sand percentage. Mean annual temperature is 25.1 ℃, varied from mean maximum of 28.4 ℃ in July to mean minimum of 20.1 ℃ in January. Mean annual precipitation is 2022 mm. The precipitation is divided two patterns: dry season (October to April) and wet season (May to September). The topography of PD site is relative homogeneous, with an average slope of above 5°.

Sixteen plots were set on CO2 flux tower footprint, four subplots were set according FIA plot design. The forest biomass (i.e. tree height, DBH) understory biomass, litter, and soil C were measured and analyzed since 2011. Soil respiration was measured using LI-8100 with survey chamber; each plot was measured in three subplots in every month. All data was conducted to Pearson coefficient analysis.

Results and discussion

The average total C pool of this research site was 27.30 Mg C ha–1, varied from 14.11 to 41.50 Mg C ha-1. The results revealed that the largest C pool was contributed by live tree, average was 21.59 Mg C ha-1, however, wildly ranged from 59.4 % to 87.1 %. The differences of distribution of live tree C pool among 16 plots were affected by growth characteristic of tree species. The C pool contributed from understory, litter, and soil ranged from 0.16% to 10.5%, 0% to 13.04, and 7.75% to 30.13%, respectively. Soil bulk density was significantly negative related to soil carbon and nitrogen content ($p<0.005$). The domain C pool was contributed by live tree, however, soil C pool size would play the importance of dynamics of decaying litter and tree debris, which influences distribution of carbon pool in subtropical broad-leaves plantation.

Soil respiration results showed mean soil respiration was 3.24 μmol m-2 s-1 and the highest value was in July and August and lowest value was in January and February. Soil respiration was showed significantly positive related with soil temperature ($p<0.001$), however, soil respiration did not show relate with soil water content. It suggested that soil texture belonged to sandy to sandy loam and due to lower soil water retardation capacity. Afforestation with different tree species showed different growth rate, litterfall amounts and quality. Soil respiration rate was related with litterfall amount in the same tree species. However, different tree species produced different litterfall accumulation, and therefore soil respiration show spatial variations. Comparing all plots of soil respiration, soil respiration showed high coefficient of variation (CV>20%), indicating that soil respiration was possible affected by different tree species.

Keywords：*afforestation, soil carbon, soil respiration, soil temperature, litterfall*

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[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Year-Round Vegetable Production for Food Security and Livelihood Support in the Humid Tropics in the Wake of a Changing Climate And Extreme Weather

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Capsicum species are high-value vegetable crops, and are also important for human nutrition due to their high nutritional contents. In the humid tropics, Capsicum is grown as an early and late season crop. The aims were to identify the environmental and crop characteristics that control all year season production for livehood sustenance of agrarian community in the rural setting. Capsicum species commonly used for large-scale production in Nigeria. The cropping seasons (rainy and late) are characterized by unpredictable onset and cessation of rainfall, shortened lengths of growing seasons, increasing intensities and duration of terminal drought situations and elevated soil and air temperatures. The responses of Capsicum species; C. annum (var.sweet pepper)and C. frutescens to growing season weather conditions was analysed in terms climatic tolerance yield and yield components during the rainy and late seasons of 2012 and 2013 on the field in Akure, a rainforest zone of Nigeria. It is hypothesized that Capsicum annum sown in the early part of the rainy season and in the late cropping season (terminal drought situation) would differ in their ability to withstand the prevailing seasonal episodes of extreme soil temperatures and soil water deficits. The weather factors of a season drove phenology, growth, biomass production, and fruit yield in Capsicum. In general, late season crops of Capsicum produced less dry matter than rainy season crop Capsicum species sown in the late season subsisted on soil water reserve to meet its water requirements, however, low values of relative water use (ETa/Eo) of late season Capsicum during this period indicated that the crop experienced high degree of soil moisture deficits during its growth. The seasonal differences in 10-day values of rainfall, air temperatures and crop water use (evapotranspiration, ET) for the two sowing seasons were related to the main phases of vegetative and reproductive development in Capsicum. These environmental conditions/factors strongly impacted growth duration,efficiency of fruit setting and fruit yield in Capsicum species.

Keywords:

Keywords : Soil and water resources, agriculture, pepper, climate (hydro-photothermal), food security

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[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Agriculture and Soil Conservation

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The idea of growing without cultivation , whether at the scale of a garden
garden or a large grain farm grows and becomes more and more popular, thus jeopardizing a founding myth of our agriculture : plowing.

In discussions with farmers or traditional gardeners, it is common to hear statements like this: 'The direct seeding [seedlings produced no tillage since the previous harvest] , it works a year, but not both! 'Or' If you do not work the ground, it settles and nothing grows ! ' . In fact, these statements are often derived from experiences.

Yet no-tillage systems can be very durable and productive : forests and permanent grasslands are good examples. So why it works in these ecosystems and not in a vegetable that is worked towards for decades? The answer comes from the soil life.

Indeed , in a plot which has been worked for many years, this is the tool (plow, tiller, spade ...) which aerates the soil and structure , while in the forest and the prairie, it is the roots of plants and soil organisms that are in charge ! The challenge is : how to replace the work of the tool by the work of living Soil life

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[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Pine and Oak Trees Had Contrasting Water Use Responses to Environmental Changes Caused by Industrialization in Southern Korea: Evidence from Tree Ring $\delta^{13}c$

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Introduction

Evergreen coniferous pine and deciduous oak trees are adapted to environments with low and high resource availabilities, respectively (Reich et al., 1995); as such they may respond to atmospheric environmental changes differently. Intrinsic water-use efficiency (iWUE), the ratio of photosynthetic assimilation (A) to stomatal conductance (gs), responds to environmental variations that alter carboxylation rate, stomatal conductance, or both (Penuelas et al., 2011). Therefore, changes in iWUE over time may be used as a surrogate for studying historical gas exchange acclimation of trees to long-term environmental variations such as global warming associated with increased atmospheric CO_2, changed precipitation patterns, and atmospheric pollution associated with fossil fuel combustion. We conducted this study to investigate the different responses of iWUE of pine and oak trees to global and local environmental changes such as air temperature (T_{air}), CO_2 concentration (([CO_2])) and atmospheric pollution since industrialization in Korea that began in the 1970s.

Materials and Methods

In October 2007, four Pinus densiflora (PD) and Quercus variabilis (QV) trees each were selected in Mt. Naejang, one of the national parks in South Korea, and disks were collected at the breast height. The trees sampled covered the range of sizes at each site and the number of annual rings was 39 to 40 for PD and 33 to 38 for QV. Ring widths were measured using a CDendro7, and basal area increment (BAI) was calculated using the width data. Annual ring samples were collected and analyzed for C isotope ratio ($\delta^{13}C$). Intrinsic water use efficiency (iWUE) was calculated. All statistical analyses were conducted using the PASW statistics (SPSS Inc., Chicago, IL, USA). The significance of annual trends of tree ring data (BAI, $\delta^{13}C$, and iWUE) was assessed by either a regression analysis or an autoregressive model of time series analysis. Further correlation analysis between environmental variables and tree ring parameters (BAI and iWUE) were explored using a linear regression model.

Results and Discussion

The $\delta^{13}C$ of PD varied between -27.6 and -26.9‰ with no systematic annual trends; whereas QV showed an annually decreasing $\delta^{13}C$ pattern from -25.4 to -27.8‰. On average of four trees, the iWUE of PD increased ($P<0.05$) from 62.6 to 81.6 μmol $mmol^{-1}$ whereas that of QV fluctuated between 70.8 and 81.1 μmol $mmol^{-1}$ without any significant annual trend. There was a positive correlation between iWUE and BAI for PD but not for QV, indicating that increased iWUE translated to better tree growth only for PD. The iWUE of PD, but not QV, was positively ($P<0.05$) correlated with air temperature and [CO_2], suggesting that water use

response of PD was more sensitive to global warming than QV. Meanwhile, iWUE of neither PD nor QV was correlated with precipitation, indicating that precipitation was sufficient in the study area and thus water availability was not determining factor for iWUE in the humid temperate forest. Photosynthesis of evergreen trees is often limited by suboptimal conditions compared to deciduous species (Warren and Adams, 2004). Therefore, it was postulated that increased carboxylation rather than decreased stomatal conductance with increasing Tair and [CO_2] led to increasing pattern of iWUE of PD over time. For PD, improved iWUE translated to better tree growth as supported by the positive correlation between iWUE and BAI. For both PD and QV, there was a positive correlation between iWUE and atmospheric NO_x and SO_x emissions, implying air-pollutant induced stomatal closure (Rinne et al., 2010).

Acknowledgment

This study was supported by grant from the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT and Future Planning (codes: 2010-0023931 and 2011-0015758).

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Keywords：*Pinus densiflora, Quercus variabilis, Cabon isotope, Water use efficiency, Climate change, Atmospheric pollution*

P2-514

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Physical and Chemical Characteristics of Rendolls in the Tigak Area of New Ireland Province, Papua New Guinea

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The objective of this study was to examine the physical and chemical characteristics of Rendoll soil developed on calcareous parent material and to assess the response to NPK applied to the soils (0-20 cm) in a glasshouse pot trial.

The soil was described and sampled under their natural vegetation (no fertilizer input). Analysis was carried out for inherent nutrient fertility status. Detailed chemical analysis of the soil (0-20 cm) indicated high levels of calcium carbonate (>35 %), organic carbon (>3.6%) and total nitrogen (>0.08 %).

Top soils (0-20 cm) were collected and used in a pot trial. Pots used in the experiment had an area of 1.5394×10^{-6} ha. NPK was applied at four levels: 0, 0.2431, 0.4862 and 0.9723 grams per pot (equivalent to 0, 15, 30 and 60 kg NPK on an area basis). The treatments were replicated four times in a completely randomized block design. Five corn seeds were planted in each pot which was filled with soil; plants were later thinned to three plants. Moist soil, equivalent to 1000 g on oven dry basis, was used in the pot trial. Soil was maintained at 3/4 field capacity by weighing and observed for a period of four weeks. Data was collected on plant height, total fresh biomass, dry matter production, root length, root weight. Observations were also made on insect pest damage and deficiency symptoms. Plants were harvested 40 days after planting. Results are discussed.

Keywords：*rendolls, physical, chemical, characteristics, pot trial, NPK*

P2-515

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Climate Change Induced Effects on Water Balance, Productivity, Biodiversity and Ecosystem Functions of Arable Soils in Austria

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For Austria, the Marchfeld region is the most productive area for arable crops. According to recent climate forecasts, periods of drought will increase as well as the number of heavy rainfall events.

In a multidisciplinary study, the impacts of these changes on the soil plant system were monitored using the specifically adapted AGES Lysimeter facility, comprising the major soil types (calcaric phaeozem, gleyic phaeozem, calcic chernozem) of this area. Besides soil hydrological and mass transport processes, chemical soil properties, emissions of greenhouse gases (CO2, CH4 and N2O) and the biological activity and biodiversity were monitored from 2011 - 2013. Furthermore, the impact on the vegetation (crop production, root growth, establishment of mycorrhizal fungi, establishment and diversity of weeds) was assessed. Depending on the parameter, quite different effects could be observed: Whereas for vegetation parameters the soil type seemed to be the dominant factor, some of the biological characteristics seemed to be more influenced by the changing precipitation pattern. An overview of the results of the 3-years investigation period will be given, analysing and discussing the relevance and consequences of the individual changes for the soil plant system. In this context, especially the integrated view of physical, chemical and biological processes in the soil plant system of the experimental site and its relevance for the development of mitigation and/or adaptation strategies will be highlighted. The major drivers of observed changes will be identified to facilitate contributions to proposals for an ecologically sound management of the soils investigated. Ideas to extend the risk assessment area in conjunction with results of other projects on the subject in the EU region will be presented.

Keywords：*soil functions, soil hydrology, soil biodiversity, soil fertility, climate change*

P2-516

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Characteristics of Rammed Earth Fence of Samurai Residence in Kanazawa City, Japan

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Rammed earth technology has been developed in Middle East and Africa from 7000 BC and in China from 5000 BC to 2000 BC, involving the compression of a damp mixture of suitable proportions of gravel, sand and clay with added stabilizers into an externally supported frame (Jaquin, 2008). The Yoshinogari burial mound (50 BC) was established by the densely compacted layered soil (Onitsuka, 2006). The wall of Horyuji Temple (constructed in 607 ?) and Totaiji Temple (constructed in 728 ? or 733 ?) in Japan was also made from rammed earth. Samurai residence in Nagamachi of Kanazawa City has been used to reside for 300 hundreds years, preserving a historical atmosphere with its remaining rammed earth fence. Kanazawa local government has intensively repaired the historical rammed earth fence as a heritage since 1964 (Tanaka, 1973). Soils at subsurface horizons of paddy rice field in the depth of 2 m in former Kosaka and Morimoto area in Kanazawa were supposed to be used for rammed earth fence of Samurai residence in Nagamachi of Kanazawa.

This study was carried out to know the materials of rammed earth fence itself, the way of repairing, and to make up an appropriate guideline for repairing. The fundamental structure of rammed earth fence in Nagamachi consisted of the lowest part of stone, lower part of rammed earth fence, upper part of rammed earth fence and wooden roof by the approximate survey. The fence was completed by the middle and final coating with fine earth on rammed earth fence. The soil samples were carefully taken from the leaned rammed earth fence of Samurai residence in August of 2012 and October of 2013 to analyze the primary and clay minerals and physical/chemical properties.

The compressive strengthen of rammed earth fence, determined by a push-cone which was available for 0 to 50.7 MPa, varied from 0.53 to 21.6 MPa, suggesting that a bullet could not penetrate hard rammed earth (40 to 60 cm thick) formed from the mixture of gravel, sand and clay. The load of Kanazawa castle evaluated the rammed earth fence as safety defense line and ordered to conserve it. Their field texture was SCL to SL in fine earth. Except unidentified rock fragments the primary minerals in the 0.044 to 0.250 mm fraction of the soil samples were mainly comprised of non-colored minerals; feldspar and quartz. Hyperthenes and iron minerals, however, were principal primary minerals as colored minerals (Okazaki and Nakatani, 2013). Few fan type plant opals derived from Japanese pampas grass (Miscanthus sinensis) were found in the soil samples with an optical microscope. Kaolinite, vermiculite and mica type minerals were main clay minerals with crystallization, determined by X-ray diffractometer. Their soil reactions were 5.25 to 5.65 of pH(H2O) and 21.2 to 39.9 mS m-1 of electrical conductivity (1:5). Total carbon in soil samples of fence, varied from 6.62 to 8.55 g kg-1, was low, reflecting by the addition of sand to build up the rammed earth fence. High exchangeable and water-soluble calcium content, ranging from 2860 to 3060 mg kg-1 and 400 to 800 mg kg-1, respectively, were found in the rammed earth fence samples compared to the paddy soils distributed around Kanazawa City (MAFF, 2008). It is evident that lime was used to stabilize the rammed earth fence by carrying a lime or shell bundle as stabilizers from outside.

Keywords：*clay minerals, primary minerals, rammed earth fence, Samurai residence*

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[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Exploiting Soil Sample Archives - Effects Of Long-Term Storage on the Solubility of Micronutrients

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Archived soil samples form an invaluable reserve for the needs of future research. Re-analysing stored soils can serve in tackling new research topics, applying new methods or developing new approaches. Samples stored for long-term are especially useful in studies on temporal changes in soil variables. Prolonged storage can, however, alter the soil properties, which needs to be taken into account while interpreting analytical results. Soil pH and solubility of exchangeable cations are among the characteristics found to continue changing during dry storage [1, 2].

MTT Agrifood Research Finland possessed a set of 3,790 soil samples collected from 30 countries around the world under a global micronutrient survey conducted in the 1970's [3]. The samples were originally air-dried and ground to pass a 2-mm sieve, after which they were subjected to a set of chemical analyses. Soluble copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) concentrations were determined by acid ammonium acetate ? ethylenediaminetetraacetic acid (AAAc-EDTA) extraction [4] and soluble boron (B) using hot-water extraction [5]. Thereafter, the samples have been stored air-dry in cardboard boxes at room temperature.

In 2013, a representative subset of 80 samples will be re-analysed at MTT for soluble Cu, Fe, Mn, Zn and B by the same methods used in the 1970's. Results will be presented comparing these to the original data to evaluate changes in the solubility of the elements during the 40-year long period of storage.

A set of 1,650 subsamples, selected to cover the variation in the archived samples, is being analysed using mid-infrared (MIR) analysis at the Soil-Plant Spectral Diagnostics Laboratory at the World Agroforestry Centre (ICRAF). Infrared spectra respond to the mineral and organic composition of the soil enabling prediction of various soil properties and functions at low cost [6]. MIR predictions of soil micronutrients will be presented.

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Keywords：*soil archive, sample storage, micronutrients, soil extraction, mid-infrared analysis*

P2-518

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Total and Soluble Concentrations of Micronutrients in the Top- and Subsoils of Sub-Saharan Africa

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Micronutrient deficiencies likely limit the quantity and quality of crop yields widely over Sub-Saharan Africa though data on the nutrient contents of soils and crops is limited. Currently, the capacity for diagnosing the nutrient status in the area is inadequate, which retards the development of new management programmes for increasing food production. Baseline information on the spatial distribution of micronutrients over the African continent is a necessity for tackling the challenge of improving human nutrition and health.

MTT Agrifood Research Finland and the World Agroforestry Centre (ICRAF) are working together on strengthening knowledge of African soils in a research and development programme, FoodAfrica, funded by the Ministry of Foreign Affairs of Finland [1]. During the programme, 850 pairs of top- and subsoil samples, collected under the Africa Soil Information Service (AfSIS) from 60 randomly located sentinel sites covering major agroclimatic zones of Sub-Saharan Africa [2], are being analysed for micronutrients. At MTT the soluble concentrations of Cu, Fe, Mn, Zn, Cr, Co, Mo, Ni, V and Se are acquired by acid ammonium acetate ? ethylenediaminetetraacetic acid (AAAc-EDTA) extraction [3] and soluble B by extraction with hot water [4]. For a subset of the samples, the total concentrations of Cu, Fe, Mn, Zn, Cr, Co, Ni and V have been determined by total x-ray fluorescence at ICRAF. Combining the data from the two sets of analysis will enable us to assess whether potential soil micronutrient deficiencies result from a lack of the element in the soil or from its low solubility.

The first results for 298 topsoil and 292 subsoil samples from 19 sentinel sites located in Kenya, Ethiopia, Tanzania, Mali, Ghana and Burkina Faso show no marked differences in the concentrations of the AAAc-EDTA extractable elements between top- and subsoil. The median concentrations of soluble Cu (2.16 mg l-1), Zn (1.00 mg l-1), Mo (0.03 mg l-1) and Fe (63.3 mg l-1) in the topsoil seem low relative to sufficiency guidelines for good crop growth. On average 0.5% of the total content of Fe in the soil was soluble in AAAc-EDTA extractant. The corresponding proportion for Zn was 4.4% and for Cu 13.9%. The soil analyses will be completed during 2014.

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Keywords： *soil survey, micronutrients, Sub-Saharan Africa, soil extractions, total x-ray fluorescence*

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[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Nanogypsum -A Promising Alternative to Remediate Sodic Soils

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Nano-gypsum was synthesized and characterized in the laboratory of the Department of Nano Science and Technology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. To assess the efficiency of the synthesized nanogypsum (NG), a green house experiment was laid out in a factorial completely randomized block design (FCRD) with two amendments viz., nano-gypsum (NG) and conventional gypsum (CG) at four levels of Gypsum Requirement (GR) @ 25, 50, 75 and 100 % and control, replicated thrice.The response of rice specific to the location (Var.Co 43) was studied in the soil reclaimed with nanogypsum and conventional gypsum. The sodic soil (non saline, non calcareous) belonging to Panjappur series-Typic ustropept with a pH of 9.38 and ESP of 44.07 was collected from Anbil Dharmalingam Agricultural College and Research Institute (ADAC&RI), Navalur Kuttapattu, Tiruchirappalli district, Tamil Nadu, India for reclamation.

The synthesized nano-gypsum was characterised for its physical, chemical and high resolution microscopic and spectroscopic properties (SEM, XRD, Raman effect and FT-IR). The nano-gypsum has surface area of 900 m2g-1, which was 15-20 per cent higher than the substrate (nano-clay). The SEM image of nano- gypsum was clustered and consolidated, while its substrate, nano-clay (montmorillionite) was scattered and sparse. The Raman effect and FT-IR spectra confirmed the presence of gypsum loaded into the nano-clay and the XRD pattern depicted the reduction in d-spacing that coincide with the ion attachment between the lattices.

The results of the percolation study conducted in the percolation reactor revealed the significant displacement of Na+ from the exchangeable clay complex by the Ca2+ of nano-gypsum as indicated by the declining concentration of Ca2+ in the leachate.
On reclamation, the pH of the soil reduced to 7.43 and ESP to 10.37 by 100 % GR as nano-gypsum in comparison to the unamended control soil and was also significant and very effective over 100% GR as conventional gypsum. A significant increase in the exchangeable Ca2+ in the clay complex and promiscuous decline in exchangeable Na+ and maximum concentration of Na+ in the leachate recorded by the application of 100% GR as
nano-gypsum indicates the successful reclamation of sodic soil. The significant leaching of associated anions was also recorded. Reclamation with nano-gypsum @ 100% GR improved the physical properties of the sodic soil by reducing the bulk density to
1.26 Mg m-3 from 1.31 Mg m-3 in the control, increasing the porosity by 6 per cent and improving the hydraulic conductivity to 0.52 cm hr-1 from 0.43 cm hr-1. Rice responded well to the reclamation by registering significantly higher number of grains per panicle and lesser number of chaffy grains per panicle (10%) in 100% GR as nano-gypsum, while the control registered 36 per cent of chaffiness with respect to total number of grains. Rice grown in the soil reclaimed with nano-gypsum @ 100% GR recorded the highest grain yield of 13.53 g pot-1 and straw yield of 18.83 g pot-1 with 22 per cent increase in grain yield over 100% GR as conventional gypsum. Nano-gypsum proved its effects in reducing the bulk density of the sodic soil significantly at all levels of GR than conventional gypsum. Application of 75% GR as nano-gypsum, 100% GR as conventional gypsum and 50% GR as nano-gypsum were comparable in reducing the bulk density, however 100% GR as
nano-gypsum was significant over 100% GR as conventional gypsum.
The application of nano-gypsum @ 75% GR proved effective as it was comparable to 100% GR as conventional gypsum in all the parameters confirming reclamation. The use of amendments in reclaiming the soil was also projected in the increase in available nutrients (N, P and K) of the post harvest soil and the corresponding increase in nutrient uptake by rice.

Keywords：*Sodic soil,nanogypsum,remediation,rice*

P2-520

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

The Effect of Climate Change Adaptation on Rural Community Livelihoods

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Background: Dependence on rain fed crop production means the impact of stresses and shocks are felt keenly by rural poor people, who depend directly on food system outcomes for their survival, with profound implications for the security of their livelihoods and welfare. However, such stresses and shocks will not necessarily lead to negative impacts, as risks and uncertainties, often associated with seasonality, are embedded in the practice of agriculture and there is considerable experience of coping and risk management strategies among people working in this sector. This study explores the opportunities for linking social protection, CCA and DRR in the context of rain fed crop production, establishing whether these three approaches would help enhance resilience to shocks and stresses in rain fed crop production areas.

Methods: The study reviewed the conceptual and policy-related similarities and differences between the three disciplines. Case studies where climate change and resilient social protection approaches were collected and an adaptive social protection framework that highlighted opportunities was developed.

Results: With climate change, the magnitude and frequency of stresses and shocks is changing and approaches such as social protection, disaster risk reduction (DRR) and climate change adaptation (CCA) will be needed to bolster local resilience and supplement people's experience. Social protection and DRR measures designed to limit damages from shocks and stresses may not be sufficient in the longer term. For social protection to be resilient to climate change impacts, it will need to consider how reducing dependence on climate sensitive livelihood activities can be part of adaptive strategies.

Conclusion: Climate Change Adaptation and Disaster Risk Reduction cannot effectively address the root causes of poverty and vulnerability without taking a differentiated view of poverty, integration with social protection can solve the problem.

Keywords：*Effect, Climate Change Adaptation, Rural Community, Livelihoods*

P2-521

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Methodology for Classifying Post-Mining Soil for Tree Planting

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A very detailed soil survey was executed on post-mining soils to evaluate initial their suitability for afforestation and reforestation. Two sites were assigned for this survey, namely; Parcel 1 which comprise of both slime and sand tailing types soil allocated for afforestation, and Parcel 2 which represent waste dump area located on hill top meant for reforestation. Parcel 1 covers an area of 1.28 ha while Parcel 2 has total area of 1.70 ha. For Parcel 1 (afforestation), a very detailed soil survey methodology is adopted within this area which is approximately rectangular in shape. Rentises were spaced at 20 m apart running north-south direction and soils were inspected by auger boring at fixed distance of 20 m apart along each rentis line. However, wherever needed, the soils were also examined at shorter distances if a change in soil or terrain was expected or seen. At each examination point, the soil was examined to depth of 120 cm or to impenetrable layer using a Jerret Auger. The properties of soils determined in-situ were colour, texture, mottles, depth of the soil, presence or absence of pedological features, drainage and depth of water-table. The intensity of examinations was approximately one examination point per 0.4 ha. This parameter was used in extrapolating the soil boundaries between the examination points. For Parcel 2 (reforestation), a system of free rentis (random basis) was used during the survey. This approach was adopted because the area consists of steep slope (> 35O), terraces and gullies, and it was not possible to cut rentises at equal spacing as normally practiced. Certain parts of the area have been filled or overlay with dumped subsoil from other mining areas. At each examination point, the soil properties were determined and recorded similar to what has been practiced in Parcel 1. The unit of soil mapping that we used in Parcel 1 is ‘Soil Type’ and not the usual ‘Soil Series’ due to heterogeneous layers whilst in Parcel 2, the mapping units are Plantable, Steep Slope and Gully. A total of 5 types of soil have been mapped in Parcel 1, and 3 mapping units in Parcel 2. We decided not to use ‘Soil Type’ unit in Parcel 2 due to mix heterogeneous dumped subsoil from mining activities, which was brought from another area and piled in this area. Soil profiles for both areas were very difficult to describe due to heterogeneous texture, layers and colour. Every examination points have different properties even within the soil profiles of the same type. Distribution of soil types of the areas are presented as soil maps.

Keywords：*ex-mining site, soil properties, afforestation, reforestation, soil map*

P2-522

[C4.5-1] The Soil Underfoot: Infinite Possibilities for a Finite Resource

Some Features Of Climate Change In Arid Regions Of Georgia And Its Impact On Soil Erosion And Degradation Processes

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Georgia's climate oscillates from subtropical conditions on the Black Sea coast to continental conditions, with cold winters and hot summers, in the extreme east, with dry lands. Activity of anthropogenic factors resulted in the considerable change of the area of underlying surface in Georgia. Namely owing to increasing of the production and building there are observed decreasing of the following units: mowing, arable, unused lands, shrubs and forests. Transformation of one type structural unit into another one, naturally, results in local climate change. Problem of desertification takes one of the important places in the cycle of climate global and regional warming problems. Desertification is the most complicated and mathematically less studier problem of present meteorology. Conditions, which stipulate the surface layer desertification are so versatile that their simultaneous consideration in a general desertification model meets unsolvable mathematical difficulty.

In the present work we have collected data of water (surface, underground, thermal, mineral and drinking) resources in the eastern dry land territory of Georgia. The specific properties of regional climate warming process in the eastern Georgia is studied by statistical methods and mathematical modelling. The effect of the eastern Georgian climate change upon water resources is investigated. The specific peculiarities of the thermodynamic model of desertification process are discussed. Some recommendations for halting the desertification process and restoration of soil active layer are given.

Keywords：*climate change, soil erosion and degradation processes, modelling*

P2-523

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Subcellular Distribution of Cadmium in the Seedlings of Two Varieties of Hydroponically Grown Paddy Rice

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Cadmium (Cd) is a non-essential element with high mobility within organisms. Once uptake by plants the subcellular distribution plays important role in the tolerance and detoxification of Cd stress. In this study, seedlings of two varieties of paddy rice, one Indica and one Japonica, were hydroponic cultivated in the Cd contained solutions (1.0, 2.5, and 5.0 ?M) to investigate their uptake and subcellular distribution of Cd. Experimental results show that the Cd in solutions cause of inhibitions in shoot height and root length, especially for Japonica. For the same Cd treatment, Japonica accumulated higher Cd concentrations than Indian. Approximately 92-99% of the accumulated Cd was bounded to the cell wall and vacuole and the Cd content declines in the following order: soluble fraction (Fs)> cell wall fraction (Fcw)> organelle fraction (Fco). Both the cell wall and vacuole play important role in the tolerance of Cd stress. There was good linear relationship between the estimated leaf areas and the accumulated Cd concentrations which may results from the transpiration.

Keywords：*Cadmium; Indica; Japonica; Subcellular distribution*

P2-524

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Lead Uptakes by Rice Plant Related to Soil Pb Availability and Rice Genotypes as Confounded with Iron Plaque Formation

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Currently, accumulation of lead (Pb) in surface soil exposed to various pollution sources has been posing risk to the food safety of rice (Oryza sativa L.). Lead concentrations in rice plant would be elevated with soil Pb contamination increasing, and thus should be emphasized for management of agro-environmental risk to human health. So far few studies were conducted on the uptake and distribution of Pb in rice plant, the Pb toxicity to rice plant growth and grain yield, and the differences among rice cultivars in Pb uptake and accumulation from soil. In addition, iron plaque on rice root surface was proposed to be a barrier to soil Pb stress and to prevent from Pb uptake into root tissue. As Pb accumulation in paddy soil is increasingly serious, more understandings about the effects of iron plaque on Pb uptake by paddy rice are required.

In this study, the relationships between plant Pb concentration and soil Pb availability were investigated to show the variations of Pb uptakes by different rice cultivars from Pb-contaminated soils. And the both effects of rice genotypes and soil characteristics on iron plaque formation were incorporated for assessing Pb uptakes by rice plant. Three agricultural soils (C, D, and N) were sampled from the potentially contaminated sites in central Taiwan. For each soil used, three subsamples were spiked with one of three levels of Pb (0, 150, and 300 mg kg-1) respectively in the form of Pb(NO3)2. Two rice cultivars, Tankang 16 (TK16) and Taichung Sen 10 (TCS10), bred in Taiwan were used. The cultivar TK16 is a Japonica type and the cultivar TCS10 is Indica. A pot experiment was then carried out for about one month to test the uptake and distribution of Pb in the rice plants of TK16 and TCS10, which were grown in the Pb-spiked soils.

The results showed that Indica rice such as TCS10, which was stated as a genotype more sensitive to metal stress, could accumulate more Pb in plant, compared with Japonica rice (e.g. TK 16). For the three soils (C, D, and N) used, Pb uptakes by rice plants were positively correlated with Pb availabilities in each soil. However, Pb uptakes by rice plant in soils D and N, even with higher Pb availabilities, would be much less than those in soil C. This could be referred to the relatively high OM and amorphous iron contents in soils D and N resulting in a large amount of iron plaques deposited on root surfaces, which would prevent from Pb absorption by rice plant. In addition, the iron plaque formation on TK16's roots was superior to that on TCS10's roots. Thus the relation with iron plaque formation to Pb uptakes by rice plant should be simultaneously concerned with soil properties and rice genotypes. Nevertheless, the sequestrations of Pb by iron plaque will be limited due to high-leveled Pb contamination making the capacity of iron plaque in sequestrating Pb saturated. If the oxidation intensity of rice roots is enough to influence the rhizosphere widely, iron plaques maybe deposit on soil solids much more than on root surfaces. And then Pb will be mainly sequestrated by the plaques on soil solids in rhizosphere.

Keywords：*paddy rice , root oxidation, DCB extractable, metal sequestration*

P2-525

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Characteristics of Cracks in two Paddy Soils and their Impacts on Preferential Flow

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Soil cracks generated in paddy fields upon drying may be main pathways of preferential flow. In this paper we aimed to characterize soil cracks in paddy field and to assess their role in preferential flow. Two paddy fields, one cultivated for 20 years (YPF) and the other cultivated for more than 100 years (OPF), were subjected to either alternate flooding and drying (AFD) or continuous flooding (CF) as a control during rice growing season. Our results showed that both paddy soils presented a temporal change of soil bulk density, soil shrinkage and cracks with cycles of AFD. The two paddy soil showed a high shrinkage capacity (COLE>0.06), in which the OPF was significantly greater than the YPF ($P<0.001$). Soil cracks were further analyzed in 2D and 3D, and their contributions to hydraulic conductivity and preferential flow were assessed by tension infiltrometer and dye tracer, respectively. Under AFD condition, the YPF presented 10-fold more cracks in quantity but these cracks were finer and shallower as compared to those generated in the OPF. All the cracks did not penetrate through the plow pan existed at 15-25 cm. Soil hydraulic conductivity at near saturation (> -6 cm pressure head) was increased by 2.5-4.5 times in paddy field with cracks, as compared to non-crack paddy field. Cracks represented the pathways of preferential flow. However, the preferential flow was considerably reduced by the dense plow pan. This study indicates that paddy soil cracks generated by AFD cycles can improve water infiltration but its role in preferential flow is minor below the plow pan

Keywords：*Paddy soil, soil Cracks, Percolation, Dye tracer,*

P2-526

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Paddy Soil Nitrogen Mineralization: Links with Physicochemical Soil Organic Matter Fractions and Enzyme Activities

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Nitrogen mineralization from soil organic matter (SOM) plays a very important role in soil productivity particularly for low input agriculture in subtropical Asia, as present in Bangladesh. Soil organic matter quality and soil enzymes are considered to play a decisive role in the N mineralization process, but little is known on how their activities are influenced by soil management in paddy soils and whether they can be used as predictors for N mineralization in these soils. Therefore, we investigated the influence of organic matter (OM) and fertilizer application management on the qualities of accumulated SOM as measured by physic-chemical fractionation and soil enzyme activities in two distinct long-term field experiments. We also assessed different physical and chemical fractions of SOM and enzyme activities as predictors for the net N mineralization measured from aerobic (field capacity) and anaerobic (saturated) soil cores in 14 weeks laboratory incubations.

One field experiment was established on a weathered terrace soil with rice-wheat crop rotation at the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) having five OM treatments combined with two mineral N fertilizer levels. Another experiment was established on a young floodplain soil with rice-rice crop rotation at the Bangladesh Agricultural University (BAU) having five mineral fertilizers treatments. Soils from all the treatments of both study sites were physically fractionated into particulate OM (POM) and silt and clay associated OM following mild ultrasonic dispersion and wet sieving. The silt and clay sized OM was further chemically fractionated by oxidation with 6% NaOCl to isolate an oxidation-resistant OM fraction, followed by extraction of mineral bound OM with 10% HF thereby isolating the HF-resistant OM (HF-res OM). At BSMRAU, total N and total OC were significantly correlated to both the aerobic and the anaerobic N mineralization rates. A significant positive correlation was also found between POM N and the aerobic N mineralization rate, and silt and clay sized N with both of the N mineralization rates. Chemically fractionated NaOCl-oxidizable N was also related to the aerobic N mineralization; and HF-resistant N was positively correlated to both N mineralization rates. Thus, total N content, physically fractionated SOM fractions were found to be useful predictors for the N mineralization rate in this site. At the other experimental site, surprisingly no correlation was found between N mineralization rate and any of the quantified SOM fractions. Thus, OM quality was not found the only dominating factor for N mineralization in paddy soils.

Next to fractionation of SOM, three enzymes activities relevant to N mineralization, namely β-glucosaminidase, β-glucosidase and L-glutaminase were measured from one week pre-incubated soils previously collected from all the treatments of both field experiments. At the BSMRAU site, all the measured enzymes activities were significantly influenced by the OM treatments, N levels, and interactive effects between OM application and N level ($P<0.01$). Enzyme activities mostly increased with application of N fertilizer and organic amendments with some exception (s), as for example with rice straw amendment. At the BAU field experiment, only β-glucosaminidase and L-glutaminase activities significantly differed among the treatments ($P>0.05$). Among the enzyme activities, L-glutaminase activity showed significant positive correlation to both the aerobic ($P<0.05$) and anaerobic ($P<0.05$) N mineralization rate for both the sites. However, N mineralization was positively related to soil N content at BSMRAU and on the contrary negatively at BAU. Although the mechanisms behind this negative relationship are unclear the present study demonstrated the overall direct importance of aminohydrolases even in the anaerobic N mineralization process, where logically ample other factors limit microbial activity and N mineralization. Thus, L-glutaminase activity was found to be a useful predictor for the N mineralization rate for paddy soils.

P2-527

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Isolation and Identification of Ferric Reducing Bacteria and Evaluation of their Roles in Iron Availability in Two Calcareous Soils

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Iron is an essential element for all organisms which plays a crucial role in important biochemical processes such as respiration and photosynthesis. Iron deficiency seems to be an important problem in many calcareous soils. Biological dissimilatory Fe(III) reduction increases iron availability through reduction of Fe(III) to Fe(II). The aim of this study was to isolate, identify and evaluate some bacterial isolates for their abilities to reduce Fe(III) in two calcareous soils. Three bacterial isolates were selected and identified from paddy soils by using 16S rRNA amplification and then inoculated to sterilized and non-sterilized calcareous soils in the presence and absence of glucose. The results showed that all isolates belonged to Bacillus genus and were capable of reducing Fe(III) to Fe(II) in vitro condition. The amount of Fe(III) reduction in sterilized calcareous soils was significantly higher when inoculated with PS23 isolate and Shewanella putrefaciens (S. putrefaciens) (as positive control) compared to PS16 and PS11 isolates. No significant difference was observed between PS11 and PS16 isolates in the presence of indigenous microbial community. The results also revealed that glucose had a significant effect on Fe(III) reduction in the examined calcareous soil samples. The amount of Fe(III) reduction increased two-fold when soil samples were treated with glucose and inoculated by S. putrefaciens and PS23 in non-sterilized soils.

Keywords：*Bioreduction, Bacillus sp, Ferric iron, Paddy soils, Shewanella putrefaciens*

P2-528

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Combined Effects of the Continual Application of Composted Rice Straw and Chemical Fertilizer on Rice Yield under a Double Rice Cropping System in the Mekong Delta, Vietnam

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The Mekong Delta is the largest rice-producing area in Vietnam. The region produces more than 18 million tons of rice annually, which constitutes approximately half of the country's total rice production. In contrast to the Red River Delta in northern Vietnam, most farmers in the Mekong Delta cultivate rice without manure or compost; moreover, farmers generally burn the rice straw, or remove it for use in mushroom cultivation, vegetable mulching, or cattle feeding. We conducted a 13-year field experiment to study the combined effects of rice straw compost and chemical fertilizer application on a double rice-cropping system in the Mekong Delta, Vietnam.

We conducted a 13-year field experiment to study the combined effects of rice straw compost and chemical fertilizer application on a double rice-cropping system in the Mekong Delta, Vietnam. We established the following 7 treatments using a randomized block design with 3 replications i.e. (1) F0C- (or control), 0:0:0 N:P_2O_5:K_2O, (2) F0C+, RSC (6 t ha^{-1}), (3) F40C-, 40% NPK (32:12:12 or 40:12:12 N:P_2O_5:K_2O kg ha^{-1}), (4) F40C+, RSC (6 t ha^{-1}) + 40% NPK (32:12:12 or 40:12:12 N:P_2O_5:K_2O kg ha^{-1}), (5) F60C-, 60% NPK (48:18:18 or 60:18:18 N:P_2O_5:K_2O kg ha^{-1}), (6) F60C+, RSC (6 t ha^{-1}) + 60% NPK (48:18:18 or 60:18:18 N:P_2O_5:K_2O kg ha^{-1}), (7) F100C-, 100% inorganic fertilizer (wet season, 80:30:30 N:P_2O_5:K_2O kg ha^{-1}; dry season, 100:30:30 N:P_2O_5:K_2O kg ha^{-1}). Treatments F0C-, F0C+, F40C+, F60C+, and F100- were initiated during the 2000 wet season. Before the 2009/2010 dry season, the F40C- and F60C- treatment plots were fertilized with RSC (6 t ha^{-1}) + NPK (16:6:6 or 20:6:6 N:P_2O_5:K_2O kg ha^{-1}) and RSC (6 t ha^{-1}) + NPK (64:24:24 or 80:24:24 N:P_2O_5:K_2O kg ha^{-1}), respectively.

Although the compost application did not show significant effect on rice yield for the first several years, the positive effects became clear in later years. Since the wet season crop in 2010, rice yields for F40C+ and F60C+ were higher than those for the other treatments. We calculated yields of the treatments relative to that of conventionally fertilized plots (i.e., without the addition of rice straw compost), and analyzed their annual trends. In the plots with rice straw compost, we observed a positive trend over 13 continuous wet cropping seasons. In comparison with conventional fertilization, application of rice straw compost with a reduced amount of chemical fertilizer is able to maintain rice productivity over a longer period. We analyzed the nutrient status of the rice straw at harvest over 4 cropping seasons. We observed that the Si concentration of the rice straw in conventionally fertilized plots was significantly lower than that in the plots where rice straw compost was applied. The N, P and Mg concentrations of the rice straw increased with fertilizer application rate. The concentrations of K, Ca, Mn, Fe, Zn, and Cu did not significantly differ among treatments. Our results suggest that continuous removal of rice straw may reduce the Si availability in soil, thereby decreasing rice productivity. In addition, we verified that rice straw compost is able to be an effective source of silicon for paddy rice.

The soil total carbon concentration in surface soil layer (0-10cm) in F40C+ and F60C+ significantly increased annually, while that in F0C- decreased. The soil carbon concentration in F100C- did not change with time.

Keywords：*nutrient blance. soil fertility, sustainable land use*

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[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Uptake of Heavy Metals by Paddy Rice on Serpentine Soils

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Serpentinitic soils are high in Cr and Ni which may have the potential risk to crop growth and eco-environment. This study used 2 serpentinitic soil samples (WR and TA) from eastern Taiwan to cultivate paddy rice by pot experiment amended with different fertilizer treatments in the open field. All treatments included control (blank), 120 N-60 P-60 K kg/ha, 120 N-90 P-60 K kg/ha, and 120 N-120 P-60 K kg/ha. The aims of this study are to explore dissolved heavy metal concentration in the soils with different treatments, and to understand heavy metal uptake in rice. The experimental results indicated that the soil pH values gradually decreased during rice growth, due to acidity of the chemical fertilizer addition. Fe and Mn concentrations were higher in the TA soil than in the WR soil, but no difference was found in Cr level in the soil solution. Rice root released O_2 to the rhizosphere through arenchyma. Ferrous iron, which is mobilized in the bulk soil solution, was oxidized to ferric iron forming precipitation of iron oxides/hydroxides on the root surface, the so called iron plaque. The metals were concentrated in the iron plaque. However, the order of metals in iron plaque in all treatments was: Fe > Mn > Ni > Co > Cr. The Cr and Ni concentrations in the rice were up to 1.16 mg/kg and 8.57 mg/kg in all treatments, which were higher than those in general plants.

Keywords：*chromium, iron plaque, nickel, serpentinitic soil*

P2-530

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Effects of Consecutive Turnover of Milk Vetch on Paddy Soil Microbial Properties

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Soil quality is the basis of sustainable development of agricultural ecosystem, and soil microbial properties are important characterizations of soil quality. In this study, we investigated the relationship between soil quality and soil microbial properties such as soil enzyme activites, soil microbial carbon (SMBC), soil microbial nitrogen (SMBN) and soil microbial diversity in order to estimate the effects of consecutive turnover of milk vetch on paddy soil microbial properties as well as illustrate the function of soil microbial properties as bio-indicator of soil quality. Long-term experiment based on rice-milk vetch rotation system was carried out since 2007 in minhou county, Fuzhou, China, which includes six treatments of control (CK), 100% chemical fertilizer (NPK), milk vetch (18000kg/hm2)+100% chemical fertilizer (NPKM1), milk vetch (18000kg/ hm2)+60% chemical fertilizer (NPKM2), milk vetch (18000kg/hm2) alone (MV), milk vetch (18000kg/hm2)+40% chemical fertilizer+straw (NPKMS). To assess whether seasonal fluctuations of measured properties might mask the effects of fertilization, soil samples were collected three times within a growing season (1th, April, 2012; 8th, August, 2012; 13th, October, 2012). The main results obtained were as follows:

（1）Crop yield. Compared to CK, treatments with fertilizer significantly increased rice grain yield by 10.7% to 25.0%, and the highest in NPKM1, NPKMS treatments. Chemical fertilizer combined with milk vetch or straw effectively promoted the increasement of rice grain yield and reduced the use of chemical fertilizer, rice grain yield of NPKM1 was 6.6% higher than NPK, while NPKMS decreased 60% chemical fertilizer dosage.

（2）Soil fertility. Compared with CK and chemical fertilizer alone, chemical fertilizer plus milk vetch significantly increased the content of soil organic matter (OM), total nitrogen (TN), ammonium nitrogen (NH4+-N), nitrate nitrogen (NO3--N), water-soluble organic carbon (WSOC), available K (AK), and available P (AP) deficiency in all treatments was seen after 5 years of rice planting except NPKMS treatment. Soil pH under chemical fertilizer application were slightly lower than CK and MV treatments. However, there was no acidification trend observed in the surface soil by chemical fertilizer utilization.

（3）Soil enzyme activities and microbial biomass. Chemical fertilizer with milk vetch incorporated greatly enhanced soil microbial biomass carbon (SMBC), soil microbial biomass nitrogen (SMBN), soil enzyme activities (urease activities, invertase activities, acid phosphatase activities). Chemical fertilizer alone (NPK) obviously decreased the content of SMBC and SMBN, while milk vetch alone (MV) lowered qMB.

（4）Microbial community structure. Denaturing gradient gel electrophoresis (DGGE) patterns revealed that the fertilization resulted in an obvious change in the bacterial and ammonia-oxidizing bacterial (AOB) community structure but little effects on the community structure of fungi and ammonia-oxidizing archaea (AOA). For bacterial community structure, turnover of milk vetch increased the abundance of Proteobacteria, however, decreased the abundance of Actinobacteria. Shannon index (H) and richness (S) of NPKM1 and NPKM2 were highest in all treatments. Redundancy analysis (RDA) revealed that the AOB community

structure in the fertilization treatments was significantly different from control treatment (CK), and the values of diversity index in fertilization treatments observably higher than CK, indicating that fertilization had a great impact on the AOB community structure. Nevertheless, there was no significant change caused by milk vetch.

（5）Population of microorganisms. Turnover of milk vetch changed the population of soil cultivable microorganisms, the population of bacteria, fungi, actinobacteria in NPKM1 and NPKMS treatments were significantly bigger than other treatments. Compared to NPK treatment, chemical fertilizer plus milk vetch or straw increased the amoA gene copy numbers of ammonia-oxidizing bacteria (AOB) and ammonia-oxidizing archaea (AOA). AOA were more abundant than AOB, the ratio of AOA to AOB ranging from 2.5 to 52.6. Moreover, the population size of AOA stimulated by ammonium (NH4+) and significant correlation was found between archaeal amoA gene copy numbers and ammonium content, implying that AOA may drive the ammonia oxidation in acidic paddy soil. The ratio of AOA to AOB was remarkably related to pH and rice grain yield, respectively, and enhanced by chemical fertilizer.

（6）Soil enzyme activities, microbial biomass and the population of cultivable microorganisms were significantly related to the content of soil basic nutrients (TN, AN, WSOC, NH4+, NO3-, AK) and rice grain yield, respectively, indicating that all of the microbial properties together reflected the level of paddy soil fertility and productivity and could be used as potential bio-indicators for soil quality evaluation.

Keywords：*milk vetch, microbial properties, soil microbial diversity, PCR-DGGE, Real-time PCR, AOB, AOA*

P2-531

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Grading Plant Available Non-Exchangeable Potassium According to its Release Rate Levels Using Sodium Tetraphenylboron

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Bioavailability of non-exchangeable potassium (NEK) depends primarily on the rate at which it can be released into more labile forms (exchangeable and soluble). Our objective was to establish the relation between plant uptake potassium and NEK release using sodium tetraphenylboron (NaBPh4) method. Ryegrass (Lolium perenne L.) was grown in four soils which with five potassium rates (0 ? 400 mg K kg-1) in a greenhouse using consecutive 28-d harvest and regrowth cycles. NEK release rate of original soils was determined by NaBPh4. The relative NEK uptake of ryegrass had very significant positive correlation with the 30-min NEK release rate and was well described by quadratic equation (R2 = 0.976). The relative NEK uptake by ryegrass of 80, 40 and 10% were obtained as four critical level (abundance, medium, low and deficient) to predict the bioavailable leves as high, medium, low and no avail of NEK released from all four soils. The results demonstrated that the NEK release rate greater than 3.3, from 1.1 to 3.3, from 0.4 to 1.1 and below 0.4 mg kg-1 min-1 was high, medium, low and poor availabe, respectively, to plant. The studies suggest that the release rate is the key factor determining NEK availability to plants, and the NaBPh4 method is proposed to quantifying NEK with different availability.

Keywords：*Non-exchangeable potassium (NEK); bioavailability; release rate; sodium tetraphenylboron (NaBPh4)*

P2-532

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Effect of Lactate and Anthraquinone-2,6-Disulfonate on Pentachlorophenol Degradation and Bacterial Community Composition in Paddy Soil

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Pentachlorophenol (PCP) is a class of persistent pollutant and has been widely used as pesticides, herbicides and wood preservatives. After prolonged nonprotective usage, PCP accumulates and settles in soil posing a risk to the surrounding environment and human. However, knowledge of the microbial dynamics driving PCP biodegradation has been limited, particularly in paddy soil. The purpose of this study was to examine the effect of lactate and anthraquinone-2,6-disulfonate (AQDS) on anaerobic PCP biodegradation in paddy soil and to investigate the changes of the bacterial community during the PCP degradation. Three treatments including control and addition of lactate and/or AQDS were designed. PCP was readily biodegraded in all treatments, with the highest biodegradation rate obtained under the lactate and AQDS amended condition. Although reductive dechlorination of PCP was observed in all treatments, terminal restriction fragment length polymorphism analysis revealed distinct bacterial community compositions. Clostridia, betaproteobacteria, Mollicutes and Negativticutes were observed in all treatments during the degradation of PCP. According to principal component analysis of T-RFLP profiles, the microcosm communities in all treatments were classified into three distinct clusters, suggesting that lactate was a major driver of microbial community structure and after reaction for 14 days, the microbial community structure resiled. Quantitative PCR for detecting the dehalogenating bacteria showed that Dehalobacter 16S rRNA gene copies increased up to 1 order of magnitude after the addition of lactate. Overall these studies provided a new line of evidence of the key bacteria enhancing PCP degradation and demonstrated the involvement of Dehalobacter sp. in the reductive dechlorination to PCP.

P2-533

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Estimation of Microbial Biomass Potassium in Paddy Field Soil

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Introduction

Soil microbial biomass has important roles in supply of nutrients such as N, P and S for plants as decomposers of organic materials and transformers of various elements and also as a reservoir for the nutrients. Potassium (K) is one of the three major essential nutrients and the amount of K uptake by crops is equivalent to or more than that of the N uptake. Although the inorganic K, i.e. water-soluble, exchangeable and non-exchangeable K, had been solely considered as the forms of K in soil, K in microbial cells, microbial biomass K, in soil has been recently found to be an important K pool (Lorenz et al., 2010). The aims of the present study are to evaluate the amount of biomass K in paddy field soil and to show the importance of it as a possible source of available K for rice plants. We determined the amount and the seasonal fluctuation of biomass K and examined effects of organic fertilizer application on the amounts in paddy field soil for the first time.

Materials and methods

Two experimental paddy fields located at the Aichi-ken Anjo Research and Extension Center, Anjo, Aichi, Japan (Anjo; 34º58'N, 137º4'E) and the NARO Tohoku Agricultural Research Center, Daisen (formerly Omagari), Akita, Japan (Omagari; 39º29'N, 140º30'E) were used. The paddy field plot in Anjo was cropped with rice and wheat in summer and winter, respectively. The soil was Oxyaquic Dystrudept with the Light Clay texture. Soil samples were periodically collected during rice cultivation period. The paddy field in Omagari consisted of experimental fields with long-term application of livestock manure compost, rice straw compost and chemical fertilizers. The paddy field plots were cropped only with rice in summer. The soil was Typic Fluvaquents with the texture Clay Loam. Soil samples were taken in August during the rice cultivation period. Microbial biomass K in soil was measured by the chloroform-fumigation extraction method according to Lorenz et al. (2010).

Results

Microbial biomass K ranged from 5 to 21 mg K kg^{-1} soil in Anjo paddy field and the value corresponded to be 41% of the exchangeable K on average. The average amount of biomass K per area was estimated to be 13 kg K ha^{-1}, which almost corresponded to the amount of biomass N (18 kg N ha^{-1}). The contents of biomass K showed a seasonal fluctuation and a peak was found before harvesting of rice in September, which showed about four times higher value than the minimum value recorded before flooding in May. Microbial biomass K as well as exchangeable K were increased conspicuously by the long-term application of livestock manure compost or rice straw compost in Omagari paddy field. The ratio of biomass K to exchangeable K

was higher in the soils without application of organic fertilizers than in the soils with application of livestock manure compost or rice straw compost. In particular, biomass K was higher than exchangeable K under K-deficient conditions in the long-term experimental plots without K application.

Conclusion

The present study revealed that the microbial biomass contained considerable amounts of K in paddy field soil and could be an important K source for rice plants in paddy field soil. These findings indicate the need for revaluation of the microbial biomass K as a source and a stock of K in soil that has been overlooked.

Reference

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Keywords：*Microbial biomass potassium, Paddy field soil, Chloroform-fumigation extraction method*

P2-534

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Effect of Irrigation Water Management on As and Cd in Rice Grain

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Arsenic in rice grain has gained attention when it was found that contaminated drinking/cooking water and rice were causing As risk to millions of humans at several locations. The reasons for higher As accumulation in rice grain have been receiving significant attention. It has been shown that rice grown under flooded soil accumulates higher As than rice grown in aerobic soils, which is attributed to the reduction of soil arsenate to arsenite in flooded soil and the uptake of the more soluble arsenite by the silicate transporter of rice roots. Uptake of As by rice differs from uptake by other crops in aerobic soil where arsenate is absorbed on the phosphate transporter. Because rice is grown in flooded soils, it commonly accumulates higher levels of inorganic As (iAs) than other staple grains. Focus on iAs is based on the greater carcinogenicity risk from iAs than organic-As. Thus it was important to determine if using aerobic production practices would reduce grain As in field grown rice, and whether existing cultivars would perform satisfactorily under these conditions. Because experiments were being conducted using varied water management practices to evaluate effects on greenhouse gas emissions, water use efficiency, plant diseases and plant production, grain collected from those studies was analyzed for As and other elements retrospectively to measure the effect of field water management on brown rice grain As and Cd levels.

Three rice cultivars were grown under varied water management at the University of Arkansas' Rice Research and Extension Center near Stuttgart, Arkansas on a Dewitt silt loam (fine, smectitic, thermic, Typic Albaqualfs). Standard recommended fertilization and weed management practices were used. The cultivars included CLXL745, XL723 and XL753. Four replications were arranged in randomized complete blocks. The six water managements varied from a traditional full season flood, through alternative wetting and drying, to furrow irrigation only when the soil reached 60 or 40% of soil water holding capacity. At harvest, grain samples from each plot were collected, threshed, and the brown rice analyzed. Soil total metals were analyzed by Atomic Absorption spectrometry with deuterium background correction after Aqua-Regia digestion; As was measured by a hydride generation ICP-AES method. Soil pH was measured in 10 g soil/20 mL slurries after 1 hr. Statistical analysis was conducted using SAS.

Soil samples collected prior to planting contained 30.7 mg Zn, 6.0 mg Cu, <0.10 mg Cd 1.32% Fe and 4.20 mg As kg-1 dry weight, and aerobic soil averaged pH 6.4. Water management strongly affected yields, with the driest treatments resulting in significantly lower grain yields. The effect of water management on grain total As was highly significant. Grain TAs fell from 0.24 mg/kg DW to 0.04 mg/kg DW from the full flood management to the furrow irrigation at 40% WHC irrigation. At the same time, grain Cd rose from 0.02 to 0.06 mg/kg DW. Because of the moderate soil pH and low soil Cd, aerobic production did not cause grain Cd to reach the CODEX rice limit of 0.4 mg Cd/kg. In other field studies using irrigation management to lower grain As carried out on a

soil with pH 5.3 and containing higher Cd than our test soil, grain Cd rose to high levels. These results show that soil had to become considerably more aerobic for grain As to decline, but a small change in soil aerobic status increased Cd accumulation. We will report the iAs in grain at the Congress. A new method using SPE to separate inorganic as from other species, followed by HG-ICP-AES assay of iAs may allow inexpensive and rapid analysis of iAs without requiring full speciation analysis using HPLC-ICP-MS.

These findings support earlier reports that more aerobic rice production can significantly reduce grain As concentrations. At the same time, grain Cd will be increased due to change in redox and pH. Researchers attempting to lower rice grain As through irrigation management should also measure Cd and consider other soil chemical differences which may affect yields, trace element residues, and plant disease occurrence. Other ongoing research to clarify rice As and Cd accumulation in relation to soil management and amendments will be reported.

Keywords：*RICE. ARSENIC. CADMIUM. WATER. MANAGEMENT.*

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[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Comparison of Phosphorus Species in a Chinese Paddy Soil Profile After Long-Term Continuous Pig Manure and Superphosphate Fertilization: Analysis by Quantitative 31p- Nuclear Magnetic Resonance

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Paddy soil phosphorus (P) species have a close relationship with bioavailability and they are expected to differ under long – term organic and inorganic fertilization regimes. A better understanding of P forms changes in soil profile may be of crucial importance to optimize soil – fertilizer management practice. The objective of the present study was to investigate the distribution of P species in a Chinese paddy soil profile (0 – 5, 5 – 20, 20 – 40, 40 – 60 cm) under organic and inorganic P fertilization by using quantitative 31P – nuclear magnetic resonance. A randomized block design of field experiment was conducted for both fertilization regimes, which included three replicates at four rates (0 [CKM], 26 [M1], 39 [M2], 52 kg P ha-1 [M3] for pig manure treatment; 0 [CKP], 20 [P1], 40 [P2], 60 kg P ha-1 [P3] for superphosphate treatment). Orthophosphate was the major form of P species in all soil samples and its percentage increased with P application rates. Compared with inorganic P treatment, pig manure amendment made no significant difference of soil orthophosphate content ($P > 0.05$) at the same depth. However, significant differences of orthophosphate monoesters and diesters contents were detected between the two treatments. This study indicated that long – term pig manure amendment might be the source of substantial soil organic P species whereas it made no difference of soil inorganic P as compared with superphosphate application.

Keywords：*Organic Phosphorus; Paddy soil; Manure; Fertilization; NMR*

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[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

The Evaluation of Copper and Zinc Uptake and Risk Assessment of Twelve Rice Varieties Grown in Cu- or Zn-Contaminated Soils of Taiwan

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Twelve rice varieties including 3 Indica genotype varieties (Oryza sativa L. cv. Tainung Sen #20, Tai Sen #2, Taichung Sen #10), 1 Hybrid Indica genotype variety (Oryza sativa L. cv. Taichung Sen Waxy #1) and 8 Japonica genotype varieties (Oryza sativa L. cv. Tainung #67, Tainung #70, Tainung #71, Tainung #72, Taikeng #8, Kaohsiung #143, Kaohsiung #144, and Taitung #30) were grown in two heavy metals (Cu and Zn)-contaminated soils of 8 regions of Taiwan in 2005, 2006, 2008, and 2010. There are first crop and second crop production per year. The 8 experimental regions including 8 plots of Changhwa county (total 0.81 ha), 2 plots of Taoyuan county (total 0.81 ha) and 3 plots of Hsingchu county (0.31 ha), respectively. Each rice variety was cultivated at near same area in each plot of each county with different concentration of Cu- or Zn-contaminated soils (total Cu ranged 100 to 800 mg/kg or total Zn ranged 200 to 1000 mg/kg, digested by aqua regia). The regulation of soil total content for crop production in Taiwan are 200 mg/kg (Cu) and 600 mg/kg (Zn) based on the Soil and Groundwater Pollution Remediation Act of Taiwan EPA. The soil characteristics of 3 counties are quite different with different soil pH, texture, organic matter and free iron oxide content.

Brown rice, leaf, stem, husk and roots of 12 different rice varieties were harvested and the same location of Cu or Zn-contaminated soils was also sampled. The different Cu or Zn bioavailable concentration of soils was extracted by 0.1 M HCl, 0.05 M EDTA, 0.43 M HNO3, and 0.01M CaCl2. The soil total Cu and Zn contents are digested by aqua regia. The digestion solution of different parts of rice and 4 extraction soil solution were determined by ICP-OES.

The Cu concentration of brown rice almost ranged from 2 to 14 mg/kg (sample number near 2300) although four extraction concentrations of Cu-contaminated soils ranged 10 to 500 mg/kg. The relationship between Cu content of brown rice and different soil extraction Cu concentration (n= 2300) meet the 'plateau theory'. The Cu concentration of brown rice almost ranged 2 to 10 mg/kg although the different soil extraction concentration of un-contaminated soils ranged 10 to 35 mg/kg. This result indicated that there is almost same Cu concentration (only 4 mg/kg difference) of brown rice grown at very high Cu-contaminated soils ranged from 200 to 800 mg/kg (total Cu content).

The Zn concentration of brown rice almost ranged 10 to 50 mg/kg (sample number near 2300) although four extraction concentrations of Zn-contaminated soils ranged from 100 to 500 mg/kg. The relationship between Zn content of brown rice and

different soil extraction Zn concentration (n= 2300) also meet the 'plateau theory'. The Zn concentration of brown rice almost ranged 10 to 40 mg/kg although the different soil extraction Zn concentration of un-contaminated soils ranged 50 to 120 mg/kg. This result indicated that there is almost same Zn concentration (only 5 mg/kg difference) of brown rice grown at very high Zn-contaminated soils ranged from 300 to 1000 mg/kg (total Zn content).

The field studies conducted in the Cu- and Zn-contaminated soils indicated that there is almost same Cu or Zn concentration of brown rice, only 4-5 mg/kg difference, grown at normal soils or at high contaminated soils ranged from 200 to 800 mg/kg (Cu) or 400-1000 mg/kg (Zn). In Taiwan, the average total intake of brown rice is near 150 grams per person per day. The total intake of Cu or Zn of brown rice even grown at the soil concentration of Cu (<400 mg/kg) and Zn (<900 mg/kg) can be evaluated as safety level and almost no risk (less than 1 of one million) after health risk assessment.

Keywords：*rice varieties, brown rice, Cu or Zn-contaminated soil, food safety, risk assessment, regulation of*

P2-537

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Comparison and Distribution of Phosphorus Fractions in Surface Horizons of Two Paddy Soil Chronosequences

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Phosphorus is one of the important nutrients necessary for the growth of crops. It is an important limiting factor for crop productivity, but also plays a non-substitutable role in maintaining ecosystem balance. Soil chronosequences are potent instruments for pedological investigations, and they have a starring role to play in the testing of pedological theories. In this study, based on the investigation of paddy soil survey on the south bank of Hangzhou Bay, two paddy soil chronosequences were identified, one was located in Cixi city (the paddy field with 1, 50, 100, 300, 1000, 1500 and 2000 years old respectively) and the other was in Shangyu city (the paddy field with 5, 30, 100, 300, 1000 and 2000 years old respectively). P fraction in the surface horizons of two paddy chronosequences was studied by modified Hedley P fraction method. The results showed that the total P (Pt) content had no correlation to the rice cultivation time in the two paddy chronosequences. It ranged from 423.5 to 882.3 mg kg-1. The diluted HCl-extractable inorganic P (Dil-HCl-Pi) ranged from 115.0 to 564.0 mg kg–1. The Dil-HCl-Pi was the predominant P form in the surface horizons in the paddy chronosequence in Shangyu city (with on average 48.7% of Pt as Pi) and paddy fields with no more than 300 years old in Cixi city (with on average 59.6% of Pt as Pi). It probably attributed to the parent material of the two paddy chronosequences originated from marine sediments. Inorganic P comprised 84%±7% of Pt, while the proportion of organic P to Pt increased with rice cultivation time in the paddy chronosequence in Cixi city. This may due to organic carbon increasing with paddy soil age prolonged.

Keywords：*phosphorus fraction; paddy chronosequence; Hedley fractionation*

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[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Using Thermal Analysis to Investigate Physical Protection from Soil Aggregates under the Long-Term Fertilization Practices

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In China's major agricultural regions chemical fertilizer input is increasing rapidly as continue while manure application shows continuous decline. The consequences of this change on soil quality and structure are unclear. The objectives of this research were to investigate (1) the distribution and stability of different aggregate fractions and soil organic carbon (SOC) distribution within different aggregate fractions; (2) the distribution of physically separated fractions and their thermal stable and labile organic matter; (3) mechanism on physical protection of aggregates.

The experiment, initiated in 1986, has five treatments: no fertilizer（CK）, mineral fertilizer alone (CF), rice residues (8.85 Mg ha-1 yr-1, air-dried weight) plus mineral fertilizer (RCF), low manure rate (31.8 Mg ha-1 yr-1, wet weight) plus mineral fertilizer (lMCF), and high manure rate (63.6 Mg ha-1 yr-1, wet weight) plus mineral fertilizer(hMCF). The cropping system consists of barley (Hordaum vulgare L.) (Nov. - Apr.), early rice (May - July), and late rice (July - Oct.). Soil samples were collected from the 0-10cm soil layer and the following items have been analyzed: soil aggregate size distribution, aggregate stability, distribution of particular organic matter (POM), microaggregates (mM), and silt and clay (scM) within the small macroaggregates by physical separation, SOC distribution, thermal stable and labile organic matter.

The preliminary results indicated that (1) addition of organic materials increased aggregate stability and organic content, and formed more macro-aggregates, but the improvement from the chemical fertilizer alone was limited; Except for the 0.05-0.25 mm fraction, the larger the aggregate size was, the more SOC it had; Simultaneously, SOC and aggregate stability (expressed by Mean Weight Diameter) had significant linear relationship. (2).the results of physical separation of small macroaggregates showed that mM accounted for 58-67% of the small macroaggregates and 62-67% of organic carbon in the small macroaggregates. Organic materials plus chemical fertilizer significantly increased the amount of mM and their associated OC, and chemical fertilizer alone had minor effects, indicating that mM-C could be used as a diagnostic fraction reflecting SOC changes upon management practices. Thermal analysis showed that thermal stable organic matter (OM) was greater than thermal labile OM in both free and occluded microaggregates, suggesting that thermal stable OM was critical for C sequestration. Microaggregates within small macroaggregates had higher thermal labile and thermal stable OM contents than free microaggregates, due to the physical protection from small macroaggregates. Manure plus chemical fertilizer improved both thermal stable and thermal labile OM of mM, but only improved thermal labile OM of free microaggregates, revealing that thermal labile OM was more sensitive to management practices. Particular organic matter accounted for a small proportion, but had the highest OC content among the three fractions, which was important for new microaggregate formation. Application of organic material combined with chemical fertilizer could improve POM-C thus to promote microaggregate formation. Correlation analysis showed that POM-C could be an important composition of thermal labile OM of small macroaggregates. Silt plus clay fraction within small macroaggregates accounted for the least proportion, containing the lowest OC content, and scM-C (chemically protected) was positively correlated to thermal stable OM of small macroaggregates.

Keywords：*aggregates, thermal analysis, physical separation, soil organic carbon, physical protection*

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[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Nitrogen Use Efficiency of Promising Rice Genotypes in Drought Prone Northwest Bangladesh

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Nitrogen (N), the most important nutrient to increase rice yield, received little research attention in drought-prone rainfed environment. Moreover, nitrogen use in rainfed areas is generally low due to drought risk and crop response to N application might be reduced during drought stress phases. Both factors contribute to low rice yields in rainfed systems. Therefore, there is a need in rainfed systems to select rice genotypes with efficient nitrogen use. For this goal, an experiment was conducted during 2010 and 2011 wet season (WS) from June to November at the experimental farm of the Bangladesh Rice Research Institute, Regional Station, Rajshahi, Bangladesh. The present investigation was to determine optimum nitrogen requirements of new promising rice genotypes and to investigate the nutrient use efficiency of these genotypes. The experiment set up in strip-plot design with three replications assigning six rice genotypes (BRRI dhan56, BRRI dhan57, IR83377-B-B-93-3, IRRI 123, IR83381-B-B-6-1 and Binadhan-7) to the horizontal plots, while four nitrogen rates (0, 55, 83.5 and 110 kg N ha-1) in the vertical plots. Yield and N use efficiencies (Partial factor productivity of N [PFPN], Agronomic efficiency of N [AEN], Recovery efficiency of N [REN], Physiological efficiency of N [PEN], Internal efficiency of N [IEN] and Nutrient harvest index [NHI]) were determined for all entries. Significant differences ($p \leq 0.001$) among the genotypes were observed for grain yield in both the years. Across N treatments, the highest grain yield (4.43 t ha-1) was obtained by IR83377-B-B-93-3 followed by IRRI 123 (4.37 t ha-1) and the lowest yield (3.47 t ha-1) was observed for BRRI dhan57. Across genotypes but depending on the applied N rate, the highest grain yield (4.74 t ha-1) was observed for 83.5 kg N ha-1 followed by 110 kg N ha-1 (4.41 t ha-1) and usually yield was lowest (2.61 t ha-1) in the control plot. Grain yield generally increased up to 83.5 kg N ha-1 and thereafter declined. Mean grain yield increased by 35, 45 and 41% over the control for the N treatments 55, 83.5 and 110 kg N ha-1, respectively, across both seasons. Interaction of genotypes and nitrogen rates was significant ($p \leq 0.02$) in both seasons. Grain yield of the genotypes IR83377-B-B-93-3, IRRI 123 and Binadhan-7 increased up to 110 kg N ha-1. However, BRRI dhan56, BRRI dhan57 and IR83381-B-B-6-1 produced highest yields at 83.5 kg N ha-1 and then decreased. N uptake in grain and plant, PFPN, IEN and NHIN were significantly varied among the genotypes, but AEN, REN and PEN were statistically similar. N uptake and use efficiencies were highest in IR83377-B-B-93-3, which was at par with IRRI 123 and Binadhan-7. BRRI dhan56 showed intermediate performance while BRRI dhan57 and IR83381-B-B-6-1 showed lower N uptake and N efficiencies. Between 16.5 to 19.2 kg N uptake ha-1 were required to produce one ton paddy. A close relationship between total N uptake in plant and grain yield was observed and increase in grain yield was highly related to N uptake. However, the grain yield and N uptake relationship were significantly different between individual genotypes. NHI of the genotypes was highly significant ($p \leq 0.001$) and related to N uptake and use efficiency. The N efficient genotype IR83381-B-B-93-3 and IRRI 123 produced comparatively higher yields at low and high N rates and performed consistently well with all combinations of parameters, whether fertilized or unfertilized. For example, genotype IR83381-B-B-93-3 ranked first in all cases. BRRI dhan57 and IR87781-B-B-6-1 were found to be inefficient genotypes, giving comparatively lower yields at both low and high N levels. Therefore, the study identified efficient genotypes IR83377-B-B-93-3 and IRRI 123 for yield and yield components, N content and N use efficiency while BRRI dhan56 and Binadhan-7 showed intermediate; and BRRI dhan57 and IR83377-B-B-6-1 was inefficient in drought prone rainfed environment.

Keywords: *Rainfed rice, drought risk, grain yield, N uptake, N use efficiency, varietal diversity.*

P2-540

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Dynamics of Soil Pore-Water Fe^{2}+ and Mn^{2}+ Concentrations in Rice-Faba Bean Crop Rotations

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Farmers are reluctant to grow pulse crops following rice in southern Australia due to poor crop establishment and unfavourable nutrient turnover following irrigation. To understand the reasons for this phenomenon, a mesocosm system was used to study plant growth and the levels of Fe and Mn in the soil. The reduction of Fe and Mn are often strong indicators of redox reactions during nutrient turnover in irrigated rice bays. This research has focused on the reduction of Fe and Mn and persistence of the soluble forms followed over the course of a rice crop, faba bean crop and rice-faba bean transition. Flood irrigation of rice plants was provided at the seedling stage and drained at maturity followed by planting of faba bean in the rice stubble. Soil pore water was collected from four different layers i.e. 2.5 cm, 7.5 cm, 15 cm and 30 cm depth in reconstructed red Sodosol and grey Vertosol soil cores maintained in either flooded or saturated conditions.The soil moisture level in the saturated treatment was maintained at a suction pressure of-3 kilopascal. To collect the soil pore water at -9 kilopascal after draining the flooded water, nitrogen gas was injected into the soil core to pressurize the soil. Mn2+and Fe2+were analyzed using atomic absorption spectrophotometry and the Ferrozine-reagent colorimetric method, respectively. Over the period of one year, the availability of these metals was dynamic and frequently changed over the progression of time. Peak Mn2+concentrations were higher in grey Vertosol (18 mg/L) than red Sodosol (14mg/L), whereas concentrations of Fe2+were greater in red Sodosol (147 mg/L) than the grey Vertosol (124 mg/L). Reduction of manganese increased with soil depth. However, for soluble iron, the maximum reduction was recorded at 7.5 cm depth followed by 15 cm, 2.5cm and 30cm from the top of the soil. Rice plants showed no detrimental effect of the accumulation of Mn2+ and Fe2+. Flooding of soil increased the concentration of maximum level of Mn2+ and Fe2+ compared to saturation. Significant variation was recorded among the soils, with the presence or absence of the rice crop and water treatment. Mn2+ was very low at the beginning of the flooding, peaked at 3-weeks then declined between 40-60 days, followed by a further peak at drainage.Reduction of iron declined at 3 weeks after a sharp increase at the beginning; with further declines at 17weeksand at drainage. During faba bean growth, Mn2+ peaked at 4 weeks and then progressively decreased. Soluble Fe steadily declined from the beginning of the faba bean phase. Concentrations of both remained elevated for longer where faba beans were present. A significant amount of dry matter loss was noticed, along with a delay in flowering, in rice grown under saturated rather than flooded conditions. Faba beans did not emerge when planted after a rice/flooded crop. However, they grew well after rice/saturated and in flooded (no rice) treatments. These results indicated that the inhibition resulted from a combination of rice plants and flooded soil. Inhibition was not likely to be due to levels of Mn, as the threshold level of toxicity of Mn for faba beans, determined by a hydroponic study, was above the levels observed in flooded rice soil. Introduction of oxygen into the system may limit the availability and persistence of Mn2+ and Fe2+ which may also be influenced by the presence of rice and faba bean crops. The changes may also be associated with microbial activities in different layers of soil cores which are altered by anaerobic-aerobic conditions. To explore this possibility, the microbial diversity among these soils is now being studied by next generation sequencing.

Keywords：*Rice-faba bean cropping system, reduction of Fe and Mn, flooded and saturated soil*

P2-541

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Effect of Cadmium on Microorganism Urease Activity in Paddy Soil

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The effect of cadmium on soil microorganism urease (UR) activity was studied under the case of batch cultivation, as Cd2+ (1, 5, 20 or 50 mg/kg) was put into the paddy soil samples from Hunan (HN) and Shanghai (SH) in China. The results showed that the CFU of bacteria, actinomycetes and fungus were 7.6×106 , 1.1×106 and 1.6×104 in HN, while SH were 4.3×106, 1.7×106 and 9.9×105. It indicated the quantity of bacteria and actinomycetes in HN and SH was approximated, while the fungus was much lower. Normalized correlation index showed contribution rates of the three microorganisms for UR activity in HN were 0.43, 0.47 and 0.10, and that in SH were 0.43, 0.33 and 0.24. Cd2+ inhibited the activity of UR generated by the microoganisms. Curve fitting analysis further indicated that the effect of Cd2+ in HN were complete inhibition, while that in SH were complete and incomplete inhibition. The dosages of mild, moderate, and severe pollution of Cd2+ in HN were ≤30.30, 30.30 ~ 64.11 and ≥64.11 mg/Kg, respectively. To sum up, Cd2+ inhibits the activity of UR; Cd2+ completely inhibits the activity of UR for bacteria or actinomycetes, and incompletely for fungus.

Keywords：*Cd2+; microorganism; urease; activity; effect*

P2-542

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Micronutrients Dynamics in Soil And Grain Under Long Term Application of Fertilizer and Manure in a Tropical Rice-Rice System

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Micronutrients are defined as elements which are essential or toxic in small quantities to microorganisms, plants and animal organisms, including humans. They play critical roles in the biological processes of organisms. Micronutrients in foods and environments may affect human and animal health, and monitoring their concentrations is important. Micronutrient additions to arable land mainly come from chemical fertilizers, organic fertilizers such as livestock manure and sewage sludge, irrigation water, and atmospheric deposition. Soil micronutrients are strongly affected by cropping patterns and fertilization practices. Micronutrient availability is determined by soil parent material, organic matter, pH, redox potential, moisture and a host of biologic and anthropogenic factors. Micronutrient balance in soils is important in nutrient use efficiency, environment quality protection, and the sustainability of agro-ecological system. The deficiency or excess of micronutrients, such as Fe, Zn, Mn and Cu, in the plough layer may cause reduction in crop yield and/or quality. Therefore, it is essential to maintain soil micronutrients in appropriate levels, not only satisfying plant needs but also preventing any potential buildup of certain nutrients in order to sustain agricultural production. A long term fertilizer experiment started in 1969 is being carried out at Central Rice Research Institute, Cuttack, Odisha, India (20°25'N,85°55'E; elevation 24 m above mean sea level). In this experiment, a study was conducted to analyze the dynamics of soil and grain micronutrients and their interrelationship. The experiment is comprised of ten nutrient management treatments viz. control, N, NP, NK, NPK, FYM, N+FYM, NP+FYM, NK+FYM, NPK+FYM with three replications. Micronutrients in soil (total and available), added fertilizers and organic manures and in rice plant were measured. Besides, atmospheric deposition of the micronutrients to the experimental site was calculated using dust deposition and its micronutrient contents. A micronutrient balance sheet was prepared by the difference of total micronutrients output and input. The results showed that application of FYM alone or in combination with chemical fertilizer increased the DTPA- Fe, Mn and Zn over the control treatment. The treatments with NPK+FYM had the highest soil DTPA-extractable Cu, Zn, Fe, and Mn after 41 years of cropping and fertilization, thus demonstrating the important role of organic fertilizer application in improving available micronutrient status. Application of chemical fertilizers without P reduced the DTPA-Zn over the control; however inclusion of P in the fertilizer schedule maintained it on par with the control because Zn present in the superphosphate fertilizer offset its loss due to the crop harvest from the plots. Soil total Fe, Mn, Zn and Cu were significantly increased with the application of P fertilizer and FYM either alone or in combination over control mainly due to their micronutrient content and atmospheric deposition. A negative balance for Zn was observed for the N, NP, NK and NPK treatments, while for remaining treatments positive balance was observed. A positive balance for Zn in control plots is due to the low uptake of Zn by the rice crop and atmospheric deposition of Zn. The results of this study suggest that long term application of fertilizers and organic manures altered several important soil properties and increased the plant available micronutrient content of this soil.

Keywords：*Atmospheric deposition; micronutrient balance; micronutrient uptake; farm yard manure; iron; zinc;, manganese; copper*

P2-543

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

The Factors and Processes Relating with the Accumulation of Zn in Rice Grains

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The establishment of the relationship between the concentrations of heavy metals in the edible parts of crops and in soils is crucial for assessing the risks of the metals in agricultural soils. Most of the studies in this regard focus on selecting extratants or extraction methods for determining “phyto-available pool” of the metals in soils, or establishing models attempting to predict the concentration of the metals in the edible parts from the soil. A generally accepted viewpoint is that there always exists a good relationship between the soil pool and the concentration in the edible part. At the same time, the effects of physiological processes of crops on the translocation of heavy metals in the plant were more or less neglected. It is often observed that the concentration of heavy metals in the edible parts was not significantly correlated with ether total or available content of heavy metals in the soil. This phenomenon occurs more frequently for rice than for vegetables, especially leafy vegetables. It seems in doubt if the concentration of heavy metals in the soil is always a good predictor for the metal concentration in edible parts. Therefore, we studied the relationships between Zn concentrations in soils and in root, stem, leaf and grain of rice in order to probe into the factors influencing Zn concentration in the rice grains.

Fifty-two rice samples (root, stem, leaf and grains) and the corresponding surface soils (≤15 cm) were collected from an area near a Pb-Zn mining site in the west of Fujian Province of China. The Zn concentration in the rice samples was determined by FAAS after HNO3-HClO4 digestion. The total soil Zn was measured by FAAS after HNO3-HClO4-HCl-HF digestion. The soil available Zn was extracted with a solution of DTPA (0.005 mol L-1)-CaCl2 (0.01 mol L-1)-TEA (0.1 mol L-1) (pH = 7.3) and determined by FAAS. The total soil Zn ranged from 72.26 mg.kg-1 to 444.2 mg.kg-1 with 46% being higher than the limit for acid (pH≤6.5) agricultural soil (Environmental quality standard for soils of China, GB 15618－1995), indicating serious Zn pollution of the soils. The DTPA-extractable Zn varied between 5.25 mg.kg-1 and 23.59 mg.kg-1, showed significant correlations with Zn concentration in roots (r=0.578**) and in stems (r=0.203*) while had no significant correlation with that in grains, implying that the DTPA-extractable Zn was determinant for Zn uptake by root but less important for Zn concentrations in stems and grains. The Zn concentration in rice grains, varying from 15.35 mg.kg-1 to 33.83 mg.kg-1, had significant correlation with the stem Zn (r=0.313*) whereas it had no significant correlations with the root Zn (r=-0.041) and DTPA-extractable Zn (r=-0.029). This decreasing correlation between the grain Zn and the Zn concentrations in stems, roots, and DTPA-extractable Zn suggested that the Zn concentration in rice grain was mainly controlled by the Zn supply form the stem. The root Zn was less important than the stem Zn in affecting the grain Zn. The DTPA-extractable Zn was no direct effect on Zn accumulation in rice grains. The Zn concentration in grains was significantly correlated with root-to-stem TF (r=0.276*) whereas it was correlated with neither soil-to-root TF nor stem-to-grain TF, suggesting that transfer from root to stem may be the limiting transfer process for Zn accumulation in rice grains.

Conclusions: (1) DTPA-extractable Zn was not a good predictor for the Zn concentration in the grain although it was good at predicting the Zn concentration in the root; (2) The Zn concentration in the grain can be predicted by that in the stem; (3) The transfer from root to stem was more important than the transfer from soil to root or from stem to grain for Zn accumulation in rice grains.

Keywords：*Zinc, soil, rice, pollution*

P2-544

[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Status of Silicon and Cadmium in Paddy Soils of South India and their Effect on Growth, Yield and Uptake by Rice

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An investigation was conducted to know the status of cadmium and silicon in rice soils from different agro-climatic zones of Karnataka,SouthIndia; variation among rice genotypes in cadmium uptake as influenced by silicon application in soil and the effect of silicon and cadmium on growth, yield and uptake in rice and their availability in soil. The study revealed that the DTPA extractable cadmium in paddy soils of the eight agro climatic zones ranged between 0.006 to 0.088 ppm. The soils of southern transition zone recorded the highest cadmium content among the surveyed zones. The available silicon content in soils of different agro climatic zones ranged from 14.7 to 358.9 ppm.

Under the influence of silicon, cadmium effect on growth inhibition, shoot cadmium content, and translocation factor was reduced to the maximum extent in IR-38064 than other genotypes. The cadmium accumulated in the roots of the plants treated with both silicon and cadmium was higher than that in roots of the plants treated with cadmium alone. The translocation factor of cadmium in rice decreased with the application of silicon in soil.

The uptake of cadmium by rice in the pots maintained under field capacity moisture regime was significantly lower than under submergence. The cadmium availability in submergence was observed to be decreased with the increase in pH of the soil brought about by the application of silicon. The availability and uptake of silicon in soil was increased under submergence.

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[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Change of Antioxidant Compounds and Antioxidant Activity of Adzuki Bean by Drainage Methods in Poorly Drained Sloping Paddy Field

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This study investigated the changes of antioxidant compounds and antioxidant activity of adzuki bean (Vigna angularis var. nipponensis) by drainage methods in poorly drained sloping paddy field. Two drainage methods namely open ditch (ODD) and under pipe drainage (UPD) were installed within 1-m position at the lower edge of the upper paddy fields. The moisture, crude protein, crude fat and crude ash contents of ODD were 10.48, 18.41, 0.06 and 3.24 g/100 g, and UPD were 10.48, 10.70, 20.23, 0.32 and 3.10 g/100 g, respectively. The P_2O_5, potassium and calcium contents of ODD were 1.00, 1.43 and 0.31 ㎎/㎏, and UPD were 0.95, 1.41 and 0.32 ㎎/㎏, respectively. The total polyphenol, flavonoid and tannin contents, and radical scavenging activity of the ethanolic extracts of adzuki bean showed significant differences by drainage methods. The total polyphenol, flavonoid, and tannin content of ODD were 3.87, 1.34 and 1.60 ㎎/g, and UPD were 3.52, 1.20 and 1.36 ㎎/g, respectively. The DPPH and ABTS radical scavenging activities of ODD were 404.97 and 615.12 ㎎ TE/100 g, and UPD were 362.67 and 570.69 ㎎ TE/100 g, respectively. The antioxidant compounds and radical scavenging activity of the adzuki bean by drainage methods were frequently affected soil water.

Keywords：*adzuki bean (Vigna angularis var. nipponensis), drainage method, polyphenol, antioxidant activity*

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[WG4] New Approaches in Paddy Soil Management for Food Safety and Environmental Quality

Antioxidant Compounds and Antioxidant Activity of Proso Millet with Drainage Methods in Poorly Drained Sloping Paddy Field

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This study investigated the changes of antioxidant compounds and antioxidant activity of proso millet (Panicum miliaceum L.) by drainage methods in poorly drained sloping paddy field. Two drainage methods namely open ditch (ODD) and under pipe drainage (UPD) were installed within 1-m position at the lower edge of the upper paddy fields. The moisture, crude protein, crude fat and crude ash contents of ODD were 10.84, 4.17, 3.96 and 5.90 g/100 g, and UPD were 10.84, 4.88, 3.96 and 6.12 g/100 g, respectively. The P_2O_5, potassium and calcium contents of ODD were 0.67, 0.30 and 0.18 ㎎/㎏, and UPD were 0.69, 0.32 and 0.18 ㎎/㎏, respectively. The total polyphenol, flavonoid and tannin contents, and radical scavenging activity of the ethanolic extracts of the proso millet showed significant differences by drainage methods. The total polyphenol, flavonoid, and tannin content of ODD were 1,224.16, 352.11 and 226.45 ㎍/g, and UPD were 1,282.45, 372.47 and 254.44 ㎍/g, respectively. The DPPH and ABTS radical scavenging activities of ODD were 30.17 and 63.63 ㎎ TE/100 g, and UPD were 33.51 and 70.85 ㎎ TE/100 g, respectively. The antioxidant compounds and radical scavenging activity of the proso millet by drainage methods were frequently affected soil water.

Keywords：*proso millet (Panicum miliaceum L.), drainage method, polyphenol, radical scavenging activity*

P2-547

[WG6] Urban Soils-Properties, Functions and Evolution

Characterization and Soil Pollution Assessment of Peri-Urban Fadama in South Western Nigeria for Food Security

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This work was carried out in peri urban area around Ibadan metropolis in Nigeria with aim to characterize River Ona floodplain and to determine the effects of urban waste on soil properties in the area. The area was surveyed by grid method and surface samples were taken within the grids at 50m interval. Representative profile pits were dug and described. The samples were analysed for physical and chemical properties including heavy metals. The results shows that the surface soil of the flood plain was fertile with high N (0.35cmol/kg), P (51.25 cmol/kg), K (0.61 cmol/kg) with very high to toxic levels of phosphorous in the soil which range between 28.99 to 87.70 ppm. The surface soil and profile pit shows the evidence of urban waste deposit such as nylon, cloth materials, plastic and iron materials. Hence the result showed presence of heavy metals in high to toxic levels. Average lead concentration was (34.30 mg/kg), Zn (171.20 mg/kg), Fe (83.97 mg/kg), Cu (19.11 mg/kg), Mn (31.10 mg/kg), Cr (0.69 mg/kg), Cd (0.3 mg/kg). The predictions from soil-plant heavy metal transfer coefficient shows that there might be toxic level in crops planted in the area but the high yield and health of plant from field evidence and farmers interaction indicate that the high level to toxic levels of P must have inhibited uptake of some metals such as Pb, Zn and Cu.

Keywords：*Key words: Fadama, Urban waste, Heavy metals, Soil pollution, Peri-urban farming*

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[WG6] Urban Soils-Properties, Functions and Evolution

Soil Characterization and Pollution Assessment of Peri-Urban Fadama in South Western Nigeria for Food Security

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Keywords：*Fadama, Urban waste, Heavy metals, Soil pollution, Peri-urban farming, fibric*

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[WG6] Urban Soils-Properties, Functions and Evolution

Effect of Wastewater Irrigation on Quality of Urban Agricultural Soils in Metropolitan Kano, Nigeria

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This study assessed the quality of urban agricultural soils in metropolitan Kano, Nigeria in terms of ability to grow safe crops using the soil management assessment framework (SMAF) protocol. Two sites irrigated with industrial and domestic wastewaters at Challawa and Jakara, respectively, were sampled for soil and water. The samples were analyzed and compared with a control not associated with wastewater at Watari. The sites were each segmented into up, mid, and downstream. Soil functions that included ease of tillage, salinity, pollution and support for plants growth (SPG) were selected to create a minimum data set (MDS). Indicators for each soil function were selected to include, bulk density; EC; NPK and organic carbon; as indicators of tillage, salinity and SPG respectively. Total, soluble and exchangeable heavy metals were used to assess pollution. Heavy metals in water were determined and correlated with concentration in soils. Results revealed that the soils, including the control site were of marginal quality with score index averaging 4.5. The investigated sites had medium to high values in parameters for which 'more is better' (organic carbon, P, N, K). These were counter balanced by high values for indicators for which 'less is better' (heavy metal pollutants and bulk density). In the control sites however low to medium values for parameters for which 'more is better' were countered by high and low values in parameters for which 'less is better'. Correlation analysis revealed a significant relationship between heavy metals concentrations in soils and water for Pb, Cr, Zn and Cd (r = 0.487, 0.787, 0.405 and 0.556 respectively); while Ni showed non-significant relationship (r = 0.069); whereas Cu showed negative, but non-significant relation with concentration in soil (r = -0.369).

Keywords: *Soil, quality, urban, agriculture, Kano*

P2-550

[WG6] Urban Soils-Properties, Functions and Evolution

Industrially-Contaminated Land: Soil Quality and Environmental Significance

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Our environment is simple as well as complex. It is simple as long as it remains clean. It gets complex when industrial activities grow. The control measures for the abatement of pollution cannot be properly devised unless we are aware of the extent or level of pollution. Such level can be ascertained by precise measurement and analysis of the environmental pollution. This report is designed to serve as environmental (soil) models added to existing database to formulate novel methods for mitigation of pollution. In the process of monitoring pollution hazard at the sites, two simplified sampling procedures used were: lateral and vertical spread. Laterally, assessment on the spread of properties with surface displacements at 0-15, 15-30 and 30-60 cm depth exceeded several meters to cover 20 sampling stations around the gas plant. Additionally, vertically stratified coring approach was adopted at two depths of 0-50 and 50-100 cm on the premise that downward ground movement of effluent continue under gravity loads until a state of minimal potential energy (at 1 meter depth) is achieved. Therefore, the broad objectives of this study was to assess the level of risks (to both the environment and people) resulting from the dragging, construction, pipe-lying, production and transportation of the crude and associated gas from the field in the Niger Delta region of Nigeria.

The field falls within the saline (mangrove) zone of the Niger Delta, which is straddled by the belt of beach-ridges seaward and the freshwater alluvial zone on the inland side of latitude 50 141 E and longitude 60 431N. In addition, a network of rivers/creeks and creek-lets intersects the field, and mangrove swamps/forests abound. The major soil types in the Obieba mangrove swamps consist of soft mud, Chikoko (Peaty Clays) and saline sands. However, soft mud constitutes about 90 % of the Soils. Most of the land is inundated by salt water during high tide. The diurnal average for temperature is 29.60 oC, while maximum and minimum air temperatures were 35.50 oC and 24.00 oC, respectively. The diurnal average for relative humidity was 61.60 %. However, the relative humidity was maximum (84.00 %) and minimum (41.00 %) recorded at 04:00 GMT and 13:00 GMT, respectively. The average wind speed measurement was 2.10 m/s. A high percentage of the wind (45.00 %) was north and northwesterly, and this corresponds to the direction of the sea. The study area is a coastal region known to be affected by land and sea breezes. These breezes are products of local pressure differences resulting from the alternate warming of adjacent land and sea. The cloud measurements indicate a low mean of 3.00 Oktas. This was so because much of the sky was clear during the period of field measurements. However, the months of July and August have the highest mean cloudiness.

The fieldwork plan consisted of soil sampling pattern and sample distribution. A sampling plan involving a combination of judgment and systematic samples was adopted. Six sampling stations were distributed, in a stratified random manner, to cover the area of discharged effluents, the adjoining oil-well sites and the adjacent areas. In addition, considerations were given to all the observed soil morphological types. The sampling stations were coded STR1, STR2, STR3, STR4, STR5 and STR6. Furthermore, another set of twenty sampling stations were distributed to traverse the study area in a Southeasterly direction to reach the South easternmost and South-westerly well-site areas. In all cases, considerations were given to the observed soil morphological types. At each of the sampling stations random spots were augered at three depth levels, viz: 0-15 cm and 15-30 cm, and 30-60 cm with the aid of a 9 cm diameter Dutch auger and bulked together to give a composite sample. Soil samples were physically, chemically and biologically examined, analysed data were interpreted with statistical analysis of computer programme. Although the concentrations of the polycyclic aromatic hydrocarbon in the soils around the gas plant area were low. Generally, the TPH and PAH experienced strong synergistic effect with THC (0.567**, and 0.715** respectively) for increasing contamination. Therefore, TPH and PAH concentrations increased considerably with increasing THC content and vice versa.

Keywords：*Contamination, peaty mud, industrial waste, lateral and vertical sampling*

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[WG6] Urban Soils-Properties, Functions and Evolution

The Capabilities of Mycological Display in Determining the Potential Level of Pollution Landscape of Heavy Metal

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The indicator properties of biological objects are widely used in assessments of the status and monitoring of natural and man-made complexes. Relatively new direction of ecological-geochemical research ways of migration of chemical elements, including trace elements (TE) and heavy metals (HM) was the use of mushrooms ? mycological indication.

The purpose of our work was to determine the level of contamination of the technological elements in the soil of ruins of glass factory in the region of Ryazan (rR) on the watershed of the rivers Oka and Pra in the buffer zone of the Oksky State Nature Biosphere Reserve; and to demonstrate the possibility of mycological indication when determining the level of pollution HM on any territories.

In the course of our research in the summer of 2012 it was important to clarify the question about the level of absorption HM one type of fungus in different habitats and quantitative accumulation of metal-to-metal mushrooms of different species growing near. With this purpose were compared content of HM in russule pink and green (hereinafter mix), boletus green and annulated boletus grain grown on the ruins of the factory. Also compared the levels of accumulation of HM boletus green, who grew up in the birch forest on the territory of the ruins of the factory for the production of mirrors in the Ryazan region and heavily wasty roadside plot in a birch forest, Moscow region (near railway century ≪Platform 52 km≫ Paveletsky line). During fieldwork in one sample United mycofallus of one species of macromycetes with area not exceeding 5 m2. HM is defined in the form of powder of the dried mushrooms roentgen-fluorescent method in the analytical laboratory of Soil Institute of V.V. Dokuchaev.

Our researches have shown that hypsographical level of territory affect the chemical composition of macromycetes. To the greatest extent contaminated HM symbiotrophic of birches, occupy the lowest place in of the factory for the production of mirrors.

Mushrooms absorb quite a lot of zinc and copper, and regularity greater accumulation of metals in the depressions compared with elements of high relief, better observed for zinc than for copper. Maximum accumulation of Zn is observed in biomass of annulated boletus and russule, likely, this element physiologically necessary for build-to-enzyme systems of all types of macromycetes (Quinche J.P.). Beyond the ruins of the factory, where the population gathers mushrooms, maintenance of man-made elements several times exceeds maximum permissible concentration (MPC is taken from the who data for vegetables and fruits, the MPC values for mushrooms yet).

The results show that the use of macromycetes for Express determination of the potential level of accumulation of HM plants technogenically polluted ecosystems. Traced the trend of accumulation in biological objects in the vicinity of the plant strontium, rubidium, and chromium.

Keywords：*the capabities of mycological*

P2-552

[WG6] Urban Soils-Properties, Functions and Evolution

Heavy Metal Contamination Characteristics of Greenbelt Soil and Tree Enrichment in Harbin City, China

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Soil heavy metal contamination (SHMC) in greenbelt functional areas and their enrichment characteristics in seven tree species (Salix matsudana et al.) were evaluated. The results showed that the pollution degree of Zn, Cu, Cd and Pb in Harbin City (HC) is different. Of all 4 heavy metals, Cd contamination is the heaviest and reaches heavy degree. The primary pollution source is refuse containing Zn, Cu, Cd and Pb in industrial areas, automotive emission and tire abrasion. The pollution level decreases in following order: Industrial Park Greenbelt, Urban Road Greenbelt, Greenbelt along Both Sides of Songhua River, City Park Greenbelt, Agricultural Land, Forest and Nursery Greenbelt. As for Zn, Cu and Cd contaminants, the bioconcentration factor of Populus lasiocarpa is higher than that of other main plant species, therefore, it should be selected as an important species to repair heavy metal pollution soil; the other tree species with relatively lower bioconcentration factor, such as Pinus koraiensis, Salix matsudana and Pyrus bretschneideri, can be selected as reserved tree species.

Keywords：*soil heavy metal; contamination; tree enrichment; Harbin city; greenbelt*

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[WG6] Urban Soils-Properties, Functions and Evolution

Sources of Heavy Metal Pollution Risk in Agricultural Soils of a Rapidly Industrialized Area in Yangtze Delta Region of China

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With the quick and continuous progress of industrialization and urbanization in developing country like China, the potential risk of soil heavy metal pollution has caused great concerns due to the threats imposed on human health and the environment. A total of 230 topsoil samples (0-20cm) collected from the agricultural fields of Jiaxing City, a rapidly developing area with quick industrialization and fast urban expansion in Yangtze Delta of China, sequential Gaussian simulation (SGS), and multivariate factorial kriging analysis (FKA) were used to identify the possible areas of soil heavy metal pollution risk for eight metals (Cu, Zn, Pb, Cr, Ni, Cd, Hg, and As), and explore the potential sources of the heavy metals as well as pollution risk. Moderate variations for the eight heavy metals were observed, and the coefficient of variation (CV) varied from 13.6% to 52.4%. The potential pollution risk of heavy metal, defined here as measured metal concentrations which exceed regulatory limits of background values in Chinese Environmental Quality Standard for Soils (GB 15618-1995), was observed for Cu, Zn, Pb, Cr, Ni, and Cd, and was predominately represented as hot spots with very limited areas (0.48%, 0.58%, 2.84%, 2.41%, 0.74%, and 0.68% of the study area, respectively), while the areas with Hg pollution risk covered approximately 38%. No potential As pollution risk was found. The Cr and Ni concentrations are mainly affected by large-scale geochemical factor and point sources of pollution. Although the predominant affecting factors of Cu, Zn, and Cd were similar to those of Cr and Ni due to the strong correlations among the three metals (Cu, Zn, and Cd) at nugget and long-range scales, continuous process at local scale (4km) like diffusion pollution resulting from small factories that intermixed with the agricultural fields also have significant influences on Cu concentrations. And such diffusion pollution arising from current and historic industrial emissions and urbanization, and the soil parent materials jointly determined the current concentrations of Pb. However, the Hg concentrations were mainly attributed to the atmosphere deposition of industrial emission, in particular cement plant and electroplating factory. With respect to As, although the pollution risk in the area is still small due to relatively low concentrations, the widely-spread leather-making factories may lead to potential pollution risk in the future.

Keywords：*Soil heavy metal, Pollution risk, Industrialization, Diffusion pollution, Hotspot*

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[WG6] Urban Soils-Properties, Functions and Evolution

Soil Usage in the Construction of Local Building in Old Kuntunkun Communities in Gwagalada Area Council of the Federal Capital Territory, Abuja Nigeria

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In Nigeria, some of these soils have been identified. They include mainly; the black cotton soils which occur widely in the north-eastern part of Nigeria and the sokoto soft clay shale (attalpulgite) in the north-western Nigeria, Ola (1987). Adesunloye (1987) and geotechnical information on typical tropical soils are important.

Environment changes are crucial to the sustainable development, human resources are also vital to the contribution factors in enhancing the available resources in different localities.

A research was conducted in the various usages of tropical and residual soils in Old Kuntunkun Communities in Gwagalada Area Council of the Federal Capital Territory, Abuja Nigeria. Findings is that soil were being used in the construction of buildings, Agricultural practices, surveying of land .Pictures were taken questionnaires were distributed and administer and analyzed. This paper presented the over all pictures, suggestion were made to the best usage of the soil, for productive purposes, creation of an inventory that would serve as an information database for International Countries and Nigerians This is very important for the safe design, usages and important aspect of soil.

Keywords：*Soil usage , construction Federal Capital Territory , Environment*

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[WG6] Urban Soils-Properties, Functions and Evolution

The Ways of Chernozem's Transformation in the Conditions of Urbopedogenesis in South Russia

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In the conditions of Rostov agglomeration chernozems became the basis for formation of city soils. The soil profile of urban areas can be completely altered by human activity, in which horizons are moved, withdrawn, replaced to imported materials, mainly sand, clay or peat.

Following the transformation process of chernozem in the cities of Southern Russia, there are some possible ways of its changes in urban areas. The most characteristic for urban genesis transformation process is complete or partial (all horizon A) scalping of soil profile of chernozems, followed by its stagnation under man-made layers. In such case we deal with urban soil formed on chernozem, it has special feature urbic horizon UR(U), it's a kind of sinlitogenic diagnostic horizon which is formed because of introduction of various substance on a soil surface in the conditions of settlements, it has various color characteristics and contains no more than 10% of the artifacts distributed in the material of horizon.

One more kind of essential transformations of soil cover of city landscapes is its closing by impenetrable (water-proof) substratum. As a result, the following way of Chernozem transformation is its conservation in the conditions of urban environment, thus soil profile can keep its capacity practically in initial condition quite frequently. In Rostov agglomeration open uncovered areas differ a lot in various parts of the city and also depending on the type of economic usage. As a whole, the same percentage is applicable for anyone large Russian city. Most sealed territories are industrial zone (80-90%). The natural lands and agricultural zone are sealed for 10-20% of the territory. The territory of the residential areas can vary in the degree of sealing up 20 to 75%.

In the city considerable part of open spaces is occupied with lawns, forest parks, parks and gardens, and this vegetative cover, as in any other part of the world, makes its usual work to transform solar energy and accumulate it in the form of a humus in the soil profile. In the conditions of Rostov agglomeration, where there is thick underbrush under the trees and good herbage, we observe a fast development of sod-forming process, here the humus concentration reaches 8,5?9,0%. It's 2-2.5 times higher than the humus content of the top layer of arable Chernozems.

In the city conditions there is a certain domination of wood vegetation, which is not characteristic of steppe zone, and processes of humus formation and storage are proceeding alongside with radical changes of substance circulation in parks and forest parks. The root system of virgin land grass annually dies out completely or partly, and it causes direct receipt root waste in soil layers and gradual decrease of humus with depth. The wood vegetation provides annual receipt of foliage mainly on a soil surface. As a result, the humus profile gains the forest features, i.e. significant humus reduction with depth is noted in comparison with the top horizons. In other words forest-park 'protective' plantings in the city suburbs provide not only creation of wind hazards and city microclimate, but also becomes the dynamic environmental factor, leading to formation of sites with absolutely different redistribution of substance in plants-soil system in the conditions of steppe circulation.

In such a way wood plantings in the steppe zone are the centers of more intensive circulation of substances, rather than steppe communities, and more over, agricultural ecosystems. They provide the intensification of soil formation process, it means more intensive process of a humus accumulation, higher rate of soil profile leaching from carbonates. At the same time shading of soil surfaces reduces physical evaporation of moisture what, in its turn, weakens carbonates migration with rising streams of moisture, consequently the absence of such characteristic feature of chernozems of Ciscaucasia, as a carbonate mycelium. Therefore a special kind of the chernozem is formed under forest vegetation, which is called secondary leaching, caused by human activity to form artificial wood plantings.

Thus, soil forming process in urban condition defines three ways of morphological transformation of Chernozem within the city boundary: stagnation under buried layers, conservation under the hard water-proof surface and intensification under forest vegetation. But we shouldn't exclude one more way it's metamorphosis, influenced by considerable chemical pollution.

Keywords：*urban soil, Chernozem, sealed soils, chemical pollution*

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[WG6] Urban Soils-Properties, Functions and Evolution

Effectiveness of Chelator Washing of Acid-Contaminated Soils and Potential Risk of Edta Leaching to Groundwater

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In South China there are many Pb and Zn co-mines and thus soils contaminated by multi-metals are frequently encountered (Wang et al., 2001). Chemical washing with EDTA is necessary for efficacious remediation of these soils. However, the potential phyto-availability of toxic metals left in soil after soil washing may not be adequately reduced and therefore requires further investigation. The objectives of this research were to: (i) estimate the bioavailability of heavy metals and the feasibility of agriculture production on the washed soil with and without liming, and (iii) evaluate the potential risk of heavy metals to contaminate groundwater based on EDTA adsorption and degradation studies.

The soil samples were collected from the 0-20 cm layer within a plot of a paddy located at the Lechang Lead and Zinc Mining Site in northern Guangdong Province, China. The soil is classified as a Red soil in the group of Udic ferrallisols. The soil was contaminated with Cd, Pb, Zn and Cu. The chelator used in our experiments was a MC comprised of citric acid, EDTA and KCl at a molar ratio of 10:2:3.

The air-dried soil (8 kg) was placed in plastic pots (25 cm i.d. × 21 cm height). Soil washing with MC treatment was applied with a 4 L MC solution at 50 mmol L-1 (= 25 mmol kg-1 of soil, equivalent to about 9 Mg/ha citric acid and 3 Mg/ha EDTA), while 4 L of distilled water was applied to the soil receiving no treatment (control). Chemical washing was conducted for 2 times. Lime was applied to the treatments, “lime” and “washing + lime (W+L)” at the rate of 32 g•pot-1 (0.4%) after the washings. After liming treatments, corn (Zea mays) was planted to assess bioavailability of heavy metals. After planting corn, 2 collections of soil leachates were conducted with the addition of 4 L distilled water to each pot.

Washing solution leachate samples were analyzed for Cd, Pb, Cu and Zn with Atomic Absorption Spectroscopy (Hitachi Z-2700). The method of Nowack et al, (1996) was performed for determining EDTA in soil by high performance liquid chromatography (HPLC).

The results showed that the concentrations of Cd, Pb and Zn in the corn grain with the EDTA washing treatment were still higher than the food standard limits in China. Liming the washed soil did not effectively decrease Cd and Pb concentrations in the corn grain. In fact, liming the washed soil significantly increased heavy metals concentrations in the leachate. This study suggests that the bioavailability of heavy metals could still be high after washing; liming the washed soil may release the adsorbed metal-chelates. This was due to the fact that the newly formed metal-chelates remained in the soil after washing; subsequent liming then promoted the release of these negatively charged metal complexes due to competition for sorption sites with hydroxide.

The adsorption of EDTA onto soil was significantly higher for acid contaminated soils from Guangdong Province (Lechang, Shangba and Guangzhou red soils) when compared with the alkaline soil from North China (Shanxi cinnamon soil). The results of field investigations showed that the EDTA concentrations in the topsoil in the Fougang field was in trace amounts after 120 days , and non-detectable after 1 year of EDTA application, respectively For the Shangba field, the EDTA persisted longer: half of the original EDTA application amount detected in the topsoil after 45 days. After 1 year, only a trace amount of EDTA was found in both the topsoil and subsoil. These results suggest that the risk of high residual EDTA persistence in the field environment is negligible. The results of degradation incubation experiments showed that the EDTA half-lives in Guangzhou, Shanxi and Shangba soils was 71 days, 25 days and 53 days, respectively. Based on high EDTA adsorption and rapid EDTA degradation on the contaminated soils studied, the potential risk of EDTA leaching to groundwater appears to be low.

Keywords：*Chemical washing, EDTA, Udic ferrallisols, multi-metals, bioavailability, leaching risk*

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[WG6] Urban Soils-Properties, Functions and Evolution

Principles of Creating a Soil Map of Urban Areas (by The Example Of St. Petersburg) Ye.yu. Sukhacheva (1); B.F. Aparin (2) (1) state Scientific Institution Central Museum of Soil Science Named after V

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Knowledge of laws of formation of soil in natural landscapes and farmland is the basis of generation of soil maps. However, their use in creating soil maps of cities is inapplicable.

Soil cover of urban areas is fundamentally different from that of natural landscapes in terms of composition and its structural organization. In order to create a soil map of urban areas, it is necessary to introduce the concept of soil space. The urban soil space includes areas with a continuous soil cover as well as the territories with a discrete distribution of soil due to human factors - a combination of soil areas and non-soil formations in various proportions (urban pedocombinations).

Soil space is characterized by fractional area pattern and clear geometric structure of the separations. The composition of such territories is dominated by a variety of introduced soils, which are artificially created from borrowed materials of natural soils. Genetic link between such soil components is missing. The space limited by the pattern of streets and avenues has formed geometrically defined surface type under the influence of direct or indirect human impacts.

In the course of creation of a soil map of the City of St. Petersburg, areas where there is practically no soil were primarily identified using aerial photographs. Such separations on the map are surfaces that are under construction, asphalt or other non-soil formations. Mostly, they are located under shopping centers with adjoining asphalt territory and under industrial areas; more rarely, they lie under “old town” boroughs.

Then, 6 types of soil space structure were identified on the basis of analysis of the percentage of the zones of soil areas and non-soil formations, as well as the geometry of soil contours and characteristics of their distribution.

Dispersive Type

Soil areals are small (areas of 300–500 m2) and are generally square or rectangular in shape, enclosed and isolated from each other, and are punctual in character. The soil areas are located in the midst of non-soil formations and occupy from 5 % to 20 % of the area. The soil cover is dominated by introduced soil formed on the basis of anthropogenic layered deposits.

Fragmentary type

Soil areals of various geometries (rectangular, elongated, rounded, irregularly shaped) and sizes (300-500 m2 to 1,000 m2) are located in fragments without any patterns in the midst of non-soil formations. Typically, the soil contour here is represented by an elementary soil area.

Background type

Soil areals occupy more than 50 % of the surface. Non-soil formations are distributed in a dispersed or fragmented manner. Soil map outlines can be represented both by a single soil variation and by soil combinations. The component composition is diverse: from introduced soils to humic-influenced soils and natural soils.

Linear type

Soil areals of a narrow, elongated shape (width of 20–50 m and length of up to several kilometers) are interspersed with areals of non-soil formations.

The following map outlines can be identified in the urban area:

- areals of introduced soils combined with non-soil formations; separations are typical for streets with vegetation.
- areals of introduced soils interspersed with non-soil formations and regosols areas; separations are characteristic for areas along railway lines.

Monocontour type. Separation on the soil map is represented by a single soil.

Continual type. Soil cover of areas with natural vegetation, parks, forest parks, and farmland with preserved genetic links between the components. The component composition is dominated by natural or humic-influenced soils.

The legend of the soil map of St. Petersburg contains more than 60 soil separations. The following characteristics were taken into account in the course of map generation: soil space organization type; composition of the soil cover; nature of the spatial distribution of soil areals and non-soil formations.

The soil map is implemented in the scale of 1:50,000 using MicroStation V8i software.

Keywords：*Urban soils, soil map, principle soil mapping, soil map of St.-Petersburg*

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[WG6] Urban Soils-Properties, Functions and Evolution

Decomposition in Soil - Evaluation of Cemetery Soils

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Interment is a very common burial practice all over the world. According to surveys in Germany, 30-40 % of the cemeteries are concerned with insufficient decomposition and the formation of adipocire, forcing the operators to extend the resting times or even shutting down cemeteries.

In order to investigate the specific soil conditions leading to insufficient decomposition, 20 cemetries in Germany were mapped with respect to soil type, texture and occurrence of stagnic or Gleyic conditions. Additionally, undisturbed soil samples were taken from graves in order to investigate soil physical properties above and below the coffin.

Each cemetery was rated in terms of decomposition and filtration efficiency. The decomposition efficiency was evaluated by the air capacity, the soil type and the pH-Value. From the decomposition efficiency, recommended resting times were derived. The filtration efficiency was assessed by air capacity, CECpot, pH-value, water impact and detention period of the seepage water in the unsaturated zone. For melioration of the decomposition efficiency, drainage, reduced irrigation, shallower burial and the omission of double burials in one grave are recommended.

The decomposition efficiency was rated low in 67 %, medium in 18 % and high in 15 % of the surveyed soil units. The filtration efficiency was rated very low in 51 % of the soil units.

The probed cemetery soils were often deeply humous, and contained on average 2.11 % humus above the coffins (20-90 cm depth) and 1.09 % humus in the coffin layers (90 cm – burial depth). The humus accumulation is mainly caused by the mixing of humous surface soil and potting soil with the subsoil, and is therefore often more pronounced in the upper 90 cm than in the coffin layer.

Soil physical analysis of undisturbed samples from earth graves revealed, that the gas transport efficiency of the air filled porosity does not necessary decline because of soil refilling and the accompanying soil structure disruption. In all studied mineral soil profiles air capacity and air permeability was higher above the coffin than below the coffin or in the grave walls. The soil above the coffins also revealed higher sautrated hydraulic conductivities than the surrounding soil. This promotes water pounding in the grave. Therefore the gas exchange is blocked rather by water filled pores than by a general decrease in soil structural functionality. The lack of oxygen, occuring from the water saturation, was also documented in continuously measured matric and redox potentials in earth graves.

Keywords：*Cemetery soils, decomposition efficiency, soil areation*

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Pedogenesis on a Former Settling Pond of Iron Industry

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In densely populated areas, humanity has become a major soil-forming factor, by generating technogenic parental materials and by modifying pedogenesis conditions. The group of Technosols, introduced in World Reference Base of Soil Resources in 2006, accomodates soils containing a significant amount of artefacts (made or extracted from earth by humans) or sealed by technic hard rock. As natural bedrocks, technogenic materials evolve under the influence of environmental factors (climate, organisms). However, the nature, localization, and extent of the pedogenetic processes occurring in Technosols are still little known. Knowledge on pedogenesis of Technosols would be useful to better predict evolution of these soils and of the potentially contaminated materials they contained.

From the thorough characterization of a Technosol developing on iron industry deposits under forest cover in temperate region [1, 2, 3], some pedogenetic particularities of Technosols can be discussed.

Despite technogenic origin of parental materials, observed pedogenetic processes seemed to be similar to processes occurring in natural soils. However, the strong diversity and spatial heterogeneity of materials and the original mixture of their constituents related to their technogenic origin made possible the simultaneity of processes coexisting rarely in natural soils (e.g. andosolization, carbonatation) as well as the existence of processes occurring usually in other pedoclimatic regions (e.g. sulfate migration) and with different temporalities. Therefore, it seemed possible that a Technosol displayed properties of well-developed soils (e.g. andic properties) in spite of a relative short pedogenesis period. These properties could have developed during the production of technogenic materials under the influence of anthropic processes and conditions (e.g. high temperature and humidity) and/or could result from intense and rapid weathering during early pedogenesis of Technosol.

Concerning evolution of Technosols, it can be assumed that technogenic materials will alter more or less rapidly according to the nature of artefacts and pedogenetic processes and that the influence of their technogenic origin will be reduced with time. Hence, Technosols will evolve progressively towards other soil groups, depending on the combination of pedogenetic processes occurring in the soil and their potential interactions. Owing to the possible influence of human activities during soil formation (addition of new materials, mixing), Technosols are likely to have complex pedogenesis in several steps. Addition of new technogenic materials can rejuvenate soil and maintain it to the stage of Technosol. In contrast, burying by material additions or sealing can slow even stop soil development.

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Keywords：*pedogenesis - Technosol - settling pond of iron industry*

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[WG6] Urban Soils-Properties, Functions and Evolution

Treatment of Acidic Mine Soils: Effects on Heavy Metal Dynamics and Growth of Corymbia Citriodora Var.variegata Seedlings

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Establishment of vegetative cover is crucial to mine land rehabilitation. However, sulfidic mine soils usually have low pH and frequently contain high baseline concentrations of heavy metals. The operationally defined labile fractions of heavy metals are also high in these soils due to the acidic conditions. These poor soil conditions inhibit natural colonization of plants. Therefore, establishment of artificial vegetation following soil amendment is usually needed for mine site re-vegetation.

Research into heavy metal dynamics in soil-plant system could provide fundamental knowledge that is required for development of cost-effective techniques for mine land re-vegetation. There has been a diverse range of research on heavy metals in mine-related soil-plant systems, with a focus on heavy metal-tolerant and heavy metal-hyperaccumulating plants although the feasibility of using heavy metal-hyperaccumulators for the clean-up of mine sites is questionable.

Mine site rehabilitation frequently involves substantial capital inputs, which could be economically prohibitive in many developing countries. The uses of economic plants for reclamation of disturbed/abandoned mine lands are more desirable given that the economic returns from the agricultural or forestry production can partly offset the costs associated with the rehabilitation of decommissioned mine sites. Fast-growing plant species are among the plants of significantly economic value. They can be used for paper pulp and energy production. Given that plant seedlings are more sensitive to environmental stresses, compared to mature trees, seedling establishment is a key step for re-vegetation in acidic mine sites. The objective of this study was to understand the status of several common heavy metals in the soil-plant system under various amendment conditions, with the seedlings of a selected plant species, Corymbia citriodora var.variegata being used as a test plant.

A pot growth experiment was conducted to investigate the status of Cu, Zn, Pb and Cd in the soil-plant system under various soil amendment conditions. Two mine soils of different acidity were used as test soils and corymbia citriodora var.variegata was chosen as a test plant.

The results show that treatments of the acidic mine soils with acid-neutralizing agents caused marked pH elevation and the associated decreases in the concentrations of soluble and exchangeable heavy metals. However, there was a trend that soil pH in the acid-neutralized soils decreased over time, reflecting continual consumption of the added OH-1 by the stored acidity in the soils. This temporal variation in pH led to gradual increase in soluble metal concentration over time. Overall, acid neutralization caused

reduction in the concentration of soluble and exchangeable heavy metals while there was a tendency that concentrations of less labile forms of heavy metals increased accordingly. However, heavy metal uptake by the plants grown in the non acid-neutralized soil was weaker than in its acid-neutralized counterpart. This suggests that the chemically labile forms of a metal are not necessarily more phytoavailable. The bioavailabilty of a heavy metal is also dependent on the ability of a plant to extract that metal from the soils. The observed weaker activities of soil urease and acid phosphatase in the non acid-neutralized soils, compared to their acid-neutralized counterparts suggests that inhibited soil microbial activities induced by the same environmental stresses may also play an important role in affecting plant growth. It was also found that the rate of metal translocation from the soil to the plant for the investigated heavy metals was in the following decreasing order: Cd >Zn >Cu >Pb.

The results obtained from this study have implications for remediation of acidic mine soils. Amendment of the acidic mine soils with lime and red mud can rapidly raise soil pH and reduce soluble and exchangeable pools of heavy metals and therefore assist in relieving environmental stresses that the plants experience. However, as the interactions between the added acid-neutralizing agents and the retained acidity stored in the soils continue, soil pH may decrease, leading to release of the previously-immobilized metals. To prevent the re-acidification of the neutralized soils from occurring before the plants become more tolerant to acidity and heavy metal stresses, sufficient amounts of acid-neutralizing agents need to be added. For highly acidic mine soils, it may be necessary to consider a multiple-step strategy for the application of the acid-neutralizing agents during the period when the plants are still sensitive to environmental stresses.

Keywords：*Heavy metal, Corymbia citriodora, Mine soil, Revegetation, Pot experiment*

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[WG6] Urban Soils-Properties, Functions and Evolution

Evaluation of Hydraulic Properties of Urban Technosoils Built with Recycled Waste

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Introduction

Cities are continuously spreading. The market demand for urban soils adapted for green spaces such as trees, green lanes or gardens is continuously increasing in order to improve rainwater retention, to mitigate urban heat island effect and to foster biodiversity. City practitioners are usually building urban soils from agricultural soil stripping and from aggregate quarries. These two materials are non- renewable and these resources should decrease in the future. Furthermore, the transportation of these materials has a non negligible cost and footprints. On the other hand, waste construction materials such as concrete are available near cities. This waste material, added with compost, could be reused as an urban soil adapted for greening.

SITERRE project was launched to check the possible compositions of urban technosoils by studying available waste material, and their agronomic properties, bearing properties, environmental impact and time evolution of properties. SITERRE project should also provide necessary methodology and tools to green space practitioners to configure their adequate urban soil.

The aim of this study is to estimate and check time evolution of hydraulic properties of different configurations of urban soils studied in the SITERRE project.

Material and methods

Two cylinders of 1.8 m height and with a surface area of 1 m² were used as lysimeter devices (L1 and L2) at the GISFI experimental station in Homecourt (France). Lysimeters were filled with two mixtures of waste materials. For lysimeter L1, at the down layer, a 1 m thick layer of mixture of ballast and paper mill sludge (Ba/Sp) was placed. The upper layer consists of a 0.8 m thick layer of mixture of brick and green compost (Br/Co). For the second lysimeter L2, a 1 m thick layer at the down was placed with a mixture of acid soil, concrete and green waste (Ta/Be/Dv). At the upper layer, a cylinder of 0.8 m height and 0.2 m of radius was filled with a mixture of Br/Co. Then a ring of mixture of Ta/Be/Dv was used to fill the lysimeter.

Each Lysimeter is placed on monitored weight balance system. Rainfall infiltrates in each lysimeter and drains to outlet through a drainage layer. The water outflow on each lysimeter is discharging in a tipping bucket mechanism. All data were recorded with hourly time step.

The modeling of water flow in the vadose zone is usually based on the generalized Richards equation, which combines the Darcy-Buckingham Law with mass conservation. The numerical solution to Richards equation requires knowledge of both boundary and initial conditions along with the two hydraulic characteristic curves, e.g. the water retention curve $h(\theta)$ and the hydraulic conductivity curve $K(\theta)$.

Water retention curves and hydraulic conductivity functions were described using the van Genuchten -Mualem model. Pedotransfer function, numerical inversion of multi-tension disk infiltration data and wind evaporation method in laboratory are used to estimate hydrodynamic parameters. Parameters estimated with the different methods are then used to simulate water flow in each lysimeter using Hydrus 3D software. Numerical data such as simulated outflow are compared with experimental data and discussed.

Keywords：*Technosoils, Hydraulic properties, numerical inversion, cumulated infiltration, wind evaporation, waste management*

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Organic and Synthetic Soil Amendments Influence Soil Quality and Growth of Tropical Urban Trees

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Soils in urban areas suffer from a range of physical, chemical, and biological limitations. Therefore proper application of appropriate soil amendments (inorganic, organic or mixtures) may help limit many of the exposure pathways for pollutants and thus reduce soil phytotoxicity. However, the type of soil conditioner added depends on the soil composition, climate, and the type of plants to be grown. An effective soil conditioner, consisting of mixture of components assists the plant growth processes in a synergistic way, more effectively than any single polymer or fertilizer product, by significantly increasing the water and nutrient holding capacity of soil and reducing the amount of inputs necessary to maintain plants in optimal conditions. A small number of studies have compared use of organic and synthetic soil fertility amendments for growing trees in tropical urban environments.

A factorial trial was undertaken in an open environment for six months to evaluate the short-term effect of organic and synthetic polymers on soil quality as indicated by a selected range of indicators (aggregate stability, C, N, P, K, Ca, Mg) and growth of two common urban tree species (Calophyllum soulattri and Syzygium myrtifolium). The amendments were mixed with two different soil types (loamy soil and sand) in different proportions and the tree species were planted with the following treatment combinations: without amendment (control, T1), soil + compost (1:3, T2), synthetic polymer @ 3 kg m-3 (T3) and synthetic polymer @ 5 kg m-3 (T4). The treatments were laid out in a randomized block design and were replicated five times. The experimental soils were characterized with pH 5.8 and 6.3, bulk density 1.4 and 1.8 g cm-3 and organic matter content of 0.63 and 0.18% for loamy soil and sand respectively.

There were significant increases in soil extractable P, K and organic matter content after addition of the amendments compared to control for both the soil types. However, soil properties did not differ significantly across the plant species. Loamy soil amended with synthetic polymer @ 5 kg m-3 (T4) recorded the highest extractable P content and were increased by 131 and 423% over control across Calophyllum and Syzygium respectively. Whereas sand recorded the highest extractable P content when mixed with compost (T2) and observed to increase its content by 137 and 246% across Calophyllum and Syzygium respectively. Application of both organic and inorganic inputs also proved beneficial in increasing extractable K content significantly. The extractable K content of loamy soil and sand varied significantly between 27 to 60 mg kg-1 and 10 to 24 mg kg-1, respectively. There was a significant increase in soil organic matter content with addition of organic and inorganic amendments. Results also suggest that plant growth parameters such as root and shoot dry weight and plant girth diameter were significantly enhanced after addition of organic and inorganic amendments for both plant species. The highest root dry weight of Calophyllum was recorded under T3 and T4, whereas the highest root dry weight of Syzygium was recorded under T3 and T2. Plant heights were also significantly increased after addition of organic and inorganic amendments as compared to control and inorganic amendments have shown its superiority over the organic treatment.

Differences in soil properties were more related to amendment type than to their production history. The commercial synthetic polymer used, is a proprietary mixture of more than twenty components from six different groups which assist the plant growth processes in a synergetic way in the initial growth phase of the plant. They activate root cell elongation and differentiation, and biomass production. In addition, roots are encouraged to grow more rapidly to depths where more water is present. The soluble mineral fertilizers absorbed by the hydrogels, feature a classic NPK mixture used as a starter component for the initial growth phase of the plants. The slow release fertilizers offer a constant flow of nutrients and play an important role in soil fertilization for many months. Besides increasing the organic matter content, compost also help to stimulate microbial activity in the soil and thereby contribute to overall soil conditioning. Synthetic polymers can be recommended as alternative soil amendments for growing trees in tropical environment, especially in areas, where water and labour are factors.

Keywords：*Urban soil, Compost, Synthetic polymer, Urban tree*

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Distribution of Organic Carbon on the Roadside Soils of a Tropical Urban City

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The percentage of the global population living in urban areas is increasing drastically. In 2010, 51% of global population lived in urban areas, projected to rise to 71% by 2050. The most rapidly changing and densely populated cities are located in the tropics. Urbanization will increase environmental pressures and impacts on soils. Soils of urban areas represent a wide spectrum in terms of composition and degree of development. Consequently, urban soil, a crucial component of global soil, is playing an increasingly important role in the global carbon cycle. However, very little data are available to assess whether urbanization leads to an increase or decrease in soil organic carbon (SOC) contents. This paucity of data makes it difficult to predict or assess the regional effects of land-use change in urban cities on SOC content in various parts of the world. Most soils research has concentrated on soils of rural sector and many of the processes in these soils are understood. On the other hand, comprehensive soil data relating to the changes in its properties with time are scant in tropical cities. Therefore a study was conducted at the tropical city of Singapore with a view to assess the distribution and variability of SOC of the roadside soils, so that efficient soil management programmes could be implemented to strengthen C sink in urban soils.

In this study, Singapore city-state was divided into five administrative regions according to Urban Redevelopment Authority (URA) Master Plan 2008: North, North-East, East, Central and West. For each region, four major roads were selected randomly for sampling. Each road was divided into three locations, each location was again sub-divided into three sub-locations and the soil samples were collected from both sides of the road in a quadrate from each point. These sampling points were defined at ~200 m intervals along the entire accessible length of the street. At each point, composite samples were collected from 0-100 cm depth, with subsequent division of three such as 0-30 cm, 30-50 cm and 50-100 cm. GPS reference points were also recorded for each sampling point for future sampling.

Results showed a significant negative correlation existed between the SOC content and the depth of soil profiles. The mean SOC content (0-100 cm) was 21.4 g kg 1 across the streetscape soil and there was a significantly higher concentration of organic carbon (10.3 g kg 1) stored in the top 0-30 cm soil depth compared to the deeper (30-50 cm, and 50-100 cm) soil depths. The results also indicated significant variations of its content regionally. The North-East region had a significantly higher amount (10.5 g kg 1) of SOC compared with other regions (0-100 cm). Depth distribution of SOC showed significantly higher variations for North region, which had a significantly higher (10.8 g kg 1) SOC at the top soil layer followed by 8.2 g kg 1 and 7.0 g kg 1 at 50-100 and 30-50 cm soil depths respectively. Considering the bulk density of the soils studied, North-East region showed overall (0-100 cm) significantly higher C density (422 Mg ha-1) followed by East (390 Mg ha-1), Central (382 Mg ha-1), North (337 Mg ha-1) and West region (306 Mg ha-1) respectively.

As with rural soils, urban soils are likely to be subjected to more extreme variations in climate over the coming decades. The overall C storage in urban landscapes depends on urban soils due to relatively high belowground to aboveground C ratios and high SOC densities. Similar studies also showed comparable SOC content in the highly traffic districts of the global cities. Soil mixing during construction of urban landscapes can result in burying of topsoil rich in organic matter, and translocation of organic compounds from natural but also anthropogenic origin to deeper soil layers. In urban condition, trees along the streets are planted by using different soil-based media which significantly affect soil SOC content and bulk density along the roads. More detailed study is required including other land uses to better understand the SOC pools, their spatial distribution and annual C flux in order to increase the potential of urban soils to sequester and store more C.

Keywords：*Urban soil, Soil organic carbon, Tropical city, Soil depth*

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Use Of Metal Contaminated And Edta Washed Garden Soil In Field Experiment

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The consequences of living with harmful and potentially toxic metals (PTMs) in our living environment are not easy to comprehend, because they take a longer time span to manifest themselves. Recently urban allotment gardens are offered by local governments encouraging low income senior citizens to produce their own food yet many cities have inherited a long industrial history and an associated legacy of urban soil contamination. For example, 52% of crop samples from the Berlin (Germany) inner city vegetable gardens exceeded EU standards for Pb concentration in food crops. Efficient soil remediaton technologies are urgently needed. There is an extensive body of literature on ethylenediaminetetraacetate (EDTA) or other chemical soil washing of PTMs; however these remediation techniques all too often concentrate only on metal removal efficiency or recently also on residual metal bioavailability and overlook treated soil's overall health, functioning and potential use after remediation. Examples of efficient remediation technologies, scale-ups and studies on using such remediated soil as a plant substrate in field conditions are also scarce.

We demonstrated in a pilot-scale experiment, the feasibility of EDTA-based washing technology for soils contaminated with potentially toxic metals. Acid precipitation coupled to initial alkaline toxic metal removal and an electrochemical advanced oxidation process were used for average recovery of >75% of EDTA per batch and total recycle of water in a closed process loop. No waste-water was generated, solid wastes were efficiently bitumen-stabilized before disposal. We applied multi-level approach to access the quality, toxicity and functioning of Pb, Zn and Cd contaminated / remediated soil from vegetable garden in Meza Valley, Slovenia. Contaminated / remediated soil was placed into experimental plots equipped with lyzimeters. Soil properties were assessed by standard pedological analysis, fractionation and leachability of toxic metals by sequential extraction and TCLP and metal bioaccessibility by UBM tests. Soil respiration and enzyme activities were measured as indicators of soil functioning. Remediation reduced the metal burden for 80, 28 and 72% for Pb, Zn and Cd respectively with limited impact on soil pedology. Toxic metals associated with labile soil fractions were largely removed. No shifts between labile and residual fractions, during seven months of experiment were observed. Initial metal leaching measured through lyzimeters eventually sized entirely. However, remediation significantly diminished potential soil enzyme activity and no trends were observed for remediated soil to recover its biological properties. Furthermore we studied plant performance on contaminated / remediated soil, and safety of crops produced. Selected cultivars were rotated within 16 months. Pb, Zn, Cd and micronutrient plant uptake was measured by AAS and their phytoaccessibility by DTPA method. Plant fitness was assessed by chlorophyll fluorescence and gas exchange measurements and evaluation of root colonization with mycorrhizal fungi. Remediation reduced Pb and Cd concentrations in roots, green parts and fruits in most of the plants. Phytoaccumulation of Zn was reduced in approximately one half of the cultivars. Soil Mn was diminished for 4 times, phytoaccessibiliy of micronutrients Cu, Fe and Mn for 54, 26 and 79%, respectively and plant yield for up to 10-times (Spinacia oleracea). Photosynthetic parameters of plants grown on original and remediated soil were similar except for reduction in Spinacia olearecea. Frequency of mycorrhizal colonization in roots of Pisum sativum was reduced five times, no significant changes were found in Allium cepa roots.

Soil washing successfully removed labile forms of Pb, Zn and Cd and thus lowered the human and environmental hazard of remediated soil; however remediation also extracted the trace elements essential for soil biota. Conjointly with lowered water potential soil health was not completely restored. Remediation reduced plant uptake of Pb bellow concentration stipulated by legislation. Measures to reduce plant accumulation of other toxic metals and to revitalize remediated soil are needed.

Keywords: *Remediated urban soil, soil health, metal plant uptake, plant fitness*

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Contribution of Bricks to Urban Soil Properties

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Bricks have been used as construction material since 5000 years and are regularly found in urban soils where they can be used for dating and indicator for a anthropogenic impact on the soil. Bricks can also strongly impact the soil properties.

The purpose of this study is to investigate abundance, especially in the fine earth fraction, and properties of bricks in urban soils, focusing on rooting, plant nutrition and contamination.

Three different urban soils from the city of Berlin have been studied for their brick contents in the coarse and fine earth fractions by hand sorting. Light (LM) and scanning electron microscopy (SEM) were employed to investigate bricks for proofs of rooting. Third,

CEC, pH, EC, Corg, nutrient and contaminant storage and availability have been investigated for bricks and the fine earth fractions of the corresponding soil horizons.

The fine earth fractions of the investigated soils contain 3 to 5 % of bricks, while the coarse

fractions contain up to 50 %. The LM and SEM micrographs made the proof that roots enter brick pores or attach to brick surfaces. Therefore, they can use the water and nutrients stored in bricks and bypass pore system discontinuities between bricks and surrounding soil. The CEC of bricks is grain size dependent and reaches a maximum of

6 cmolc kg−1 for particles smaller than 0.063 mm. This dependency is the result of the restricted diffusion into the brick pore system due to the short shaking time in the CEC

analysis protocol and of the rising surface with decreasing particle size. From the nutrient storage and availability, we conclude that bricks can better supply plants with K, Mg, Ca

and S than the investigated sandy bulk soil.

The nutrient availability from bricks is low compared to control soils, except for Ca and S. Because of the water and nutrient storage, low contamination status and the possible rooting of bricks, they can be used for amelioration of poor sandy soils and for constructed Technosols, preferably employed in small grain sizes.

Keywords：*urbic technosol, bricks, water availability, indicator, rubble*

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[WG6] Urban Soils-Properties, Functions and Evolution

Heavy Metal Investigations in the Urban Soils of a Hungarian City

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In the course of our investigation we have analysed the physical, chemical parameters and heavy metal contents of urban soil in Sopron town in Hungary. Our aim was to identify the main feedback effects between the town and its environment. We collected 208 samples on 104 points from 0 to 10 and from 10 to 20 cm depth in a standard network and we have been represented our results in a GIS system, which could give a useful basis for our soil investigation. In the laboratory we have been focused on the following properties and components: acidity (pH(H2O), pH(KCl)), calcium-carbonate content, particle size distribution, humus content, total nitrogen content, ammonium-lactat-acetous acid (AL) solvent potassium and phosphorus content, KCl solvent magnesium and calcium content, the strength of ethylene-diamin-tetra-acetous (EDTA) or diethylene-triamin-penta-acetous (DTPA) measurements of manganese, copper, zinc and iron element and the heavy metal content of 24 elements especially Co, Cd, Cu, Pb and Zn. Using the data we observed the relationship between these elements in both layers. The acidity and calcic soils are determined fundamentally by the parent material, but in the downtown the acidity of soils were alkaline (by the greatest number of point). The cause of this is the calcareous deposited debris. In most cases there was a high value of organic substance in the downtown area, partly due to frequent grass fertilisation and soil spreading. The particle size distribution of soils showed various appearances, but there was not possible to discover the tendencies. In the city the highest iron (over 1000 mg Fe/kg) and manganese contents of the soils were found in the forest areas. Downtown sites can be characterized as having high levels of extractable zinc. The lead was very high (>100 mg Pb/kg) in both layers on the whole area of the town. Urban soils with high copper content have been collected from garden and viticulture areas by us. Cadmium contents were the highest in traffic zones, where these values could be more than 3 mg Cd/kg according to the literature. The cobalt and zinc results were under the limits. According to our measurements we founded the highest average values in the soils of parks. This could be contamination of the lead from traffic, which bind in the soil of urban green spaces.
Now we could continue our examinations with the investigations of these polluted green areas, which can effect to human health.

Keywords：*polluted urban soils, green areas, heavy metal content, GIS methods*

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[WG6] Urban Soils-Properties, Functions and Evolution

Influence of Asphalt Pavement on Major Element Forms in Subgrade Soils

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Road area in Japan occupies about 7500 ㎢ equivalent to approximately 2% of Japanese land area and now it is still enlarging. In particular road cover in the Tokyo region is high reaching to 183 ㎢ corresponding to approximately 8% of the total land area of Tokyo. Road area also spontaneously expands in world cities due to urbanization and increase in population. The conversion of land use by urbanization probably affects material cycling in that ecosystem. Materials consisting of road construction probably influence soil beneath the asphalt pavement, which is Ekranic Technosols (WRB). In our previous study, we determined vertical distribution of major elements and physico-chemical properties of soils in the subgrade horizons, crushed-stones in subbase horizons and asphalt layers depending on road constructed years. Soils beneath asphalt pavement were characterized by a specific elemental composition mainly occupied by Fe, Al, Ca and Si. Additives in blacktop layer can be mixed with soils in subgrade, resulting in alkaline soils with high value of pH. In this study, composition of major oxides and carbonate in alkaline subgrade soils were addressed to reveal specific soil formation process in urban road construction.

Blacktop, crushed-stones and soils in the subgrades in an asphalt construction were collected taking account of road constructed age. Soils were sieved with 2mm mesh. Stones consisting of subbase horizons and in the blacktop were crushed for further analyses. The selective dissolution method using oxalate solution (amorphous fraction) and citrate-bicarbonate solution with ditionite (crystalized oxides) were used for determination of composition of amorphous and crystalized oxides. Carbonate was determined from consumption of acid to decompose carbonate in solid samples.

Content of extractable iron and aluminum increased with depth at newly constructed pavement. Amorphous Fe and Al (Fe_o and Al_o) in subgrade soils covered with new asphalt pavement were remarkably lower than those of unpaved soils. Amount of Fe_o and Al_o in unpaved soils indicated the andic property in the WRB soil classification. The indicator of subgrade soils beneath the new asphalt construction barely filled the criterion of the andic property. The subgrade soils covered with old asphalt construction passed the standard value of the andic property. Amounts of other oxides were also lower in soils and materials beneath the new pavement than those of the old asphalt construction and natural soils. Crushed-stones and the blacktop of new asphalt pavement contained extremely high content of calcium carbonate despite of its only slight detection in the natural soils. Concentrations of calcium carbonate in subgrade soils beneath asphalt pavement were higher than that of the unpaved soil. Soils beneath old pavement contained the highest content of calcium carbonate in the deeper horizon. The amount of calcium carbonate indicates the presence of inorganic carbon caused by asphalt paving even in acidic soils in Japan.

Soils affected by asphalt construction, that is subgrade soils, showed great difference in the soil property as compared to adjacent natural soils, indicating that contamination of materials in the asphalt construction changed the subgrade soils into the carbonate containing alkaline soils from usual acidic Japanese soils. Origin of the carbonate is still unclear. The origin of inorganic carbon in the subgrade soils is important to reveal C dynamics in soils covered with asphalt. The characteristic composition of oxides in asphalt affected soils indicates large change in soil property and specific soil formation processes in the soils. Knowledge about elemental dynamics in soils beneath asphalt pavement is necessary to understand how asphalt paving strongly affects underlain soils, how the material cycling changes therein, and how asphalt construction influence the surrounding environment through river systems.

Keywords：*urbanization, urban soils, oxides, alkalinization, carbonate*

P2-568

[WG6] Urban Soils-Properties, Functions and Evolution

Effect of Population Density on Heavy Metal Concentration in Urban Areas: Differences Between Urban Soil and Street Dust

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The growth of population, industrial and commercial activities and vehicles are the major causes of pollution in urban areas. Amongst different pollutants, heavy metals are the most harmful to public health and to the environment in urban systems due to its persistence and accumulation. Top soils and street dusts are most used indicators of environmental urban pollutants, however it is not clear which one of them is the best and more sensible indicator for risk assessment.

Therefore, the aims of this study is to evaluate the effect of population density on metals concentration in urban soils and street dust under semiarid climate, and to identified which material (dust or soil) is more useful to determine sources and assess human health risk by heavy metals in urban areas.

In order to achieve these objectives, three cities with different population density from Murcia province were selected, and soil samples were collected in parks of each city for a total of 35 samples. Each soil sample was taken from the surface (0–5 cm) using a soil spade and it was composed by three subsamples. In addition, samples of the street dust were collected in each city for a total of 13 samples. The dust sampling was carried out by sweeping using a plastic brush. Finally, In order to determine background metals concentration, a natural area was selected and 10 soil samples and 5 street dust samples was collected. Samples were then taken for analysis. Physical-chemical characterization of the samples was carried out, including pH, salinity, organic carbon, and carbonates contents, also total metals concentration (Zn, Cr, Pb, Cu, Cd, Ni and Co) was determined after acid digestion. The results were statistically treated for an adequate interpretation of the results.

The results showed that the concentration of metals in street dust and soils from the three cities decrease in the order as follows: Zn, Pb, Cu, Ni, Cr, Co and Cd. Concentrations of zinc, lead and copper were higher in street dust samples than those found in urban soils; however concentrations of chromium, nickel, cadmium and cobalt were statistically similar for both materials. In addition, the concentrations of Pb, Zn and Cu in dust samples from urban soils were more than 3x higher than those reported in dust collected from natural areas, however, for soil samples the concentration of these metals were similar in urban soils and natural soils. This indicates that street dust is more sensible to accumulate Zn, Pb and Cu than the urban soils and, therefore, the monitoring of street dust should be used as a tool for risk assessment studies and for identifying a potential pollution in urban areas.

The results showed that concentrations of Pb, Cu, Cr and Zn in street dust samples increase when the population density increase, suggesting that these metals come from anthropogenic sources and these sources depend of the population density. Contrary, no relationship was found among population density and metals concentrations in urban soil samples, indicating again that the use of street dust is more adequate as indicator of urban pollution than the urban soils.

Keywords：*urban soils, street dust, metals, population density*

P2-569

[WG6] Urban Soils-Properties, Functions and Evolution

Speciation of Metals over Different Chemical Fraction in Street Dust from Different Uses as Basis for Risk Assessment

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Dust has been linked to adverse human health conditions because it is one of the main sinks of pollutants, and is mainly composed of fine particles that can be re-suspended in the atmosphere and transported over long distances. Dust samples were collected from an urban area, a suburban area, two industrial areas, highways, and a natural site, all situated in the vicinity of Murcia City, Spain. Chemical and physical properties were determined (pH, organic carbon content, salinity, cation exchange capacity, carbonate content) as well as the partitioning of the heavy metals Cu, Pb, Zn and Cd over exchangeable pools, association with carbonates, oxides, organic complexes and a residual phase.

The results showed differences in the concentrations and percentages of the metals extracted from the five chemical phases among the studied dusts. The observed differences were attributed to the sources of metals, total metal concentration of the dust samples, dust physical and chemical properties, and the specific affinity of some metal for some solid phases.

Metal distribution in the different phases was found to depend on each metal and each land use. Pb found to mainly reside in the residual phase of dust from natural area; while Pb was mainly bound to Fe and Mn oxides in industrial dust. In dust from the urban and industrial sites Cu was equally distributed over Fe and Mn oxides and the residual phase, while in highway dust it mainly resided in the organic fraction. Zn mainly resided in the residual phase in dust from the urban and natural site, while in dust from the suburban site a large proportion of Zn was bound to Fe and Mn oxides. Cd was mainly associated to Fe and Mn oxides in dust from the urban site. In dust from the natural, the industrial and suburban sites, Cd predominantly resided in the carbonate fraction. .

According to the risk assessment code (concentration of exchangeable and carbonate-bound fractions), Zn was the most mobile metal. This suggests that variations in environmental conditions, such as pH or salinity induced by anthropogenic activities, could increase the availability of this metal and could stimulate its release into the environment. In turn, Cu was the least mobile metal with an associated lower risk for the environment, while Cd and Pb showed medium risks of being mobilized. When comparing the different sites, the risk of metal mobilization decreased in the following order: Industrial-NW > natural areas > urban areas > suburban areas > highways > industrial-SW areas. The high ranking of the natural area is a result of the presence of carbonate bound anthropogenic Cd and Pb from a nearby industrial area.

Keywords：*heavy metal, risk assessment, dust, sequential extraction, land uses*

P2-570

[WG6] Urban Soils-Properties, Functions and Evolution

Soil Capping for Vegetative Establishment in Red Mud Disposal Areas

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Alumina production from bauxite processing generates substantial amounts of caustic residue (collectively known as red mud due to its color) with pH ranging from 10 to 13. Some red mud also contained elevated concentrations of radioactive materials. Therefore, red mud disposal sites are a potential source of hazardous dust particles, which could cause health problem in the area surrounding the red mud storage facilities. After the storage facility is decommissioned, establishment of vegetative covers in the red mud disposal area is an attractive strategy for the control of red mud-derived air pollution since this also has ecological and aesthetic benefits. However, apart from low nutrient status and poor soil structure, the strong alkalinity and salinity of red mud are also significant constraints for colonization of vegetation. Therefore, red mud needs to be treated and amended to create soil conditions that are suitable for supporting plant growth. Soil conditioning may be achieved by incorporating various inorganic and organic amendments into the surface layer of red mud. However, this approach is generally insufficient to ensure long-term survival of vegetation. Alternatively, soil capping can be used for vegetative cover establishment in red mud disposal sites. A successful example was reported at the Alcan Gove's bauxite refinery in Gove, Northern Territory of Australia where seawater-neutralized red mud was capped with a layer of soils. However, seawater treatment of red mud is only feasible in alumina refineries that are located near coastlines. It remains uncertain whether the same success can be achieved for the highly basic red mud at the alumina refineries located in inland areas. The possible upward movement of alkaline materials from the underlying red mud to the capping soil layer through capillary action is a major concern for maintaining suitable soils conditions for the formation of a self-sustaining vegetative cover. In this study, acidic soil with an embedded layer of zeolite was used as the capping materials in an attempt to minimize alkalinization and salinization of the root zone in the capping soil layer that are likely to be caused by upwardly moved saline and alkaline materials. A nearly 3-year microcosm experiment was conducted to test the effectiveness of this design in sustaining the growth of a salt-tolerant grass species on the capping soil underlain by both un-neutralized and neutralized red mud. Under the set experimental conditions in this study, capping red mud using acidic soil with an embedded layer of zeolite allowed self-sustaining growth of PaspalumvaginatumSw no matter whether the underlying red mud was neutralized or not. During the stage of vegetation colonization, the plant growth performance was better when the underlying red mud was not neutralized with MgCl2 probably due to alleviation of acid stress in the root zone as a result of partial acid neutralization by the upwardly moved OH- from the underlying red mud. Neutralization of the underlying red mud reduced the magnitude of upward OH- flux and led to the salinization and slight pH decrease of the root zone. However, the difference in plant growth performance between the neutralized and un-neutralized scenarios became less remarkable over time during the subsequent period of the experiment presumably due to gradual improvement of soil conditions in the neutralized scenarios. Continuous leaching of soluble salts and alkaline materials by rainwater caused gradual soil desalinization and de-alkalization and effectively extended the root zone to the red mud layer. As a result of vegetative cover development, organic matter rapidly accumulated in the soil, which facilitated microbial activities and consequently improved the supply of nutrients. This, in turn, enhanced the growth of the plants.

Keywords：*Soil capping, red mud, waste management, vegetative cover, salinity, alkalinity*

P2-571

[WG6] Urban Soils-Properties, Functions and Evolution

Heavy Metal Retention of Different Roadside Soils

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Emissions from major highways contain different kinds of contaminants such as heavy metals, polycyclic aromatic hydrocarbons and road salts which can occur in both particulate and dissolved form. Pollutants are transferred to the environment via aerial transport or the infiltration of road runoff and spray water. A significant rate of the road runoff infiltrates into the embankment which is usually built during road construction and located next to the road edge. Especially in the long term development there is an increasing problem of soil contamination and groundwater pollution.

According to valid German law, newly constructed embankments have to provide a specific bearing capacity to enable trafficability in emergency cases. Therefore the applicable materials consist of accurately defined gravel-soil mixtures, which can fulfil this requirement. To determine and com-pare the total and dissolved concentrations of Pb, Cd, Zn, Cu, Ni, Cr in the road runoff and seep-age water of newly constructed embankments, we installed 6 Lysimeter along the edge of the German highway A115. Three lysimeter were filled with different materials which are recently used for embankment construction in Germany. Three further lysimeter where installed and filled with plain gravel, to observe the distribution, quantity and quality of road runoff.

First results showed that heavy metal concentrations determined in the road runoff were compara-ble to literature values. The solute concentrations in the seepage water of the different embank-ment materials are smaller than in the road runoff water. In between the treatments, the solute con-centrations do not show considerable differences and only sporadically exceed the trigger values of the German Federal Soil Protection & Contamination Ordinance (BBodSchV). However, due to the very high infiltration rates (approx. 4000 mm/a) high loads of heavy metals might be trans-ported to the groundwater. Total concentrations (solute plus particulate) of the seepage water are significantly higher than sole solute concentrations. The particulate concentrations are considera-bly higher in one of the stable variants as compared to the other ones.

In order to give a realistic estimate of the risk of groundwater pollution further monitoring of seep-age water quality in the lysimeter will be performed.

Keywords：*heavy metals; roadside soils; soil solution; seepage water; lysimeter*

P2-572

[WG6] Urban Soils-Properties, Functions and Evolution

Modern Soils on Bronze Age Settlement in Ural Region (russia): Genesis, Properties and Evolution

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The ancient Bronze Age (3,5 th. BP) settlement located in the humid part of the Ural (Russia) region. But modern soils have a lot of gypsum just from the surface and specific micro relief which is typical for gypsum deserts. All other area without cultural layers of this settlement has normal chernozems without any gypsum upper 2meters.

Our multidisciplinary research together with archaeologists have been show that ancient people (Andronovsky culture) came from the dry areas of Kazakhstan. Most likely that they brought the tradition to build the houses using gypsum. Gypsum is an excellent material in dry climate but dissolves quickly in humid.

According archaeological excavations, ancient people rebuild their houses more then 5 times during 100 years. They again and again brought a lot of gypsum on this place. And finally people left this settlement.

Nowadays it is impossible to live here because the water from the nearest small river bitter and not drinkable plus specific micro relief.

Morphological, chemical and physical analysis of this soils have shown that gypsum is practically not been washed away.

So, the functioning of modern archeosol is directly related to the genesis of the cultural layer and 3,5 thousand years is not enough to restore the natural soils.

These conclusions are very important for the prediction of velocity transformations of urban soil over time.

Keywords：*ancient settlement, modern soil, properties, gypsum, velocity of transformations*

P2-573

[WG6] Urban Soils-Properties, Functions and Evolution

Diagnosis of Heavy Metal Pollution in Urban Soils: The Case of Mexico City

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Cases of cancer have been increasing in major cities of the world during recent years, in part due to pollution with heavy metals. In several cities in Mexico regulation about the quantity and quality of gases emitted by automobiles is missing, so a large part of the urban environmental pollution is estimated to come from combustion gases of motor vehicles. Our goal was to evaluate the levels of pollution with the heavy metals as lead, zinc, copper, chromium, and vanadium in locations at Mexico City. Three types of samples were taken: tree leaves, which capture polluted fine breathable particles (FBP); urban dusts (UD) (short term pollution); and soils (long term historical pollution). Leaf samples were analyzed by inductively coupled plasma (ICP), and UD and soil samples, by X-ray fluorescence (XRF). Data were evaluated compared to maximum permissible limits (MPL), pollution factor (PF), and pollution load index (PLI). Maps were created using ordinary kriging interpolation and indicator kriging with LMP and a PF equal to 3 as threshold values. FBPs from leaves contained Pb, Cr, Cu, and Zn. The contents of V and Pb in soil samples exceeded the established MPL. Regarding PF, UDs are polluted with V, Pb, Cu, and Zn. The probability maps from indicator kriging analysis show areas in which remediation actions are needed. Likewise, the map of the interpolated PLI allowed for identifying the areas in Mexico City that are most polluted with the analyzed heavy metals, a knowledge that is of great value for designing urgent remediation measures. No clear differences were found in level of heavy metal pollution by urban land use; however, main streets are more polluted compared to secondary, tertiary, and rural streets.

Keywords：*indicator kriging; Technosol, urban soils, urban dust; leaves with heavy metals*

P2-574

[WG6] Urban Soils-Properties, Functions and Evolution

Magnetic Properties of Dusts and Urban Topsoils from the Mexicali (Mexico) - Calexico (U.S.) Binational Conurbation

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Mexicali-Calexico is an international metropolitan area on the border between California (United States) and Baja California (Mexico). The metropolitan area lies in the Imperial Valley and Mexicali Valley. Mexicali is the Mexican city with the worst air quality, represented by annual mean concentration of fine particulate matter (PM10, particles smaller than 10 microns) according to the Urban outdoor air pollution database (World Health Organization, 2011). The goals of this study are to define the areas of higher pollution by mapping the magnetic properties of dust deposited on the streets and urban topsoils, due to the increase of magnetic minerals from human activities and relate them to land use and traffic. Systematic sampling was carried out in the metropolitan area in the month of April 2013. A total of 148 dust samples, 150 topsoil samples (depth between 0 and 5 cm) and 15 control samples (depth between 20 and 25 cm) were collected within the metropolitan area at 150 georeferenced sites. The distance between sampling sites was approximately 1.5 km. Dust and soil samples were air-dried, sieved through 1 mm mesh size. Magnetic susceptibility (κ) of samples was measured on a Bartington MS2B with dual sensor at low and high frequency (κlf 470 Hz, κhf at 4700 Hz). Mass-specific values (χ) were calculated taking into account samples weight. Frequency dependent susceptibility was performed to identify the presence of superparamagnetic grain size (<0.05 μm). Stepwise acquisition (impulse magnetizer ASC IM10) of Isothermal Remanent Magnetization (IRM) was conducted for identification of magnetic mineralogy using the coercivity spectra and Saturation Isothermal Remanent Magnetization (SIRM) at 700 mT. All IRM measurements were carried out using an spinner magnetometer Molspin. Georeferenced data matrix was built and geostatistical analysis (ordinary Kriging interpolation) was performed to model spatial variability of magnetic properties of dust and urban topsoils . The analysis of variance performed with the values of χ and MRIS for land use and traffic shows that the P-value of F-test is less than 0.05 for both cases so that there is a statistically significant difference between the categories with a 95% level of confidence. The low-frequency magnetic susceptibility reveals the presence of magnetic particles of diameter less than 10 microns in some sites. We conclude that the obtained values for the magnetic properties found in urban dusts and soils have a high dependence on land use and traffic.

Keywords：*environmental magnetism, urban topsoils, urban dust*

P2-575

[WG6] Urban Soils-Properties, Functions and Evolution

Magnetic Susceptibility and Saturation Isothermal Remanent Magnetization and their Relationship with Heavy Metals in Urban Soils in Mexico City

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Many studies have focused on the magnetic susceptibility mapping to identify the most contaminated area in a large number of cities. However, the data can be initially difficult to interpret because the original materials that make up the soil play an important role as the magnetic signal are also recorded. Studies show that magnetic properties on vehicle emissions dominate ferrimagnetic particles, these particles are deposited on the ground surface by increasing the magnetic signal the particulate matter is deposited in soil surface. The aim of this study is to determine whether it is possible to establish a relationship between susceptibility magnetic and saturation isothermal remanent magnetization parameters and concentration of Cr, Cu, Ni, Pb, V and Zn for urban soils found on volcanic and lacustrine environments. The study area is the Mexico City and Metropolitan Area located in the central part of Mexico into valley, area surrounded by mountain of volcanic origin and covered in some parts by lacustrine and clastic deposits. There are approximate 16 million of people and 4 million of vehicles in the city. In order to trace spatial pollution patterns, 88 sampling site were selected covering the whole city. To evaluate the spatial distribution, sampling was conducted in a systematic by a mesh of 45 km2. The distance between sites was of 4.5 km approximately. The top soil samples were collected between April and May 2011. In each sample site, top soils samples were recollected under one old tree antic with of PVC (polyvinyl-chloride) core with a depth between 0 to 5 cm. All the samples were kept in PVC packages and were georeferenced using a GPS Garmin Etrex with WGS84 reference. All samples were subjected to magnetic measurements analyses, such as magnetic susceptibility (κ) in a Bartington MS2B with dual sensor at low and high frequency (klf 470 Hz, Khf at 4700 Hz): from these values mass specific susceptibility χ was calculate. We calculated frequency dependence of susceptibility κdf% as [(κlf-κhf)/ κlf)x100], to determine the possible presence of superparamgnetic (SP) grain size in the magnetic fraction of <0.05 μm. The magnetization acquired at 700 mT was considered to as the saturation isothermal remanent magnetization (SIRM). Following the acquisition of SIRM, All remanent magnetization were performed using an AGICO JR6 spinner magnetometer.

We constructed a georeferenced database taken account magnetic topsoil properties and subsequently performed a geostatistical analysis by kriging interpolation. The Magnetic susceptibility in soils shown range value from 0.2 to 0.6 x10-6 m3/kg. Frequency dependent susceptibility magnetic (κFD) was also quantified. The obtained values range from 0.0 % at 5.5% for the topsoil sample, which indicate a content of mixture of small grain (superparamagnetic SP) and material more coarse (MD grain). The IRM curves showed different behavior for soils that are on different types of roads, more intense values for soils nearby streets in residential areas. The determination of heavy elements was conducted through an analysis of x-ray fluorescence. Some sites show high Pb content (654 mg/g) that surpasses the standard as the content of V (111 mg/g) the content of V exceeds the Mexican standard.

This study will use magnetic parameters and chemical methods for determining whether the anthropic activities are closely related, by an analysis of variance was observed that roads with high traffic clearly show strong signals for more land in the city of Mexico, indicating that the main contribution of material comes from vehicular traffic. We found that by a linear regression analysis of the magnetic susceptibility and IRM values of soils found on lacustrine deposits show a better correlation with heavy metals. Spatial analysis of magnetic parameters and concentration of studied heavy metals, indicate that central areas of the city is where the highest values. Furthermore, soils that come from volcanic areas were difficult to correlate. Currently there is no analysis in Mexico City in order to establish the characteristics of the soil in terms of magnetic parameters and to determine the background signal.

Keywords：*ferrimagnetics mineral, lineal regression, analysis of variance, kriging interpolation*

P2-576
[WG6] Urban Soils-Properties, Functions and Evolution

A Comparison of the Efficiency of Sediment Control Devices on Stockpiled Material at North Turramurra Recreational Area

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The need for effective sediment control is of increasing concern for the construction industry. There are at present, two standard industry devices, sediment socks and sediment fencing that are widely used to prevent soil loss from sites. Between suppliers, these sediment control devices differ in terms of materials used, manufacturing technique and price. There has been little research to compare the effectiveness of each of these devices with different soil types.
An investigation to compare the effective use of sediment socks and sediment fences from two suppliers using two soil types was undertaken to provide a better basis for the selection of sediment control devices for construction sites.

The soils, a silty clay and a loamy sand, used in this investigation were taken from North Turramurra Recreational Park. This site, surrounded on three property boundaries by National Park, slopes towards the natural watercourse of Cowan Creek. The main sources of potential sediment loss from this site are sheet erosion from fill areas and stockpile runoff. As excavation takes place over 14 hectares, there is the potential for large areas of site to be exposed at any one time.
Large quantities of a variety of fill material are stored on site at any one time. This poses a critical need to retain all fill material on site in the event of a severe rainfall event.
Two types of sediment fences and socks were selected to test for their effectiveness with the silty clay and loamy sand. Water mixed with the sediments was reticulated down a flume with each of the sediment control devices at the end retaining the sediment. The experiments continued for a nominated period of time or until failure, whichever was reached first. Primarily sediment retention capacity, and water flow through rate as a function of time were analysed to determine effectiveness. The ponding depth as a function of time, and sediment control device failure were also assessed. The data collected was analysed and results compared for each of the devices. It was found that one product outperformed the other depending on the soil type. The volume of water to pass through the devices and the amount of retained sediment upstream depended on the difference in the weave in the two products and also the type of devices used.
From these results it was determined that that the effectiveness of sediment control devices that had been selected to prevent soil loss from this construction site was more effective using one manufactured product than other depending on the soil properties.
From these experiments recommendations were made was to employ a sediment fence from best performing product across the site for all three sediment stockpiles and at the catchment areas from site.
To prevent relatively small sediment loss from lower volume sheet runoff where a sediment fence is not able to be employed (i.e. across footpaths, driveways, site access ways), the geofabric sock from the same supplier should be used.

Keywords：*sediment control, erosion, manufactured devices*

P2-577

[WG6] Urban Soils-Properties, Functions and Evolution

Metal Trace Elements in Fruits and Vegetables in France

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Conducting a nation-wide survey on the exposure of carrot and lettuce crops to Cd and Pb

European regulations have set the maximum levels for Pb, Cd and Hg in foodstuffs (Regulation n° 420/2011). On the other hand, the EFSA issued a new recommendation regarding the level of human exposure to Cd. On the basis of a recent epidemiological studies, EFSA(2) established a tolerable weekly intake of 2.5?g Cd/kg body weight. That threshold is almost 3 times lower than the one proposed by the WHO(3) (i.e., 7 µg Cd/kg b.w./week) and leaves little tolerance concerning European populations' exposure to Cd. Finally, in France, ANSES (French Agency for Food, Environmental and Occupational Health & Safety), on the basis of the latest survey of the French populations' exposure to food contaminants (EAT2, published in 2011), draws attention to Cd, and points out that fruit and vegetables are an important source of consumer exposure to Cd (21 to 27% depending on the age group). Based on the above, current thresholds for Cd are expected to be lowered. Pb and As are currently also under surveillance, which could lead to new regulations in the near future. However, fruits and vegetables are recognised for their "health value" (antioxidants, vitamins, fibres, mineral elements…). In France, within the framework of the PNNS (national nutrition and health plan), numerous studies are being carried out with a view to encouraging fruit and vegetable consumption, using strong incentives towards children, who are also the most vulnerable to Cd contaminations. The health benefit must go hand in hand with food safety. In a context of increased protection of the populations against contaminants, in this case Cd, Ctifl initiated a prospective study in 2011 and is conducting a huge nation-wide survey on two vegetable species, namely carrot and lettuce. Those vegetables are among the most significant contributors to consumer exposure to Cd, because of the particular phytoavailability of Cd, and the importance of the latter in human nutrition patterns.

The chosen method was to identify carrot and lettuce production areas within the territory. The RMQS (French soil quality assessment network) maps were used, which indicate Cd levels and the values of variables that may affect Cd accumulation in plants. The selection of plots to be sampled was conducted by superposing the RMQS maps over the carrot and lettuce production areas. In 73 lettuce plots and 34 carrot plots, of respectively 10 and 4 production areas, soil and plant samples were collected according to protocols adapted to each species and cropping method (field crops or protected crops). Cd and, for some plots, Pb were analysed, as well as mineral elements and physicochemical parameters influencing the mobilisation and accumulation of the trace elements in the vegetables. In addition, information related to plot history, cropping practices, growing methods (conventional, organic), and the proximity of pollution sources (roads, industrial sites…) was recorded.

Assessment of contamination of vegetables is under way. The first results emphasise the influence of pH on the (soil-plant) transfer coefficient, and indicate the consumption threshold for lettuce as compared to the toxicological reference value (TRV(4)). Furthermore, phosphate fertilisation represents a source of contamination highlighted by specific studies carried out on carrot. Ctifl is also a partner in a research project aimed at developing a tool for assessing the sanitary quality of plants with regard to the presence of metal trace elements in the soil. A plot-by-plot diagnosis offers a real opportunity for growers who are subjected to strict product compliance regulations in an open and highly competitive market.

(1) : Centre Technique Interprofessionnel des Fruits et Legumes
(2) : European Food Safety Authority
(3) : World Health Organisation
(4) : Toxicological Reference Value

Keywords：*Cd, Pb, carrot, lettuce, survey, food security, phosphate fertilization*

P2-578

[WG6] Urban Soils-Properties, Functions and Evolution

Biochemical and Chemical Indicators of Anthropogenic Transformations for Soils in Urbanised Areas

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The studies were conducted between 2010 and 2012 on soil material sampled from the humic layers of 12 park gardens situated within the administrative borders of the following cities: Bytom, Cracow, Lublin, Miasteczko ?l?skie, Zabrze and Zamo??. The park gardens selected for the studies were situated in central zones as areas under pressure of anthropogenic contamination, and in city outskirt zones characterised by similar physiographic conditions but not subject to the direct impact of anthropogenic factors.
In soil samples, activities of the following enzymes were determined: dehydrogenases, acid phosphatase and alkaline phosphatase, urease, protease, pH in 1 mol.dcm-3 KCl, organic carbon, total nitrogen, content of heavy metals (Zn, Pb, Cd, Cu), and content of polycyclic aromatic hydrocarbons (PAHs).
The results showed that the location of the park gardens and the related intensity of anthropogenic pressure had a significant impact on the chemical properties and the biological activity of the soils. In the soils of parks situated in central zones, increased inflow of organic C of anthropogenic origin to the soil environment resulted in a significantly wider range of values for the C:N ratio than in the soils from the outskirts. The content of analysed heavy metals and (PAHs) in the studied soils, as well as the activity of the tested biochemical parameters, represented a wide range of values, yet clearly depended on the intensity of anthropogenic pressure. Soils from Upper Silesia (Bytom, Miasteczko ?l?skie, Zabrze) were the most contaminated with trace elements and PAHs. The concentrations of the analysed trace elements and PAHs were several times higher in the soils from parks situated in the city centre zone than in the soils from the outskirts.
In the soils from central parks, the activity of enzymes was several times lower than in the soils from the outskirts. This shows that the ecological system in central city areas differs from that in the outskirts of the cities. The soils from Upper Silesia were characterised by having the lowest biochemical activity. The interrelationships between the biochemical and chemical soil indicators varied depending on the location of the parks, and thus also on the intensity of anthropogenic pressure (central or outskirt zones). A significant relationship between the activity of biological indicators and the content of organic carbon and total nitrogen was demonstrated only in the case of soil samples from those parks situated in the outskirts. A total lack of correlation between the organic carbon content and the enzymatic activity of soils in the central zones could be connected with the low share of humic substances in the total organic matter in these soils and, as a consequence, with the limited availability of easily assimilable carbon, hence determining the development of the soil bacteria that produce enzymes. Similar tendencies were observed in the case of the relationship between biochemical indicators and heavy metals or PAHs. In the soils from central parks, the activity of dehydrogenases, acid phosphatise and alkaline phosphatase negatively correlated with the content of Zn, Pb, Cu, Cd and total PAHs, the activity of urease negatively correlated with the content of Cd and PAHs, whereas the activity of protease negatively correlated with the content of Cd only. In soils from parks situated in the outskirts, significantly positive correlations were observed between the activity of all the tested biochemical parameters and the content of both organic carbon and total nitrogen. A total of the 16 PAHs and individual heavy metals were shown to have a stimulating influence on the activity of dehydrogenases, acid phosphatase, alkaline phosphatise and urease. A statistical analysis has confirmed that the ecological conditions in central and outskirt zones differ, indicating that the degree of contamination of urban soils depends strictly on the urban zone. Nonetheless, it should be emphasised that the unfavourable changes in the ecological and chemical condition of soils (increased alkalisation and content of both heavy metals and PAHs, lower biological activity) demonstrated in these studies, intensifying as the years go by, were observed also in the outskirts of the majority of the cities, demonstrating that anthropogenic pressure in urbanised areas in Poland is increasing.

Keywords：*urbanised areas; urban soils; landscape; biochemical and chemical indicators*

P2-579

[C4.2-1] Linking forest Management and Soil Processes to Ecosystem Productivity and Functions

Pontoscolex Corethrurus Earthworm Boostent Soil Biological And Physicochemical Properties And Induced Edible Mushroom Production

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Numerous international investigations proved that tropical earthworms are marvelous in their ability to improve soil quality. Their burrowing activities in conjunction with vermicomposting, organic matter incorporation, mixing and distribution within the soil depth contribute immensely to enhance soil biological and physiochemical properties, and thereby environmental health, soil productivity and food security. Pleurotus sp. Mushroom the white-rot tropical basidiomycete, as a result of their large size and unique extracellular enzymatic ability can bioremediate the soil in an ecologically responsible, safe and cost effective way. They can promote soil fertility status, aeration and drainage through synthetizing the building blocks of humus and transforming organic residues to useful growth hormones and mycelia. The management of high rainfall acid soil of Nigeria is becoming increasingly problematic. There is dearth of information on the ecology of these soils especially the ecology of soil micro- and macro-organisms that are necessary for efficient utilization of the soil resources. Nigerian high rainfall acid soils are particularly vulnerable. These soils are low in organics, exchangeable bases and CEC. To cope with low productivity in organic fertilizers mostly (NH4)SO4 were intensively applied within the past decades. This escalated the soil problems including depletion of organic matter, CEC, increased soil erosion and acidification. Applied inorganic phosphate becomes quickly immobilized and non-available to plant. There is serious need to develop adequate alternative cultural practice and harness soil biological resources, such as earthworms, Pleurotus-white rot basiomycetes etc. This paper reports Pontoscolex corethrurus (PC) positive contribution to soil biological and physicochemical properties and also to Pleurotus tuberregium mushroom production. Soil analysis and soil enzymatic studies on potted Nigerian acid soil mulched with either largostroemia speciosa, or Paspalum grass or Trema gunense leaves and inoculated with (P.C) adult earthworms highlighted (PC) unique capability and beneficial impact on soil physicochemical and biological properties. (PC) induced release of extracellular enzymes, phosphatase and growth hormones to boost P, and N availability and production of high quality humus Soil dedrydrogenese activity increased 4-7-fold, acid - - phosphatase 2-2.8-fold, available P 4.5-to5.5 ?fold, total N-40% to 2.4-fold, soil organic carbon 2.3 to 3.7-fold depending on the mulch diet-type. Of particular remark is (PC) ability to bioplough and distribute organic C within the soil. In fact, (PC) induced greater C and N availability more in 10-11cm depth (where its cocoons were located in specially synthetized organo-mineral chambers) than within 0-10cm depth. Particularly outstanding was (PC) efficacy to increase soil pH from very strongly acidic to moderately acid and slightly acidic CEC increased from low to moderate level. Soil available P increased from very low 4.8 ugg-1 to high 22.5-32.6 ugg-1 depending on the mulch type, paralleling (PC) beneficial impacton soil biological and enzymatic activities. Regression analysis showed proportionality between soil enzyme activities and available P, soil organic C, and total N. Higher, correlation coefficient recorded within 10-11.2cm (?=+0.9476+0.0435) than within 0-10cm (?=+0.8190+0.1098) indicated the greater impact of (PC) to soil nutrient availability and (PC) bioploughing activities within the sub soil and promotion of soil biological and physicochemical properties. The positive interaction between (PC) and the edible mushroom Pleurotus tuberregum (P tub) was clearly demonstrated by the potted experiment set up using sub soil inoculated with plugs of Pleurotus (P tub) sclerotium and inoculated or, not with (PC) Pontoscolex adults and also adequately mulched with paspalum sp.grass. Promptly (within 7days), (P tub) growth and copious induction of the mushroom fruiting bodies occurred in the presence of actively bioploughing (PC). In contrast, in the control without (PC) earthworms, no (P tub) growth nor mushroom fruiting bodies were observed. This underscored the positive interaction between (P tub) and (PC) and their combined enhanced soil biological properties and food security.

Keywords：*Pontoscolex corethrurus; high rainfall acid soils; Pleurotus tuberregium; soil Phosphatase activitie*

P2-580

[IDS17] Surface Soil Resources Inventory and Integration: Soil Value and Erosion

The Detection of Temporal Variation of Land Cover Types Using Landsat Data Fusion

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Identifying agricultural fields from satellite data can be straightforward by interactive thresholding of spectral vegetation indices. However, interactive techniques are impractical for large area application and are not amenable to automation(L Yan., 2014). Data fusion and semi-automated classification approaches of land cover types were used for detecting temporal variation of soil loss, however land cover types are changed by factors including spatial variations in soil moisture, fertility, soil pollution and diseases of vegetation. In this study, the temporal variability and spectral similarity between crops and non-crops as a function of their phenological stage were classified by Landsat data fusion with high resolution UAV and Airborne image, and Land cover types of soil loss with degree of soil background were classified by the time series of satellite observation.

Keywords: land cover, soil loss, data fusion model, UAV, Landsat
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P3-1

[IDS8] Soils, Land Use and Heat

Impact of 2030 Climate on Suitability of Tuber Crops Cultivation in India

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The objective of the present study was to analyse the impact of present day climate and future climate (2030) on suitability of tropical tuber crops (cassava, yams and Amorphophallus) in major growing areas of India. We studied the changes in climatic parameters in major tuber crops growing areas of India, current climate suitability and constraints to tuber crops production, future climatic changes in India and changes in suitability of these areas for tuber crops cultivation. The study used long-term average climatic data (1960-2000) of monthly maximum, minimum and mean temperatures, and total monthly precipitation at 30 arc-seconds (<1 km) spatial resolution (WorldClim data) aggregated to the resolution of 10 arc-minutes (- 20 km at the equator). Statistically downscaled outputs of 25 selected Global Circulation Models (GCMs) from the 3rd and 4th assessment reports of IPCC for 2030 period under SRES A1B emission scenario was used as the future climate data. The world inventory of soil emission potentials (WISE) database was also used to find out the suitability of tuber crops in these areas. The impact of climate change on suitability of major tuber crops growing areas of India was studied using the ecological niche model, ECOCROP. All spatial analyses were done in GIS environment using DIVA GIS and ARCGIS 10. The study showed that, there is positive impact in many areas where tuber crops are cultivated. The study also resulted in developing a map of the potential tuber crops growing areas of India. A detailed quantification of the impact of climate change is also done in the paper. The study clearly indicated the areas which are positively and negatively impacted for tuber crops cultivation in India.

Keywords：*tuber crops, cassava, yams, Amorphophallus, ECOCROP, climate change*

P3-2

[IDS8] Soils, Land Use and Heat

Soil Phosphorus Retention Capacity of Different Amendments

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Non Point Source of Phosphorus Contamination (NPSPC) poses serious threats to environment. One way to control NPSPC is to use soil amendments which can enhance soil Phosphorus (P) retention capacity. To enhance soil P retention Blast Furnace Slag (BFS), Fly ash (FA), Water treatment residues (WTR) and Hydrotalcite (HYD) were amended in soil and incubated for 16 weeks. Fly ash and BFS were amended at the rate of 5%, WTR at 3% and HYD at 0.06%. Animal compost, Sewage sludge and KH2PO4 were used as P source each at the rate of 400 g kg-1 soil. Subsamples were taken during the incubation period for labile P fractions, bio-available P fractions, sesquioxide bound P, and calcium bound P fractions analysis. Results indicated that labile P fractions extracted with H2O were the lowest with WTR and BFS followed by FA and HYD. Bio-available P fractions extracted with NaHCO3 were higher from BFS and the lowest in WTR. Iron and Al bound P fractions extracted with NaOH were maximum from the soil amended with WTR followed by FA, HYD and BFS. Calcium bound P fractions extracted with HCl were highest with FA and BFS followed by WTR and HYD. Water treatment residues and BFS were observed very much effective in enhancing soil P retention capacity. In second experiment, growth response of spinach (Spinacia oleracea L. “Virginia”) was test in WTR and BFS amended soil. Animal compost, sewage sludge and KH2PO4 were applied at the rate of 300 kg ha-1 while WTR and BFS were amended at the rate of 1.7%, 3.4% and 5%. Results showed that both amendments did not affect the dry matter yield of crop under any P source.

Keywords：*Blast furnace slag, Phosphorus retention capacity, water treatment residues, hydrotalcite.*

P3-3

[IDS8] Soils, Land Use and Heat

Accumulation and Leaching Potential of Soluble Nitrogen in Greenhouse Soil

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Nitrogen (N) is the primary limiting factor for crop production. Total soluble nitrogen (TSN) is the active nutrient in soil and includes soluble inorganic N (SIN, including NH_4^+-N and NO_3^--N) and soluble organic N (SON). TSN is highly mobile with soil water in many soils, which can easily leach into deep soil layer or underground water by management practices (e.g., irrigation and fertilization, etc.), and causes environmental pollution. SON is generally defined as the organic N extracted from soil by water or some salt solutions, and is present in substantial quantities in forest, grassland, and agricultural ecosystems, and plays an important role in the N cycle of soil-crop system. Soil SON originates mainly from the decomposition of soil organic matter, applied organic manure, metabolic product and secretions of root system, and microbial debris. With the rapid expansion of intensive vegetable production in the Northeast region of China, organic manure is heavily applied in greenhouse soil to maintain the long-term vegetable productivity and improve soil quality. However, unreasonable application of manure decreases N use efficiency, increases N loss, and causes a series of environmental problems. Until now, most studies focused on the transformation and leaching loss of SIN in greenhouse soil, and the dynamics of SON was paid little attention. The objectives of the present study were to evaluate the effects of organic manure application on the amount, distribution and leaching risk of soluble inorganic and organic nitrogen (N) in different soil layers of greenhouse soil in the Northeast region of China. The study was conducted at the typical intensive vegetable production base of Xinmin County, Liaoning Province (41°59′N latitude, 122°50′E longitude). This site locates on the Liao River alluvial plain, with a continental monsoon climate of temperate zone. Mean annual temperature is 6-9 °C, with a minimum and maximum mean monthly temperature of -12°C (January) and 24°C (July), respectively. The duration of frost-free season is 150-200 d. Mean annual precipitation is about 600 mm. The tested soil was an aquic brown soil. Nine rectangle micro-plot experiments were installed in the 1-year field plastic greenhouse on 14 December 2006. Each micro-plot has an area of 3.6m×5.2m and was randomly arranged. The spacing interval of each micro-plot was 60 cm. Three treatments were set up, i.e., (1) no chicken manure (CK); (2) a low application rate of chicken manure (22 t/ha/year, CM_{22}); and (3) a local routine application rate of chicken manure (33 t/ha/year, CM_{33}). Each treatment had three replicates. In all treatments, chemical N fertilizer (Sakefu Complex Fertilizer) was applied annually as basal with the application rate of 160 kg N/ha, 70 kg P/ha and 130 kg K/ha following the local farming practices. Chicken manure was rotted and applied annually as basal manure in December, with an application rate of 0, 22 and 33 t/ha/year (dry-weight basis) for 3 consecutive years. Lettuce and cucumber were planted in September and December each year, respectively. The results showed that NO_3^--N accounted for the majority of total soluble N (TSN), followed by soluble organic N (SON) in different soil layers of CK and CM_{22} treatments (chicken manure application at 22 t/ha/year), however, the trend was reversed in the 0-10 cm and 10-20 cm soil layers of CM_{33}treatment (chicken manure application at 33 t/ha/year). The amount of NO_3^--N and its proportion to TSN significantly decreased from the 0-10cm to 10-20cm soil layer, and then increased from the 10-20cm to 20-40cm soil layer, suggesting the leaching and accumulation of NO_3^--N from topsoil to deeper layers. Compared with CK, applying chicken manure significantly enhanced the amount of SON and its proportion to TSN in different soil layers. This indicated that application of chicken manure at rate routinely used significantly increased the accumulation of SON in topsoil, and extended its leaching risk into deeper layers under intensive cultivation of greenhouse soil for vegetable production.

Keywords：*Leaching risk, Soluble nitrogen, Greenhouse Soil*

P3-4
[IDS8] Soils, Land Use and Heat

Nutrient Stocks and C Sequestration in Forest and Forest-Derived Land Use Systems in the Rainforest Zone of Nigeria

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Changes in soil properties, soil organic carbon (SOC) and total nitrogen (TN) associated with forest derived land use systems (mature oil palm plantation, bush fallow, alley cropping with multi-purpose trees [MPTs] and continuous cropping) were compared with natural forest in the rainforest zone of Nigeria. Soil samples were collected from adjacent large unreplicated plots with different histories and length of cultivation but uniform characteristics (slope, elevation and soil texture). Soil pH was generally acidic, decreased with depth and was significantly different, but did show any definite trend among the different land use systems. The acidic nature of the soils was more a reflection of the nature of the parent material (quartz rich, coarse textured and strongly leached) than effect of land use. Exchangeable K, Mg, Na and Al, cation exchange capacity (CEC) and exchangeable acidity were significantly highest for the natural forest (NF), while Ca and base saturation were highest for the oil palm plantation (OP) system, when compared with the other land use systems. Exchangeable acidity, Al saturation and bulk density increased with depth, while the other soil properties (K, Ca, Mg, Na, Mn, CEC, SOC and TN content and storage) decreased with depth. Conversion of forest to agriculture resulted in decrease in SOC and TN content and storage. In the 0-10 cm depth, for example, the NF system had the highest SOC and TN storage (46.9 and 3.6 kg ha-1 respectively), while the alley cropping with irvingia (Irvingia gabonensis L.) (IG) system had the lowest SOC and TN storage (13.6 and 1.1 kg ha-1 respectively). The total SOC and TN storage in the whole soil profile (0 - 40 cm) decreased by an average of 48% and 40% respectively due to forest change to agriculture. Five and 10 years of bush fallow and alley cropping with MTPs trees respectively and 30 years of oil palm plantation were not sufficient to re-establish fertility levels similar to the primary forest. Soil bulk density was significant, while C:N ratio was not among the land use systems. The results of this study emphasize the fact that forest soils have the capacity to conserve and enhance soil organic matter (SOM), which in turn, has positive implications on SOC sequestration, TN storage and conservation of soil nutrients.

Keywords：*nutrient stocks, C sequestration, forest-derived land use systems*

P3-5

[IDS8] Soils, Land Use and Heat

Comparison of the Temperature Regime Measured inside a Containerized Lysimeter Station, Inside Lysimeter Vessels and in Surrounding Soil

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Lysimeter investigations are subjected to stringent requirements in terms of their representativeness. This is in particular valid to the soil temperature determining almost all soil chemical and biological processes (including germination, plant growth, microbial decomposition of soil organic matter, redox reactions). The soil temperature regime interacts also with the soil water balance. Individual elements of the soil water balance equation can only be accurately quantified by weighable lysimeters, when soil temperature profiles measured in lysimeters and in situ are comparable.
Lysimeter vessels filled non-monolithic (disturbed) or monolithic with soil columns are used to study soil bio-chemical and physical processes. In practical operation, large volume vessels are integrated in lysimeter stations depending on the existing site conditions and research questions. In addition to the traditional design of lysimeter cellars in monolithic reinforced concrete construction several alternative design solutions for lysimeter stations are currently known. Thus, the construction of a containerized lysimeter station (container made of PE-HD as single, twofold or fourfold subsurface lysimeter station) enables the operation of lysimeters on sites with fluctuating groundwater levels or contaminated sites, as these stations are sealed and prevent entry of (contaminated) waters.
This study was aimed to compare soil temperature profiles in monolithically filled lysimeter vessels with temperature profiles measured in surrounding soil and indoor in the containerized lysimeter station. Conclusions to advance the construction design of the container lysimeter station are to be derived.
Data from a temperature sensor with integrated data logger placed hanging on a rope inside a fourfold containerized lysimeter station (1 m below ground level) were used for this study. These data are statistically compared with temperature measurements inside a lysimeter vessel (2 m depth, surface area 1 m2 made of black PE-HD), where soil temperature data are gathered by using electronic thermometers (Pt 100) installed in 0.3 and 1.0 m depth. For comparison, temperature measurements in depths of 0.2 and 1.0 m of the surrounding soil by the standardized climatological station at the Helmholtz UFZ Lysimeter station in Falkenberg (52° 51'33 'N, 11° 48'45' E), Germany, were included. The long-term averages of precipitation and air temperature for the site Falkenberg, calculated for the period 1968 - 2008, amounted to 560 mm and 8.2 °C, respectively.
The curves of the soil and indoor temperatures show a typical seasonal course. The highest values were measured in late summer (mid-August), the lowest in the winter months (January and February). The soil temperature of the upper measuring depths (0.2 and 0.3 m) in the lysimeters and in the reference soil was in summer above the values measured at 1m depth. As expected, the winter months showed a reverse trend. The soil temperatures inside the lysimeter vessel (in both depths of 0.3 and 1.0 m) were distinctly increased (~1.5 K) compared to those in surrounding soil. They also exceeded the indoor temperatures of the lysimeter station. The temperature of the surrounding soil in 0.2 m and the indoor temperatures of the lysimeter station were closely connected during summer months. In winter, the indoor temperature exceeded that of the surrounding soil.
In summer, the soil temperatures measured inside the lysimeter vessel exceeded the indoor temperature of the lysimeter station up to 5 K. Soil temperatures in 1.0 m depth in lysimeter vessels and in surrounding soil were increased compared to the indoor temperature of the lysimeters station during winter months (by ~1.5 K). Statistical significant mean differences were proven by a one way analysis of variance between indoor temperature in the lysimeter station and the soil temperature inside the lysimeter vessel in 1.0 m depth. Significant differences between soil temperature of surrounding soil and soil inside the lysimeter vessel could not be proven.
An improved thermo isolation of the lysimeter station (sealing and hatch) could contribute to a better consistence between temperature profiles in the lysimeter station and the surrounding soil. Another approach for improved thermo isolation consists in the usage of weak heat conductive construction materials.

Keywords：*lysimeter, temperature measurement, lysimeter station, improvement*

P3-6
[IDS8] Soils, Land Use and Heat

Changes in Microbial P and Related Soil Properties as Affected by Low Molecular Weight Organic Acids (lmwoas) in a Neutral Soil of China

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Purpose, Low molecular weight organic acids (LMWOAs) can mediate nutrients acquisition by altering soil chemical, physical and biological properties. Soil microorganisms and microbial P are consequently affected by LMWOAs addition. But little is known about the effects of LMWOAs on soil microbial P so far. The aim of this study was therefore to investigate the impacts of three common organic acids (citric, malic and oxalic acid) on soil microbial P and related properties.
Materials and methods, Surface layer (0-20cm) of the black soil was collected from Hailun (47°26'N, 126°38'E) Experimental Stations of Ecology, Chinese Academy of Sciences. The test soil was the major type of agricultural soil in its local area. Soil samples were air dried and ground to pass through a 2-mm sieve before use. Triplicate 200 g of the samples were placed in brown jars. The jars were incubated for 15 days at 25 °C. The water content was adjusted to about 50% water holding capacity. Oxalic, citric and malic acids were added at the rate of 0, 10, 20 and 40 mmol kg^{-1} soil. After incubation, Soil microbial P, pH, organic C and available P were determined. The amount of microbiological P was measured by extracting from both the fumigated and non-fumigated samples with 0.5 mol L^{-1} $NaHCO_3$.
Results and discussion, Soil microbial P contents were increased in the treatments with LMWOAs. Specifically, with the addition of 10, 20 and 40 mmol LMWOAs, the level of microbial P was increased by 32.73, 52.63 and 68.35%, respectively. A comparison of impacts of LMWOAs types indicated that the amount of microbial P decreased in the order of citric acid > malic acid > oxalic acid. Our results suggested that LMWOAs types had a significant effect on microbial P.
Soil pH values were lower in the LMWOAs applied treatments compared to the control. The reduction in pH ranged from 0.95 to 1.35 units. A comparison of impacts of LMWOAs types indicated that citric acids led to the highest decrease in soil pH. However, what surprised us was that soil pH values were not decreased but almost increased with the rate of LMWOAs added. The mechanism was not very clear.
Soil organic C levels were higher in the LMWOAs applied treatments compared to the control. Additionally, organ C levels were generally increased with the rates of LMWOAs addition. For example, organic C levels in the 10, 20 and 40 mmol LMWOAs treatments were respectively 2.38, 5.07 and 8.96% higher compared to the treatment without LMWOAs. The comparison of LMWOAs types within each soil suggested that oxalic acids resulted in the highest increases in soil organic C. Compared to the treatment without LMWOAs, the availability of soil P was increased in other treatments. The largest amount of available P occurred in the treatment with oxalic acid.
Correlation analysis showed that soil microbial P was negatively correlated with soil pH at $p < 0.01$ but positively correlated with organic C at $p < 0.05$. There tended to be a positive relationship between soil microbial P and available P, but the correlation was not significant ($p > 0.05$). Path analysis showed that the total effects of soil properties on microbial P were decreased in order of pH > organic C > available P. But this cannot explain completely. Direct effects between soil microbial P and soil properties were greater than the indirect effects except the direct effect of available P on microbial P. The direct effects of soil properties on microbial P were decreased in order of organic C > pH > available P. These findings indicated that changes in soil pH and organic C mainly influenced the contents of microbiological P directly. Moreover, soil organic C was the most important factor.
Conclusions, LMWOAs had significant effects on soil properties and microbial P. Specifically, LMWOAs decreased soil pH and generally increased soil organic C, available P and microbial P. Statistical analysis showed that soil pH, organic C and available P had greater direct effects than indirect effects on microbial P, among which, organic C was the most positive direct factor.

Keywords: *Citric acid; Oxalic acid; Malic acids; Soil properties; Microbiological P*

P3-7

[IDS8] Soils, Land Use and Heat

Effect of Cadmium on Biomass and Qualities of Different Chinese

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With the rapid development of industry and agriculture, soil Cd pollution is more and more serious, because of soil Cd pollution has irreversibility and long-term nature, so it is difficult to remove the Cd from the soil, affects the yield and quality of soil, crop productivity. How safe and efficient utilization of soil Cd pollution, reduce the absorption of Cd concentration of agricultural products, has become a hot research topic. One way to solve this problem is: selection of low accumulation of crop varieties. The study was conducted at Research Station of Shenyang Agro-ecosystems. This Station locates on the Lower Liao River Plain, with a humid and semi-humid continental monsoon climate of warm-temperate zone. Mean annual temperature is 7-8°C, with minimum and maximum mean monthly temperature in January (-13°C) and July (24°C), respectively. Mean active accumulated temperature (≥10°C) is 3300-3400°C. The duration of frost-free season is 147-168 d. Mean annual precipitation is about 700 mm. Three rectangle micro-plot experiments were installed, and each micro-plot has an area of 12m × 13.5m. Three treatments were set up, i.e. (1) CK, the concentration of Cd was 0.26mg.kg-1, (2) T1, the concentration of Cd was 0.81mg.kg-1. 8 Chinese Cabbages were planted on 12 August 2012 and were harvested on 20 October in the same year. After harvesting, cabbage root and shoot were collected, washed with distilled water, blotted up the water and weighed the fresh weight (FW). After that, cabbage samples were firstly dried at 105°C for 30min, then dried them at 70 ℃ until constant weight, and measured its dry weight (DW). The dried plant samples were boiled and digested by mixed acid HNO3-HCLO4 (87:13, V/V), then Cd was determined by atomic absorption spectrophotometer (AAS Hitachi 180-80). Analysis of the soluble sugar content, soluble protein content in Chinese cabbage, the content of ascorbic acid and amino acid content, effect of Cd on Chinese cabbage quality, the main conclusions are as follows:

1. Biomass in the control treatment in 8 kinds of Chinese cabbage are 285.6 -1283.4g/plant, differences between varieties were significant ($P < 0.05$), biomass or order of Qiumei>Shuishiying91-2>Lvxing80>Yaguan>Beijingxin3>Dongbao>Qiuguan>Qinglvwang. In the pollution treatment, biomass of 8 species of Chinese cabbage are 495.7 -1157.8 g/plant, differences between varieties were significant ($P < 0.05$), the order of biomass are Shuishiying91-12>Beijingxin3>Qinglvwang>Qiuguan>Qiumei>DongBao>Yaguan>Lvxing80.
2. In the CK treatment, the Cd content range of 8 Chinese cabbage in the 0.16-0.36 mg kg-1 DW; in the pollution treatment the Cd content range of 8 Chinese cabbage are 0.189 -0.462mg kg-1DW. According to the Cd content in leafy does not exceed 0.2mg kg -1FW national standard of concentration limits of Cd in vegetables (GB2762-2006), in two Cd concentrations in this experiment, 8 kinds of overground parts Cd contents were lower than the national standard .
3. In the pollution treatment, the Cd content of Dongbao and Shuishiying91-12were lower than the national standard, biomass of overground parts was not affected by the impact of Cd pollution, and BF was less than 1.0, TF was more than 1.0, can be used as low accumulation planting security at the same levels of Cd concentration in soil.
4. Determination of 4 Chinese cabbage quality of overground, low Cd pollution increase low Cd accumulation Dongbao and Shuishiying91-12 soluble protein content and ascorbic acid content, and the difference reached significant level, while the effect on the soluble sugar content was not significant; the influence of the content of amino acid had no obvious regularity.

Keywords：*Chinese cabbage; soil Cd pollution; screening; low accumulate*

P3-8

[IDS8] Soils, Land Use and Heat

Qualitative Land Suitability Evaluation for Principal Crops of Southern Iran

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Qualitative land suitability evaluation is land efficinecy assessment for specific utilization or Land evaluation is the act of predicting the use potential of land on the basis of its attributes. The objective of this study was to evaluate qualitative land suitability for irrigated Wheat and barely crops about 10000 ha in kaftar lake located in southern Iran.the evaluation based on FAO framework and the proposed of Sys. Crop requierments of the land utilization types were determind using the table development by Sys et al and Givi.Growing cycle was determined These soils were classified based on semi details studies with 5 physiographic units and were classified in four orders of Alfiisols , Vertisols, Inseptisols and Entisols which consisted of eleven soil families based on soil data and Keys to Soil Taxonomy 2010. Qualitative evaluation was carried out using the square root of parametric (SRP) method and quantitative evaluation was performed on the basis of observed yields under an average management level. The results showed that in the surveyed area, the climatic class had moderate suitability (S2) for Wheat and barely due to limitations imposed by the relative humidity of the growing cycle. The most important land limitation factors were soil parameters like Salinity, pH, texture ,$CaCO_3$,gravels , as well as topography and drainage in the area of study. Based on qualitative evaluation 27.62% of land had non-suitable class (N1) for wheat and barely, respectively.

Keywords：*Qualitative land suitability evaluation, square root of parametric, irrigated Wheat and barely*

P3-9

[IDS8] Soils, Land Use and Heat

Access to Lysimeter Measurements with Affordable, Ready-To-Use Lysimeter Technology

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Field lysimeters are high precision tools to determine the water balance of specified measurement sites as interaction between soil, plants and atmosphere. A freestanding soil monolith with natural vegetation and under natural climatic conditions can be weighed with a high resolution. This way the evapotranspiration is measured directly. Therefore lysimeter data are basis for many hydrological models and important indication for soil internal processes such as relocation of soil or contaminants or biological activity of the soil. But because of their size and the necessary high accuracy and robustness lysimeters are expensive tools. Additionally the installation of lysimeter stations and the cutting of large soil monoliths require a high level of expertise and special equipment making the assist of a company essential. And according to the size of a lysimeter station of up to 3,5 x 3,5 x 4 m and a vessel with a length of up to 3 m and a surface area of up to 2 m² shipping or transport in general can be very expensive. Those costs are definitely adequate to well planed big lysimeter projects in order to get reliable and reasonable data but very high for just getting started with lysimeter technology or in case you are not sure if a lysimeter is an appropriate tool in your case.

The newly developed “Ready-To-Go” Lysimeter by UGT provides an affordable access to lysimeter measurements. It is a small lysimeter station for soil columns with a surface area of up to 0,5 m² and a length of up to 1 m that can be filled by hand (disturbed soil monolith) or be cut by UGT staff (undisturbed soil monolith). The “Ready-To-Go” Lysimeter comprises a compact PE-HD lysimeter station with integrated weighing system and seepage water reservoir with tipping counter, a PE-HD lysimeter vessel, a weather station, a data logger and a set of soil hydrological sensors. Everything is prepared to work as plug and play system so that the complete station can be set up and put into operation without any special staff or tools. The data can be displayed and read out on any PC that is connected to the internet using a data bank system and a server.

All this enables the application of lysimeter technology in hard to reach areas like countries with travel warnings or measurement sites far off the infrastructure and may help to establish measurement sites in poor countries to help improving the food security and save water and soil resources. Further they can help to determine the need of lysimeter technology at specific sites before making major investments thus improving the reasonable use of project budgets.

Keywords：*Lysimeter, Low cost, ready-to-use lysimeter*

P3-10

[IDS8] Soils, Land Use and Heat

Land Use Type as a Factor for Carbon Accumulation in Urban Soils from Elements of Green Infrastructure

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Urbanization and formation of dense populated urbanized centres poses questions related with quality of life and mitigation of climatic changes at local level. The finding the best solutions for environmental problems is these regions is related with creation and sustainable management of Green infrastructure in cities as well as improvement of soil quality as a main component of urban ecosystems. Carbon accumulated in soils is good indicator for presence of degradation processes in urban soils. In the context of climatic changes the carbon stock in soils are important for establishment of good practices and adaptation strategies. The present study focuses on carbon accumulation in urban soils (Urbic Anthrosols) from Sofia region (Bulgaria). Different forms of urban land use were studied through GIS and net approach application on elements of green infrastructure. The whole diversity of land use types is covered including grass areas, gardens, small forest parks, road alley stands etc., which were grouped in three land use types: 1. Lands under dense forest vegetation; 2. Urban green spaces; 3. Agricultural and abandonment lands. As control sites the main urban forest parks in Sofia were chosen for reference. Carbon content in urban soils (determined per soil layers 0-10 cm, 10-30 cm and 30-50 cm) from land use types 1 and 3 could be considered as average (> 2 %) for 0-10 cm, while in land use type 2 is low. Higher heterogeneity in carbon content distribution through the soil profiles of land use type 3 was determined. The highest soil carbon content was determined in control sites – the urban forest parks. The carbon stocks in soils in urban forest parks in Sofia varied in a high degree from 59 tCha-1to 125 tCha-1 due to differences in management practices applied. The processes of decomposition of organic substances in studied land use types are slower compared with these in urban forest parks. The results obtained confirmed the high potential of green infrastructure and urban forest parks to accumulated carbon and to contribute the mitigation of climatic change at local level.

Keywords：*urban soils, carbon stock, green infrastructure*

P3-11

[IDS8] Soils, Land Use and Heat

Restoration of Chernozems Fertility under the Influence of Green and Organic Fertilizers

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The paper presents the results of implementation the economic and available agrophitoameliorative procedures to remedy and long-term preservation the quality state of degraded arable chernozems in Republic of Moldova. As a result of incorporation of vetch green mass as an intermediate crop and 50 t ha-1 of manure was established that the organic matter in soils have increased by 1.3%, the soil physical parameters changed in favorable status, the harvest of winter wheat and sunflower have increased significantly by 2-5 times.

Keywords：*humus content, physical parameters, manure, vetch*

P3-12

[IDS8] Soils, Land Use and Heat

Land Use Change Effect on Carbon Stocks in Mountain Ecosystems from Rhodope Mountain, Bulgaria

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Land-use changes (LUCs') are widely accepted as measures for mitigating climate change through carbon sequestration. The present study focuses on the influence of interacting factors such as land use history, soil type, and climate on carbon stocks in different components of mountain ecosystems as well as on comparative analyses on effect of land use changes on carbon stocks in whole ecosystem. The data obtained is designated as a reference for changes in soil organic carbon. Five representative experimental sites were established in Rhodope Mountain. Each experimental site is characterized by a different type of forest-related land use –Douglas fir (Pseudotsuga menziezii Mirb. Franco) plantation, created on adjacent arable land and Scot's pine (Pinus sylvestris L.) and Black pine (Pinus nigra Arn.) plantations created on abandonment arable land. Results are discussed both for each sampled ecosystem component including soil, forest floor, natural regeneration and aboveground vegetation and for the whole ecosystem. The study confirmed the role of cropland afforestation as a soil carbon sink for the selected climatic zone but showed conflicting evidence for abandonment-forest land conversion and highlighted the need to consider the forest floor.

Keywords：*land use changes, soil, forest floor, biomass, carbon stock*

P3-13

[IDS8] Soils, Land Use and Heat

Quantifying Small-Scale Variability in Water Storage and Root Water Uptake on the Edwards Plateau, Texas

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On the karst Edwards Plateau in central Texas, woody plants, especially Ashe juniper and honey mesquite are invading grasslands and savannas. These plants typically have deeper roots than grasses and can potentially exploit more stable sources of water. Quantifying the water loss through tree roots to water uptake is crucial for understanding how much soil water eventually recharges groundwater. However, karst ecosystems are often characterized by soils that are shallow and rocky overlying bedrock or other substrates that limit water storage capacity and root growth, and create high spatial variability in plant available water. This complex below-ground structure, while not uncommon, has of not been adequately characterized by most hydrological models. In particular, we tested the hypothesis that shallow roots provide the most of water consumed by the woody plants on the Plateau. We evaluated water storage and root water uptake in the karst of the Edwards Plateau, at a typical savanna site with ~50% woody cover, mainly Ashe juniper (Juniperus ashei) and honey mesquite (Prosopis glandulosa). Water content profiles to a depth of 1.6 m were measured by neutron thermalization and time domain reflectometry at 36 locations in a 25 m × 25 m grid (5 m node spacing). Bulk density profiles were measured by gamma densitometry. Temporal changes in water storage were compared with eddy covariance measurements of evapotranspiration (ET) to evaluate relative amounts of ET originating from root water uptake at various depths. Water storage capacity in the measurement grid ranged from 185 to 401 mm, and coupled with heterogeneous distribution of trees created high spatial variability in root water uptake. Water uptake was higher beneath trees than beneath grass, in part because tree roots were able to extract water from regions of the root zone with high rock density. On average, 81% of the water uptake occurred from the upper 1 m of the profile with the greatest uptake occurring at depths of 0.4 to 0.8 m. An estimated 10% of the uptake occurred from below the maximum measurement depth of 1.6 m. While this result confirms the hypothesis that trees on rocky substrates take up water from greater depths compared to similar ecosystems on soil, it also refutes the view that trees in karst regions have greater access to groundwater.

Keywords：*Root water uptake, rocky soil, spatial variability*

P3-14

[IDS8] Soils, Land Use and Heat

Effect of Land Use Change on Soil Physical Properties of Disadvantageous Cultivated Areas

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The area of abandoned cultivated area has increased dramatically since 1980s in Japan. This is more noticeable in hilly and mountainous areas where many cultivated areas are disadvantageous because of their size and accessibility. Abandoned cultivated areas have many side effects as well. There are studies saying that they attract animals and birds that ruin crops in surrounding cultivated areas because they can hide inside bush. It is also known that they can damage the landscape. Recently, there has been a trend among owners of abandoned cultivated areas to plow and weed but not to plant so that areas are kept more-or-less bare and such side effects can be avoided. Those areas are referred to as "plowed-but-not-cultivated areas." Changes in land use directly affect the physical properties of the soil. When those abandoned cultivated areas and/or plowed-but-not-cultivated areas will be used again, we need objective data on soil properties to make prompt but appropriate decisions on land use. The main objectives of this study thus are to reveal the effect of plow-but-not-cultivate on soil physical properties of cultivated areas and to investigate the effect of changes in land use on soil physical properties at disadvantageous areas.

The study site is Fujimi-machi in Nagano prefecture, north east of Tokyo, Japan. The area is very hilly and mountainous and is known as disadvantageous as there has been no land consolidation in cultivated areas. This area is diminished as many cultivated areas have been abandoned, due to a shortage of successors and the cultivated areas have been damaged regularly by animals. In the last decade, many cultivated areas in this site became "plowed-but-not-cultivated." Soil samples were collected up to 100 cm depth from three fields: an area with no cultivation over more than 40 years, a plowed-but-not-cultivated area where the last cultivation was 3 years ago, and a typical cultivated area. Standard soil physical properties, such as organic matter content, hardness, density, quantity of large pores, water holding property and permeability, as well as soil aggregate stability have been measured for all soil samples. Soil aggregate stability is important for retaining high fertility and is related to organic matter content in the soil.

There are plough pans at the depth of around 30 cm in most areas. Our discussions are then focused on soil data from those above the plough pans. At the abandoned cultivated area, organic matter content was lower than the cultivated area. It is because organic fertilizer and plowing residues of farm products have been continuously supplied at the cultivated area. The hardness is lower and permeability is higher for the abandoned are than the cultivated area mainly because there has been no artificiality for a few decades. Although the amount of large pore is lower, water holding property is lower for the abandoned area. As for the plowed-but-not-cultivated area, soil physical properties, except hardness and the amount of large pores, have shown similar to those of the cultivated area. Hardness and the amount of large pores are higher than those for the cultivated area. It may be caused by the compaction of the soil during weeding. Although we can reduce weeding to resume cultivation at plow-but-not-cultivated areas, soil physical fertility may be deteriorated by artificiality like weeding. On the other hand soil physical fertility in abandoned cultivated areas may be improved by abandonment. As a result, we need a comprehensive plan for land use for the entire areas not for each area.

Keywords：*Abandoned cultivated area, Soil physical properties*

P3-15

[IDS8] Soils, Land Use and Heat

Temperature and Water Flow in an Agricultural Area under Different Land Uses.

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The temperature and water flow in agriculture areas may influence soil physical, chemical and biological processes, with consequences for the quality and quantity of the watersheds water resources. This study assesses the evolution of soil temperature, and of surface runoff and drainage from agriculture areas under different land uses. The study area is an agricultural catchment in southern Brazil under Atlantic Forest cover on a typical Aluminium Cambisol, characterized by the presence of incipient B horizon and aluminic in character through most of the first 100 cm of its B horizon. Two volumetric drainage lysimeters containing undisturbed 1m3 soil blocks are installed in the catchment, one cropped with maize (Zea mays) and the other under perennial pasture with batatais grass (Paspalum notatum). In each lysimeter, soil temperature at the surface was measured together with rainfall and profile water content measured by tensiometers at depths 10, 30 and 70 cm. Surface runoff and drainage flow were also measured, with all measurements recorded in the period 2010 to 2012. The annual average rainfall was 1715.8 mm, well distributed over the months, with a maximum of 305.9 mm recorded in August 2011. The daily average temperatures of topsoil were identical in both lysimeters, but temperature variability, as measured by standard deviation, was smallest in the pasture lysimeter, so that the heat flow within it was steadier. In this lysimeter, the daily average temperature ranged between 9.5 and 30.8 °C. The largest differences in daily averages temperatures were registered during the period of maize development. The runoff coefficient for the maize lysimeter was 0.013 compared with 0.025 for pasture. Drainage flow from the maize lysimeter was about 18% higher than that from the pasture lysimeter, resulting in a water loss by evapotranspiration of 48.5% in the maize lysimeter and 54.5% from pasture. Thus the greater variation in temperature in the maize lysimeter did not result in greater water loss through evapotranspiration. Under pasture, the soil is always covered completely and roots take up water all the time. Maize covers the ground for just a short period (~ 3 months) so that the amount of water transpired during the year is reduced, whilst crop residue from the maize left on the soil surface promotes infiltration, reducing runoff.

Keywords：*Lysimeter, agricultural land use, water flow*

P3-16

[IDS8] Soils, Land Use and Heat

The Design and Development of the Sustainable Land Management System in Ceylanpınar State Farm

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In this study, agricultural land sustainability of Ceylanpınar State Farm soils were predicted using MicroLEIS DSS (Computer based Mediterranean Land Evaluation Information and Decision Support System). The advantages and disadvantages of the MicroLEIS in arid regions as Mediterranean and Southeastern Anatolia Climate were studied. The Pro&Eco (Agro- ecological land evaluation system) and its five models were used in the study. The results shows that soil-water balances of almost all soil series were suitable for rainfed cultivation in the study area but frost risk were found limiting factor to productivity. Land capability classes were determined as S2 (Land with good agricultural use capability) and S3 (Land with moderate agricultural use capability). Crop yield were predicted on each soil series for wheat, cotton and maize. Ceylanpınar soil series were predicted as the best productive soil series for wheat cultivation as 5674 kg/ha, Aburman soil series were predicted the best productive soils for maize and cotton as 6693 kg/ha and 2955 kg/ha, respectively.

Keywords：*SLM, Agro-ecologic land evaluation, decision support system, MicroLEIS DSS*

P3-17

[IDS8] Soils, Land Use and Heat

Evaluation of Land Use in the Watershed of Ribeirao Extrema, Distrito Federal, Brazil, with the Aid of Remote Sensing Techniques

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The development and application of appropriate environmental management tools have been the target of several studies and researches, with emphasis on application of geotechnology, which include Geographic Information Systems (GIS) and Remote Sensing. The GIS facilitates managing spatial information and enable the elaboration of diagnostics and prognostics subsidizing the decision making. The Remote Sensing is an effective form of environmental monitoring at local and global scales. Whereas the sustainable use of natural resources in agricultural areas have been neglected in favor of increased areas of productivity and have reached critical levels resulting natural vegetation cover damage and water resources degradation, affecting the environment as a whole. Become necessary evaluations of vegetation, topography, drainage and soil classes in watersheds to subsidize data for planning and monitoring of appropriate uses, obeying the natural characteristics of the river basin, allowing the sustainable development. Thus the objective of this study was to evaluate the use and occupation of the lands of watershed Ribeirão Extrema, Distrito Federal, Brazil, which constitutes a tributary of the Preto River, belonging to the basin of the São Francisco River. And constitutes a representative area of the grain-producing region with the presence of highly technified handling, various important classes of soils and hydrous bodies. So to create the Map of use and occupation was used ALOS satellite images, sensor AVNIR, 1215 and 1216 scenes, 2011, with a spatial resolution of 10 meters, which are georeferenced and mosaicked and clipped with the aid of ENVI 4.8 software. The automatic classification algorithm using the Maximum Likelihood (Maxver) was applied on the clipped area, a procedure by which it was possible to identify classes of use and occupation of land and generate the corresponding thematic map. For the creation of Map use and occupation the following classes were established: Agriculture (characterized as an area of annual or perennial crop and fallow areas), Riparian Forest (vegetation located on the banks of water bodies, featuring Permanent Protection Areas - PPAs) Culture pivot (characterized as an area with annual direct planting with the presence of irrigation) and Field (featured with natural vegetation area with exposed soil association). Where due to time of year (August 2011) in which the imaging occurred, many agricultural areas were which exposed soil in the fallow season. Then was exported the classified image, which was implemented in the digital database previously created in ArcGIS 10, which also contains the planialtimetric base of DF in 1:10,000 scale, from which it was extracted the thematic maps of contours, htdrography and elevation points, all in vector files. Vector thematic maps, such as the Soil Map of the DF, Map Agricultural Land Capability Map of the DF and Geomorphology of the DF were also used. Subsequently the limit of the watershed was defined generating a vector file of area limit. The study area presents flat to slightly undular relief and dendritic drainage patterns. Through the Soil Map, the following classes of soils were identified: Typic Quartzipsamment (AQ), Cambisols (Cd), Plinthosols (HL), Hydromorphic (HI), Dystrophic Red Latosol (LEd) and Red-Yellow Latosol (LVd), with a greater predominance of LEd. Through Agricultural Aptitude Map, the dominance of class 2 (b) c was identified, and secondarily 1 (a) bc, 2 (a) BC, 4p, 5 (n), 5 (sn) and 6. On the Map of use and occupation, predominates the Agriculture class, occupied by diverse cultures, followed by classes' gallery forest, field and pivots. Where through joint evaluation to the maps of geomorphology, agricultural aptitude and soil, was observed that the bands identified as field areas are preserved because they are located in areas with slopes greater development of Cambisols. The Map generated of use and occupation and the Soils and Agricultural aptitude Maps implemented in ArcGIS 10 allowed evaluating the adequation of the use and occupation in relation to agricultural aptitude of the watershed Ribeirão Extrema, the evaluation proved to be an efficient tool to study the aptitude and land use, enabling the identification and classification of the areas through GIS techniques and remote sensing.

Keywords：*Sustainable Use, Agricultural aptitude, geo-processing, GIS, remote sensing*

P3-18

[IDS8] Soils, Land Use and Heat

Properties of Fly Ash from Pha Lai Thermal Power Plant and its Influence on Properties of Haplic Acrisol

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Fly ash is the end residue from combustion of coal in the furnace of thermal power plants. However, the disposal of high amount of fly ash from thermal power plants in Viet Nam (about 1,260 tons in 2011) has not be managed sufficiently, resulting in loss of land area and various environmental pollution. Therefore, fly ash management would remain a great concern in Viet Nam. Fly ash is considered to have a great potentiality in agriculture due to its efficacy in modification of soil health and crop performance. In this study, some properties of fly ash from Pha Lai thermal power plant and its influence on physical and chemical properties of haplic acrisol and crop growth and yield under were assessed. The results showed that fly ash mainly consits of quatz (SiO2) and mullite (Al2Si2O13) being spherical in shape with small particle size ranged from 1 to 8 μm. The most granular levels is from 0.05 to 1.0 mm and 0.05 to 0.01 mm account for 56.54 % and 28.50 %, respectively. Fly ash is alkaline (pH 9.45). It contains a rather high concentration of essential macronutrients including K, Ca and Mg with 23.55, 0.46 and 0.98%, respectively and consists main oxides of Si, Al and Fe with 49.52, 19.01 and 5.25 % (Fe2O3), respectively. Also, fly trash consists heavy metals such as Cu, Pb and Zn. The concentration of Zn in fly ash is low enough to be reused as a soil amendment for the improvement of soil quality and treatment of environmental problems. When fly ash was used as a soil amendment in peanut cultivation, the concentration of some essential macroelement (P, K) in haplic acrisol and growth of peanut was sufficiently improved. Besides, the granular level of clay was also increased together with the increase of amended fly ash concentration (the granular level of clay increased from 4.05 % in 0 % fly-ash-amended soil (termed as CT1) to 17.6% in 25 % fly-ash-amended soil (CT6) after 74 days in case 60% to 100% of non-planted soil), pH was increased in all experimental formulas (pH reached at 4.8 in CT1 and 7.35 in CT6). Also, total and dissolved K and P was increased proportionally with amended fly ash concentration, especially total K was reached at rich level and dissolved K reached at medium level (CT6) compared with poor level in CT1. Additionally, amending fly ash in soil was also improved peanut and low French bean growth and their growth was optimal at 10 % fly-ash-amended soil (CT4). Therefore, fly ash from Pha Lai thermal power plant (Viet Nam) is possible to reuse as a soil amendment for the property improvement of Haplic Acrisol and crop growth.

Keywords：*Fly ash, Haplic Acrisol, Pha Lai thermal power*

P3-19

[IDS8] Soils, Land Use and Heat

Changes in Climate and Soil Temperature Regime in Korea

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Thermal regime of soil in Korea was classified as thermal family for the soil of which temperature was above 15℃, and as mesic family for the soil below 15℃ following the Soil Taxonomy classification assuming annual temperature should have equilibrated with air temperature. Climate change has led changes in natural environment. As soil is a core component of natural ecosystem, soil thermal regime should have changed according to climate change. This subject was focused on analysis on soil temperature change during past 30 years and soil thermal regime in Korea. The air and soil temperature data collected from the 20 locations of the national weather observation network under the Korea Meteorology Administration were used. The average annual soil temperature at the 50-cm depth for 20 locations was 12.7℃, which was 2.0℃ higher than the average annual air temperature. The air temperature change in 20 locations was order of 0.17℃/10yrs during last 30 years since 1970's. The change in soil temperature was 0.23℃/10yrs at the soil surface, 0.3℃/10yrs at the 10-cm depth, 0.25℃/10yrs at 50-cm depth, and 0.28℃/10yrs at 1 m depth, that showed higher degree of change than air temperature. The relationship between soil temperature at 50-cm and air temperature showed Y = 0.945 X + 2.736 (r2=0.955). Up on this relationship, soil temperature distribution through out the country was expressed on the climate map. The soil of which soil temperature above 15℃ should be classified as thermal soil temperature regime, and under 15 ℃ as mesic.

Keywords：*soil temperature regime, digital map*

P3-20

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Typology of Soil-Ecological Risks for Desertification

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The environmental soil science as a new branch of soil science is actively developing in Russia in recent years. It is designed to comprehensively investigate the fundamental scientific problem of the role of soils in the biosphere and human life (Dobrovolsky, Kust, 2012). The issue of an adequate assessment of soil and environmental risks due to land degradation and increasing global environmental and climate changes, as well as the problem of the role of soil in complex multilateral phenomenon of desertification/land degradation were called among the important areas of environmental soil science (Kust , Andreeva , 2012; Rozov, 2012). An active scientific research is conducting for indicators for early warning and risk assessment of the soil degradation processes that lead in turn to the reduction of productive land and biological resources, as well as basic life support components: air, fresh water and fertile land.

It has been shown (Kust & Novikova, 1994 , 2006), that the main premises of desertification , creating risks to reduce the productivity of ecosystems and further land degradation are forming in soil, while the plant indicators tend to reflect the results of degradation.

The role of soils in the desertification phenomenon can be considered as a triad of basic propositions, which is the foundation for further understanding and typology of soil and environmental risks : (i) the soil play a significant role in the phenomenon of desertification by regulating the availability of moisture to plants, (ii) 'healthy' soil provide the stability of arid and dry ecosystems (the concept of ‘soil health’ requires an integrated 'physical' , 'chemical ' and 'biological' soil health), (iii) the soil is one of the main livelihoods and environments in which people live . On the basis of these provisions the different categories of soil-ecological risks are designed for their classification. In accordance with these approaches the typology of soil-ecological risks of desertification allows offering the guidelines for diagnosis and early warning of land degradation by actual soil indicators.

Criteria for evaluation of soil and environmental risks for the sustainable functioning of natural and agricultural ecosystems are developed based on the quantitative characterization of the link 'soil risk factor - biotic response'.

Soil-ecological risks as arising from the interaction of geographic, biological (ecological) and socio -productive systems are investigated by the methods of geo-ecology. In schematic form, the methodology includes steps such as risk identification , identification of risk sources, determination forming factors , identification of risk recipients, and choice of risk assessment techniques. With regard to the approaches used in the desertification risk assessment, this methodology is actively being developed in harmony with the present concept of DPSIR: Driving force - Pressure - State - Impact - Response (GEF KM: Land 2010). Another group of methodological approaches used to estimate soil-ecological risks involves the use of morphological and physiological analysis of risks in the application of agro-ecosystems related to specific crops (Rozov, Kust, 2007), and are implemented through (i) typology of risks with the classification of landscape and environmental, soil , farming and agro-chemical groups of risks, (ii) risk assessment and risk ranking by rates impact and sensitivity, (iii) grouping of risks for their management with categories of removable, preventable and controlled risks.

Keywords：*desertification, soil-ecological risks*

P3-21

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Effect of Reforestation Practice on Soil Carbon Sequestration: A Case Study in Seashore Windbreak Forest of Northeastern Taiwan

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Soil organic carbon (SOC) pool is the source and sink of carbon dioxide in the atmosphere. One of the most efficient strategies for reducing CO2 emission in forestry management is to increase the forest cover area. Recently the natural disturbance occurs more frequently, making the natural environment of forest growing destroyed. Reconstruction of forest stands in these environments with harmful conditions will have the effect of land protection, and also can result in increasing cover of forest accumulation and forest carbon sequestration. The study area was located at seashore, Wanli Township, Northeastern Taiwan. Reforestation was conducted in November, 2004. Litter fall and soil (0-5, 5-10, 10-30, 30-50, and 50-100 cm) were sampled by grid method (3 m × 5 m per grid), three replicated each grid for litterfall sample, and two replicates for soil samples. The control has ten grids (C1~C10) and the treatment has 40 grids (T1~T40). The main objective of this study was to evaluate and investigate the changes and effects of soil carbon sequestration after reforestation. The study results indicated that there is no obviously morphological change within soil profile, and the soil was classified as Typic Udipsamments based on Keys to Soil Taxonomy. The reforestation has no effect on soil bulk density. In addition, seashore reforestation has significant cumulative effect on soil carbon stocks in the study area. The mean dry weight and carbon stock of surface litterfall in the treatments was 3.6 times and 4.2 times than in the control, respectively. The estimated litter carbon sequestration rate (2005~2012) was 0.03 tons ha-1 yr-1 in the control area, and it was 0.11 tons ha-1 yr-1 in the treatment area. The summation of litter and soil carbon sequestration was 3.25 tons ha-1 in the control area, and it was 10.6 tons ha-1 in the treatment area. The summation of litter and soil carbon sequestration rate (2005~2012) indicated that it was 0.41 tons ha-1 yr-1 increased in control area and 1.33 tons ha-1 yr-1 increased in treatment area. The summation of litter and soil carbon sequestration in treatment area was 3.2 times than in control area. In Taiwan the frequently interference of typhoon and northeastern monsoon has great influence on the growth and survival of seashore windbreak forest. The results of this study suggested that indeed seashore forest reforestation projects and maintenance management, in particular the management of windproof bamboo fence, have a positive effect on the growth and survival for the seashore forest.

Keywords：*reforestation practice, seashore forest, soil carbon sequestration, Entisols*

P3-22

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Interactions between Soil, Grape Plant and Microbes in Vineyard Environment

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Cultivation of an industrial vineyard demands intensive management, entering of the big doses of mineral fertilizers, application of pesticides and herbicides. All it adversely affects soil and lead to it degradation and pollution. To avoid these adverse phenomena and to receive more non-polluting production it is necessary to enrich agrocoenosis with microorganisms and perennial grasses. Work is devoted studying of interaction between grape plants, introduced microorganisms with nitrogen fixation, phosphorus mobilization and bioprotected functions and their complex, perennial cereal and legumes grasses, and also their mixes. In a field experiment it is established that after three years cultivation grasses together with the brought microorganisms enriched soil with mobile forms of nitrogen and potassium without application of mineral fertilizers. It was marked stabilization of mobile phosphorus content. The soil was enriched with organic substances. The humus stock has increased to 20 t per hectare in a layer 0-60 cm. Soil structure was improved. The content of active carbonates breaking physiological processes of grape has decreased on 4-5 %. All these changes promoted strengthening of bushes growth, reduction of plant mortality. The grapes crop also increased. So in 2011 the crop on five years' bushes in control reached 24.8 t per hectare. The mix of grasses together with Diazofitⓒ preparation on base of active strain Agrobacterium radiobacter-204 and the Complex of microorganisms increased it by 15 %. Quality of grapes improved too. There were more sugars, acids and pH value decreased in berries. The best on influence on state, growth and efficiency of grapes recognizes a mix of grasses (rye grass + alfalfa) with the Complex of microorganisms. Such technology will allow improving quality of soil and do the cultivation of industrial vineyard more ecological.

Keywords：*soil, vineyard, microbes*

P3-23

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Spatial and Temporal Variations in Soil Properties, Plant Growth and Methane Emission from Lowland Rice of Myanmar

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It is essential to know the spatial variability of soil factors and their influence on the variability of crop growth and methane emission for developing site-specific management strategies of crop. For this purpose, a field experiment was conducted with two successive rice fields (1st field and 2nd field) in Kanyutkwin district, Pago Division, Myanmar. The fields were divided into fertilized and non-fertilized parts and all measurements were conducted at inlet, middle and outlet positions for both fields.
Decreasing trend of sand content, soil total nitrogen and total carbon content were observed, while silt content tended to increase from 1st inlet to 2nd outlet position. High grain yield and yield components were observed in 1st inlet, 1st middle and 1st outlet positions in the 1st field. Farmer practice of fertilization increased grain yield over non-fertilized part, but it was not significant in all positions in the 1st field. In the 2nd field, although grain yield significantly increased in all positions due to fertilization, yield was still lower than that in the 1st field. Considerable variations in CH_4 emissions were recorded among the positions, which were influenced by soil temperature, surface water pH, Eh, surface water depth, as well as clay and TC content of soil. The CH_4 flux of the outlet of the 1st field and inlet of the 2nd field were 53.2 and 66.5 g CH_4 m^{-2}, respectively, and were 2 to 2.5 times higher than that of other field positions. Seasonal average cumulative CH_4 emissions for the 1st and 2nd fields were 33.6 and 39.3 g CH_4 m^{-2}, respectively. The farmer's practice of fertilization reduced CH_4 emission in the 1st inlet (18.1%), 1st outlet (50.4%), 2nd inlet (15.9%) and 2nd outlet (13.4%). However, an increase in CH_4 emission due to fertilization occurred in the 1st middle (43.8%) and 2nd middle (7.7%). The higher emission in fertilized parts might be related to micro-elevation in the middle of the field, which led to a high loss of nitrogen as ammonia volatilization due to a shallow water depth.

Keywords：*fertilizer, grain yield, lowland rice, methane emission, spatial variation*

P3-24

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Anti-Wind-Erosion Characteristics and Key Influencing Factors of Bryophytic Biological Soil Crusts

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Although biological soil crusts (BSCs) play a significant role in erosion control, the extent of erosion reduction is affected mutually by vegetation, soil moisture, and other factors in the field. However, little understandings concerning these factors together or their combinations were reported so far. The present study simultaneously considered soil moisture content, vegetation coverage, and crust coverage, and the erosion–resistance characteristics of typical sandy bryophytic crusts and their key influencing factors were investigated through orthogonally design, and large scale wind tunnel simulation experiments to determine the balance between the "protection" and "destruction" of BSCs and to provide a basis for rational resource use. The results showed that below a wind force scale of 9 (wind velocity of approximately 24 m/s), soil moisture content had a highly significant effect on the wind–erosion modulus, sand–transport rate, the structure index of aeolian sand–flow, and threshold wind velocity ($P < 0.01$), the average value of wind–erosion modulus and sand–transport rate reduced 89.7% and 98.2% respectively, and meanwhile threshold wind velocity increased 50.6%, the structure index of aeolian sand flow decreased from 43.3% to 21.4% while soil moisture content increased from 0.37% to 4.15%. Furthermore, crust coverage had a significant effect on the erosion modulus and sand–transport rate ($P < 0.01$), these two index decreased 51.6% and 58.3% respectively while crust coverage increased from 60% to 90%. Thirdly, vegetation coverage had a highly significant effect on the sand–transport rate and erosion modulus ($P < 0.01$), these two index reduced 53.1% and 56.0% respectively while the vegetation coverage increased from 25% to 50%. Finally, based on the comprehensive consideration of three factors, BSCs should be protected strongly in the dry and windy season (spring and winter) to avoid exacerbating wind erosion, and can be disturbed moderately in the wet and weak wind season (early summer or late autumn) to improve the soil moisture without causing severe wind erosion.

Keywords：*bryophytic biological soil crusts; erosion modulus; sand transport rate;, structure index of aeolian sand flow; roughness; threshold wind velocity*

P3-25

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Soil Organic Carbon Change due to Agricultural Land Use in the Tropics - Comparison of Case Studies in Mozambique, Vietnam and Brazil

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Tropical soils are often highly weathered and tend to be less fertile. Even though, dense vegetation of rain forests can develop on those soils if climate conditions are favorable. Developing of those forests to farmlands leads to exposure of the vulnerable soil and easily leads to soil degradation. Strategies to maintain production at those conditions are required. Soil organic carbon (SOC) content has significant meaning for carbon sequestration, at the same time it is considered as an important indicator for soil fertility. The decrease or increase of SOC can give an insight to which direction the artificial land use is going. In this report, studies on field experiment as well as soil surveys on SOC changes conducted in Mozambique, Vietnam and Brazil are introduced. The aim of this study is to clarify the influence of agricultural land uses on SOC content and production under different soil and climate condition.

In Mozambique, the study site was Boane district, Maputo province, which has a savanna climate. Most of the studies soils belonged to lixisols. Frequent grassland fires are artificially set to clear the ground for grazing in this region. The average fire frequency in this study site was 1.5 times/year according to farmers inquiry. The pH of the surface soil 0-10 cm ranged from 4.2 to 9.2 and showed negative correlation with the fire frequency. SOC and soil total nitrogen (TN) of the surface ranged from 7.3-50.4 mg C g-1 and 2.4-14.3 mg N g-1, respectively. SOC showed positive correlation while soil TN showed negative correlation with the fire frequency. The number and coverage of the key grassland species as well as the yield showed no correlation with the fire frequency. At high fire frequency, the yield tended to decreased, indicating a negative effect of fire to the grass growth.

In Vietnam, the influence of biochar was tested at Hue, Central Vietnam, which is under the tropical monsoon climate condition. The studied soils were acrisols. A field experiment showed that the use of biochar combined with chemical fertilizer led to an significant increase in vegetable yield at the application rate more than 5 Mg ha-1, which was however dependent on the season. No significant SOC increase was found even at the rate of 25 Mg ha-1 at field condition if applied only one time. Continuous application of biochar mixed with manure for 4 seasons significantly increased SOC as well as cation exchange capacity. The yield of vegetables was significantly increased at this condition, even without fertilizer application.

In Brazil, cacao based agroforestry system at different establishment stages was investigated in Tome Asu, which climate is tropical rain forest. The soils were ferralsols. In agroforestry, SOC are expected to increase after the succession. In this experimental site, continuous agroforestry for 33 years still had lower SOC than natural forest, and showed no difference to bare soils. At surface, there was an increasing trend in SOC from 4, 10 to 33 years. The high sand content might be one reason for the low accumulation of SOC in the soil. CO2 emission was much higher in the forest compared to agroforestry systems. The productions of cacao as well as other products were maintained throughout the cultivation.

These examples showed that SOC is not necessarily a straight indicator for soil fertility. Site specific condition must be taken into account to understand the change in SOC.

Keywords：*Soil organic carbon, grassland fire, biochar, agroforestry*

P3-26

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Land Degradation and Gaseous Carbon Emission Caused by Fire in Tropical Peatland

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1. Introduction

In recent decades, large scale fires have occurred frequently in tropical peatlands in Southeast Asia, which were reclaimed for agroforestry and rice paddy. Current carbon emissions from drained and fire-affected peatlands in Southeast Asia have been estimated to be 360 TgC/yr, half of them were attributed to peat fires. To quantitatively evaluate the influence of peat fire on soil carbon loss and gaseous carbon emission, we conducted a plot-scale peat burning experiment.

2. Materials and Methods

The experimental site was established at an open area 20 km southeast from Palangka Raya, Central Kalimantan, Indonesia. The size of the burning plot was 4 m in length and 3 m in width. Gas samples of the burning plot were extracted through metallic tubes settled at heights of 1.0, 0.5, 0.0 (aboveground), -0.1, and -0.2 m (belowground). The concentrations of CO_2, CO, CH_4 and particulate matter (PM) was determined. Soil temperature was recorded every 10 minutes at -0.1 and -0.2 m. Twelve iron rods were installed in 1-m by 1-m square grid to determine the depth of burn scar. Shrubs and branches around the experimental site were cut and stacked on the burning plot as firewood. Artificial fuels such as kerosene and charcoal were not applied.
From the relationships between CO_2 concentration and other gaseous carbons, CO_2-normalized emission ratios were determined for each observation as the slope of regression lines in X (CO_2)-Y (CO, CH_4, or PM) plots. The total peat carbon loss was assigned to intervals of each observation in proportional to all gaseous carbon emissions in each interval. The gas emission during the flaming stage was assigned only to the stacked firewood, since in this stage peat soil had not substantially begun to burn.

3. Results and Discussion

After ignition, the stacked firewood was rapidly burned away within one hour. Soil temperature at -0.1 m increased tentatively but soon decreased again. After the peat soil began to smolder, the temperature largely increased and reached to 350-450°C at maximum. Response of soil temperature at -0.2 m was less prominent relative to that at -0.1 m. The smoldering stage continued for one week in spite of several times of rainfall.
Just before the experiment began, CO_2 concentration was decreased with height especially from the ground surface to 0.2 m. CO level was less than detection limited. CH_4 and PM contents were also very low. In most cases, concentrations of these gases became maximum just after ignition. During the smoldering stage, the concentrations gradually decreased. CO concentrations below the original ground surface were kept high. The influence of burning on CO_2, CH_4 and PM concentrations was prominently remained at -0.1 m; those at -0.2 m were not affected so much. After the peat burning was almost extinguished, the levels of these components returned to similar values before the experiment.
The average burnt depth was 7.5±6.2 cm. Given the bulk density of 0.22 g/cm^3 in the topsoil of the plot and the assumed carbon content of 55.5%, peat carbon loss from the plot was 110.2 kg (91.8 tC/ha). Based on the ratio of carbon emission during the flaming stage (from firewood) to that during the smoldering stage (from peat), carbon loss from the firewood was estimated as 27.1 kgC (22.6 tC/ha), one-fourth of the peat carbon loss. Page et al. (2002; Nature, 420, 61-65) estimated peat and biomass carbon losses from fire-damaged peatlands in the ex-Mega Rice Project area during 1997 as 106-127 and 63 tC/ha, respectively. The large biomass carbon loss reflected the large biomass of intact peat swamp forest.
In this experiment, most of these carbon losses were evolved as CO_2. The second major emission form was CO, which increased from 12% in the flaming stage to 20% in the last smoldering stage according to the increase in CO_2-normalized emission ratio of CO during the experiment (0.12 to 0.25). The proportions of CH_4 and PM were <1%. The total emissions of these gases were 112.5 kgC as CO_2, 23.8 kgC as CO, 0.357 kgC as CH_4, and 0.629 kgC as PM (assumed carbon content: 60 wt%). The CO_2 emission was equivalent to 4650 mgC/m^2/h, much larger than soil CO_2 fluxes previously observed in tropical peatlands (~100 to 500 mgC/m^2/h).

Keywords：*carbon emission, emission ratio, Indonesia, peat fire, tropical peatland*

P3-27

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Effect of Manure and Fertilizer Application on Greenhouse Gas Emissions and Global Warming Potential in a Corn Field in Shin-Hidaka, Hokkaido, Japan

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Agricultural production is a major contributor to global greenhouse gas (GHG) emission and global warming potential (GWP). Proper fertilizer and manure management can mitigate these effects. To evaluate the effect of chemical fertilizer nitrogen (N) and manure applications on GHG emissions and GWP, a 3 -year field experiment was conducted from October 2010 to October 2012 in a corn field in southern Hokkaido, Japan. Five plots were established namely: chemical N fertilizer only (F); composted cattle manure only, applied since 2005, (M); both manure and chemical N fertilizer applied since 2005 (MF05) and 2010 (MF10) respectively; and control plot (CT) with neither chemical N nor manure application. GHG fluxes from soil surface were measured using a closed chamber method at 4 replications. A root exclusion plot was set up to estimate heterotrophic respiration (RH). Carbon (C) balance was estimated as net biome production (NBP), and calculated as difference between C inputs (net primary production (NPP), manure) and C outputs (harvest, RH). GWP was estimated as sum of carbon dioxide (CO2) equivalents from methane (CH4), nitrous oxide (N2O) and NBP. Total mineral N supply was estimated as sum of N mineralization from soil and manure (estimated from RH values in CT and M plots and C/N ratios of soil and manure) and fertilizer N. NPP in MF05 and MF10 plots were 8.4±1.4 and 8.2±1.9 Mg C ha-1yr-1 (mean ±SD) and were significantly higher ($p<0.05$) than in F plot (6.8±0.7 Mg C ha-1yr-1). NPP values in MF05, MF10 and F plots were significantly higher than in CT and M plots ($p<0.001$), whose NPP was 3.0±0.4 and 3.6±0.9 Mg C ha-1yr-1, respectively. There was no significant difference in NPP values between M and CT plots. RH values in MF05, MF10 and M plots were 8.9±1.2, 9.0±0.7 and 9.0±1.7 Mg C ha-1yr-1, respectively, and were significantly higher than in F and CT plots (5.9±1.0 and 6.7±0.1 Mg C ha-1yr-1). There was no significant difference among MF05, MF10 and M plots. NBP values in MF05, MF10 and M plots were -0.8±1.0, -0.9±1.3 and -2.1±2.2 Mg C ha-1yr-1, respectively, which were significantly higher than NBP in F and CT plots (-5.0±1.2 and -6.1±0.4 Mg C ha-1yr-1, respectively.) Manure application significantly increased NBP ($p<0.001$), and NBP was highest when manure and fertilizer were combined. CH4 emissions were not different among all plots, and ranged from -0.7 to 5.1 kg C ha-1 yr-1. N2O emissions were 12.7±5.2, 14.9±7.6, 22.4±12.5, 8.6±4.3 and 4.4±1.2 kg N ha-1 yr-1 for F, MF05, MF10, M and CT plots, respectively. There were significant differences in N2O emission among plots ($p<0.001$) and across years. N2O emissions were significantly highest in MF10 plot, followed by MF05 and F plots, and lowest in M and CT plots respectively. N2O emissions in M and CT plots were not significantly different. N2O emission had positive correlations with total mineral N supply ($r=0.62$, $p<0.05$) and precipitation in growing season ($r=0.56$, $p<0.05$), and a negative correlation with soil pH ($r=-0.72$, $p<0.01$). N2O emission in MF05 plot was lower than MF10 plot due lower pH in MF10. Long term manure application in MF05 buffered against lowering of pH by chemical fertilizer application. Both chemical fertilizer and manure applications increased N2O emissions compared to control plot. GWP over the 3 years was 2.8±1.6, 3.7±0.9 and 3.2±1.7 Mg CO2-C eq ha-1 yr-1 in MF05, MF10 and M plots, respectively, and it was 6.6±1.9 and 6.7±1.6 Mg CO2-C eq ha-1yr -1 in F and CT plots. GWP was significantly reduced with manure application, but not with chemical fertilizer application. NBP was largest contributor to GWP in F, CT and M plots, accounting for 65-91% of net GWP, while in MF05 and MF10 plots, N2O emission was largest contributor with 68-76%. CH4 contribution was less than 0.5% in all plots. Our results suggest that chemical fertilizer application is important to increase NPP, but leads to higher net GHG emissions, while manure application does not significantly increase NPP but has potential to increase NBP. Combining manure and fertilizer has potential to increase NPP and NBP and reduce GWP.

Keywords：*composted cattle manure, chemical fertilizer, Greenhouse gas emissions, Global warming potential*

P3-28

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Spatial Variations and the Controlling Factors of Greenhouse Gas Fluxes from Drained Forest and Burnt Land on Tropical Peatland

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Peatland stocks 1/4 of terrestrial carbon, though peatland occupies 3% of global terrestrial area (Maltby and Immrzi 1993). Tropical peatland occupies 11% of global peatland area (Page et al. 2011). Researchers about carbon dynamics in tropical peatland have clarified mainly two things: (a) greenhouse gas (GHG) fluxes are different among land-uses, and (b) groundwater depth is the major controlling factor for GHG fluxes (Couwenberg et al. 2010). However, above knowledge were mainly based on the annual emissions and the average values, and the spatial variation was not considered. Our objectives of this study are (1) to evaluate the spatial variations of GHG fluxes, and (2) to make clear the controlling factors of spatial variations of GHG fluxes in tropical peatland.

We studied in Kalampangan, near Palangka Raya, Central Kalimantan, Indonesia in July 2011, which was the beginning of the dry season. The soil type was Fibric Histosols (WRB 2007), and the peat depth was 3 - 5 m. This area was developed by Ex-Mega Rice Project from 1996 to 1999 (Limin 2007), and has been drained by the canal. Because of the canal drainage, the huge area of drained forest was burnt in the dry seasons every year, and became the burnt land (Page et al. 2002). We set 18 transect plots with the 500 m intervals between Kahayan River and Sebangau River, which covered the drained forest (6 plots) and the burnt land (12 plots). We measured CO2, CH4 and N2O fluxes by the closed chamber method (Morishita et al. 2003). Additionally we measured groundwater depth, soil temperature at 4-cm depth, volumetric soil water content. We took the disturbed soil sample from the surface 10 cm, and measured soil pH and soil NO3 content.

CO2 flux was significantly larger in the drained forest with 240.9 ± 78.4 mg C m-2 h-1 (Ave ± SD) than in the burnt land with 93.9 ± 52.6 mg C m-2 h-1 ($p < 0.01$), which showed that the deep groundwater depth in the drained forest promoted the organic matter decomposition of peat soil. On the other hand, CH4 and N2O fluxes were not significantly different between the drained forest (3.02 ± 98.8 μg C m-2 h-1, 20.7 μg C m-2 h-1) and the burnt land (909.8 ± 2267 μg C m-2 h-1, 37.2 ± 115.6 μg N m-2 h-1). However, 5 in 6 plots in the drained forest showed the negative CH4 fluxes, whereas 11 in 12 plots in the burnt land showed the positive CH4 fluxes. We applied stepwise multiple regression analysis for CO2 flux for which soil water content, pH and soil temperature were used, and N2O flux for which soil water content or groundwater depth, pH and NO3 were used. Only soil water content was selected for CO2 flux, which was the negative correlation ($p < 0.001$, $R2 = 0.59$). pH and NO3 were selected for N2O flux in the drained forest ($p < 0.01$, $R2 = 0.91$), which showed that the soil chemistry was the major controlling factors because soil water content was already optimal in the drained forest. Groundwater depth and NO3 were selected for N2O flux in the burnt land ($p = 0.22$, $R2 = 0.14$), which showed N2O was completely denitrified to N2. CH4 flux had the negative exponential correlation with groundwater depth ($p < 0.01$, $R2 = 0.46$), which showed the drastic increase in CH4 flux by the increasing groundwater depth.

We concluded that the spatial variation of GHG fluxes was large in tropical peatland, especially in case of CH4 and N2O fluxes. These spatial variations were controlled by the spatial differences of water condition and soil chemistries of the peatland. Large spatial variations of GHG in tropical peatland should be considered to calculate the GHG inventory.

Keywords：*greenhouse gas emission, tropical peatland, spatial variations, Central Kalimantan*

P3-29

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Influence of Nitrogen Fertilizer Application Practices on Nitrous Oxideemission from Tea Soil in Japan

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Quality of green tea is mainly determined by the content of total nitrogen(N)or free amino acid (Muhammad, et al., 1974). Nitrogenis the most important nutrient for improving yield and quality of tea, which led to heavy N application in Japanese tea fields (Oh, et al, 2006).Heavy Nfertilizer application causes many serious environmental problems such as soil acidification and nitrate (NO3-) contamination in water. Besides, nitrous oxide(N2O) gas isproduced during the microbial processes of nitrification and denitrification process in soil (Velthof, 2003). N2O is a greenhouse gasand alsodestroys the ozone layer (ICCP, 2007). Thus, the objectives of this study wereto assess the N2O emissions and their sources under different fertilizer types and amounts, and to assess the contributions of N2O emissions from soil on row and soil under canopy to whole N2O emissions in the field.

This experiment wasconductedin a tea field in Japan from March, 2011 to July, 2012. Fourtreatments were set: no fertilizer(CONT), conventional fertilization, 660kgN ha-1 y-1by (NH4)2SO4 and 240kgN ha-1 y-1 by poultry manure(CONV:), chemical fertilization, 900kgN ha-1 y-1 by (NH4)2SO4 (CHEM:), half of conventional fertilization, 330kgN ha-1 y-1 by (NH4)2SO4and 120kgN ha-1 y-1 by poultry manure(1/2CONV). Basic fertilizer wasapplied at the first time, which were 660kgN ha-1 y-1in CONV andC CHEM, 330 kgN ha-1 y-1in 1/2CONV.that the remaining amounts were split to even amount and applied bimonthly for 4 times. Gas samples were collected at 1, 2, 4, 7, 10, 20, 35 and 50 days after every fertilizer applicationsby closed chamber.

There was little N2O emission afterthe 1st fertilizer application and in winter season. However, large amount of N2O were emitted in the all fertilized treatmentsafter2nd fertilization. The N applied at early spring is transported to first flush shoots.The amount of N taken up by tea gradually decreased from June to August. Low soil temperature led to decrease inmicrobial activities involved in N2O production (Smith et al., 1998). The correlation analysis in this experiment showed that N2O started to increase when the soil temperature was higher than 12°C.

The accumulated amount of N2O emission was lowerin CONV than in CHEM. Organic fertilizer release the N slowly and leads to more efficiently N uptake by tea plant and minimize nutrient losses to the environment (Snyder et al. 2007), thus, reduced N2O emissions. The highest amount of N2O emission at CHEM was due to highest N availability by constant application of chemical fertilizer. The N2O emission was lower in 1/2 CONV than half of that in CONV especially in the summer season, suggesting that the amount of fertilizer applied in 1/2 CONV taken up by tea plant most efficiently.

In CONV, high NO3- concentration was found and combined with the readily available carbonfrompoultry manure resulted in increasedmicrobial activity which usedoxygen and led to more anaerobic microenvironment in soil. Thus, enhanced denitrification in CONV treatment might be the reason for the high N2O emission. In case of CHEM, soil NH4+ concentration increasedmore rapidlyright after the application of fertilizer than that in CONV.Thus, nitrification process was considered to be the main contribution for high N2O emission inCHEM.1/2 CONV did not show sharp peaks due to the lowerconcentrations of soil NO3- and NH4+.

Nitrous oxideemissions from soil under tree contributed to55% of entire tea field.The N supplied by litter was the main source of N2O from soil under canopy. The applied fertilizer on row runoff by rain and spread to the soil under canopy was considered to be another reason.

Keywords：*tea fields, nitrogen fertilizer, nitrous oxide*

P3-30

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Degradation of Forest Soils with Low Acid Buffering Capacity in Cryptomeria Japonica and Chamaecyparis Obtusa Stands during Two Decades

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In Japan, there are two major plantation tree species: Japanese cedar (Cryptomeria japonica, D. Don) and Hinoki cypress (Chamaecyparis obtusa Sieb. et Zucc.). Japanese cedar prefers a moist and nutrient-rich soil, and it has a unique trait to accumulate calcium (Ca) in the surface soil with tree ages. In contrast, Hinoki cypress has been reported to grow on a relatively dried and acidic soil with low Ca with tree age. Surface soils in Japanese forests are generally acidic with both low Ca and Al contents and were divided into four groups using the concentrations of base cations and Al. Especially, forest soils with low acid buffering capacity (ABC), i.e., low base cations and high Al, can be susceptible for increasing acid deposition and acceleration of soil acidification. Until now, no studies have been evaluated changes in ABC with the different Japanese tree species as they grow. In this study, it was hypothesized that ABC of forest soils become higher with growing Japanese cedar, whereas the ABC become lower in Hinoki cypress forests, in spite of soils with high or low ABC. The objective of this study was to clarify changes in ABC of forest soils under Japanese cedar forests and Hinoki cypress forests in two contrasting ABC in the last two decades. To achieve this objective, we selected each of 4 Japanese cedar stands with the high or low ABC levels. In Hinoki cypress, 3 and 4 stands were selected for high and low ABC levels, respectively. The ABC level has been defined by the following two criteria: the concentrations of exchangeable cations and exchangeable aluminum (Al). The soils with high ABC have higher base cations than 50 mmol(+) kg-1 and lower exchangeable Al than 54.4 mmol(+) kg-1. The soils with low ABC have lower base cations than 50 mmol(+) kg-1 and higher exchangeable Al than 54.4 mmol(+) kg-1. We compared direction of changes in ABC from the archive soils (sampled from the same sites in nationwide study by Forest Agency of Japan in 1990's) to the present soils (sampled in 2010's). The shift index of soil chemical properties concerning ABC (dimensionless) was defined as a ratio of the present (2010's) to the past (1990's).

In Japanese cedar, two contrast trends of ABC were observed in the two groups of soils with high or low ABC. The shift indexes of base cations varied ranging from 0.53 to 0.91, meaning that the concentrations clearly decreased during the period from 1990's to 2010's in the low ABC sites. The index of exchangeable Ca was 0.5 or less in the low ABC sites. In contrast, the index of base cations in high ABC stands varied from 1.13 to 2.28, indicating that the base cation concentrations obviously increased during the period. The indexes of exchangeable Al concentrations varied from 0.28 to 1.10 in the high ABC stands, whereas they were relatively higher in the low ABC sites ranging from 0.99 to 1.43.

In Hinoki cypress, the shift indexes of base cations varied from 0.38 to 0.89 in the low ABC sites, and 0.30, 0.76, 1.18 in three soils of the high ABC sites. Thus, base cation concentrations decreased in the two soil groups with except one sites. The indexes of exchangeable Al were almost equal to 1 and more in the two Groups (ranging from 0.86 to 4.50). The increment degree of the shift index for exchangeable Al concentration in the low ABC sites was larger in Japanese cedar than in Hinoki cypress.

These results suggest that the soil with low ABC in Japanese cedar has more sensitive to soil acidic condition, and thus it leads to soil degradation.. Moreover, the soils with both high and low ABC in Hinoki cypress have potentials to accelerate the depletion of base cations and the increase in exchangeable Al. We conclude that the plantations of Japanese cedar and Hinoki cypress in the soil with low ABC cannot be recommended from the view points of soil degradation; shortage of base cations and increase of Al toxicity i.e., soil buffering from acidification.

Keywords：*acid buffering capacity, Chamaecyparis obtusa, Cryptomeria japonica, exchangeable aluminum*

P3-31

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Land Use Change Effect on Carbon Balance: From Managed Grassland to Corn Field

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Terrestrial ecosystems in which carbon (C) is retained in live biomass, decomposing organic matter and soil play an important role in the global C cycle (Watson et al., 2000). Exchange of C between the atmosphere and the ecosystem occurs naturally through photosynthesis, respiration and decomposition. Main import of C into the ecosystem occurs via photosynthesis as assimilation of atmospheric CO2 (gross primary production; GPP). A large part of this uptake is counter balanced by the respiration of plants and soil microorganisms (ecosystem respiration; RE). Difference of both processes is denoted as net ecosystem production (NEP). The NEP represents mainly the amount of C used to produce new biomass. The aboveground biomass is available for harvest and the contained C is exported from the ecosystem and has to be considered as well in the C budget. The sum of all C imports and exports equals the change of the carbon stored in the soil (net biome production; NBP). In this study, C balance was measured in managed grassland from 2008 to 2012, and from 2013 it was measured in corn field (Zea mays L.) converted from managed grassland. In Japan livestock farmland, managed grassland is converted to cultivation corn field to product maize for feeding livestock is accepted. These changes may have influence on the greenhouse gas emissions from soil. Therefore, strengthening the study about the effect of a conversion from managed grassland to corn field on the C balance can provide important data which useful to manage and control C cycle in livestock farms. The objective of this study is to find out the effect of land use change on the C balance.

This study was conducted in a livestock farm of Niikappu Station, National Livestock Breeding Center, Shin-Hidaka city, Hokkaido. Eddy covariance method (EC) and biometric method was used to measure the C balance. In the managed grassland, dairy cattle manure was applied at the rate of 10 Mg fresh matter ha-1 yr-1 (13-24% C; 1-2% N), while in the corn field about 50 Mg fresh matter ha-1 yr-1 (13-24% C; 1-2% N). Daily NEP and GPP in the corn field was higher than in the managed grassland, while RE between managed grassland and corn field was similar. The annual NEP was ranged from 1.7 to 2.4 Mg C ha-1 yr-1 in the managed grassland and 1.8 Mg C ha-1 yr-1 in corn field. The annual GPP in the managed grassland (15.9-19.0 Mg C ha-1 yr-1) was higher than in the corn field (14.9 Mg C ha-1 yr-1). The annual RE in the managed grassland ranged from 13.3 to 15.9 Mg C ha-1 yr-1, and was also higher than in the corn field (13.0 Mg C ha-1 yr-1). Aboveground NPP (ANPP) was higher in the corn field (10.3 Mg C ha-1 yr-1) than in the managed grassland (2.7-4.7 Mg C ha-1 yr-1). BNPP was estimated from NEP measured by EC, and ANPP and heterotrophic respiration (RH) as (BNPPest = NEP - (ANPP - RH)), then NPP estimate (NPPest) was obtain from ANPP + BNPPest. The annual BNPPest was ranged from 2.5 to 4.0 Mg C ha-1 yr-1 in the managed grassland and 0.1 Mg C ha-1 yr-1 in the corn field. The average ratio of ANPP to NPPest was 0.50 during 5 years in the managed grassland and 0.99 in the corn field. This indicated that in the corn field the distribution of growth among plant parts was maximized in the aboveground. Manure decomposition (RHm) was estimated from the different value between RH between manure plot and fertilizer plot. RHm was ranged from 0.0 to 0.1 Mg C ha-1 yr-1 in the managed grassland and 1.8 Mg C ha-1 yr-1 in the corn field. Thus, the average rate of C loss from the applied manure was 3% in the managed grassland and 32.4% in the corn field. In the managed grassland, NBP during 5 years was ranged from -0.7 to 1.5 Mg C ha-1 yr-1. In the corn field, NBP was ?2.5 Mg C ha-1 yr-1, it was lower than the managed grassland, indicating that the conversion from managed grassland to corn field leads to a net release C to the atmosphere.

Keywords：*NEP, BNPPest, RHm*

P3-32

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Use of Soil and Nutrient Management Practices for Restoration/remediation Quality of Eroded Soil

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Intensive ploughing, high rate of erosion and soil organic matter exhaustion induce the degradation of agriculture land and the loss of soil quality and crop productions. Many soils in Mississippi were degraded by erosion and nutrient depletion when these were row-cropped years ago. Permanent reductions in crop productivity of eroded soils are caused by changes in soil physical, chemical and biological properties. Also considerable work has been carried out on the application of broiler litter for improvement of the soil physiochemical conditions and enhanced crop production. However, not much attention has been devoted to determine the effects of long-term broiler litter application on the restoration and quality of degraded soil. An experiment was conducted at the Plant Material Center, NRCS, in Coffeeville Mississippi on a degraded Loring silt loam soil to determine restorative potential of poultry manure, soil and crop management on selected soil physical, chemical and biological properties. Treatments included a tillage variable (till vs no-till) and poultry manure at the rate of 0, 9, and 18 Mg ha-1 applied every other year to corn followed by winter wheat for grain. Changes in soil physical, chemical, and biological properties as well as grain yield were evaluated every year. The results indicated soil pH in the surface 0-7.5 cm depth increased with increasing poultry manure rate ranged from 4.1 for the control to 5.6 for the highest manure rate of 18 Mg ha-1. The addition of poultry manure at the highest rate (18 Mg ha-1) increased soil total C and N concentrations by 61and 53% and soil P content by 7 fold (from 4.6 to 32.2 mg kg-1). Soil bulk density reduced by 10% (from 1.39 to 1.26 g cm-3) and hydraulic conductivity increased by 2.4 fold (from 3.6 to 8.6 cm h-1) with poultry manure application. Increasing soil physical indicator values most likely attributed to increasing soil organic matter resulted from manure application and cropping systems. In addition, corn and wheat grain yield increased with increasing poultry manure application and the results were greater under the deep tillage than no-till system. This indicates that application of poultry manure and cropping system along with tillage can be considered as a good method for restoring the quality and productivity of degraded land.

Keywords：*Erodded soil, tillage, poultry manure, remediation, soil quality, C sequestration*

P3-33

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Evaluation the Criteria and Indicators of Soil Degradation in Semi Arid Area of East Qazvin

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Soil degradation phenomenon is insensible but very dangerous and its continuation lead to the land degradation, particularly in arid and semiarid regions, that have high social and economical losses. More than 90 percent of Iran's areas are located in arid and semiarid regions. The purpose of this study was to determine the effective soil degradation criteria and indicators in 44560 hectares of east Qazvin province areas. Five criteria including ground water, vegetation, soil quality, climate, and management, Consists of 26 indicators for soil degradation assessment according to the conditions of case study region. The results showed that the soil of case study are considerably degraded, so that between selected criteria soil quality and management criteria, respectively with numerical value of 1.532 and 1.570 had the greatest impact on soil degradation. Among the indicators studied, soil organic matter, electrical conductivity of groundwater and administrative policies respectively with numerical value of 1.87, 1.81 and 1.77 were the most effective indicators of the soil degradation severity and three indicators of soil depth, slope, and groundwater pH, respectively with the numerical values of 1.36, 1.34 and 1.27 have the lowest impact on soil degradation in the case study region.

Keywords：*Soil degradation, Indicators, Criteria, Qazvin, Iran*

P3-34

[IDS9] Key Processes and Factors to Mitigate Land Degradation

The Effect of Fertilizer and Manure Application on Greenhouse Gas from Grassland and Cornfield in Japan

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Recently, greenhouse gases (GHG) emission i.e. carbon dioxide (CO2), nitrous oxide (N2O) and methane (CH4), from human activities have become the main cause of global warming. Accumulation of organic matter (OM) (e.g. litter and manure) in grassland increases organic carbon in the soil. Renovation of grassland leads to a rapid decline in soil carbon, and promote N2O emission with enhanced N mineralization. Furthermore, the application of fertilizer and manure increases N2O emission with increasing mineral N. Therefore, the objectives of this study were: (1) to compare the GHG emissions from the soil surface before and after the land use change from grassland to cornfield, and (2) to find out the effect of manure and fertilizer application on GHG emissions. The study was conducted in Shin-Hidaka, Hokkaido. The study was conducted from November 2011 to October 2013, and the grassland was converted into cornfield on 15th November, 2012. Three treatment plots were set up in grassland and cornfield; first is chemical fertilizer (fertilizer plot); second one is cattle manure and chemical fertilizer (manure plot); and the last one, without chemical fertilizer or manure (control plot). In manure plot, dairy cattle manure was applied at the rate of 10 Mg fresh matter (1.3 Mg C) ha-1 year-1 in grassland, 50 Mg fresh matter (5.5 Mg C) ha-1 year-1 in cornfield. CO2, N2O, and CH4 fluxes were measured using closed chamber method. CO2 flux in planted treatments was considered as soil respiration (RS). Organic matter decomposition (OMD) was also measured as CO2 flux from bare plots.Both RS and RH (heterotrophic respiration) showed a strong positive correlation with soil temperature in all plots and treatments both in grassland and cornfield, and increased after plowing in November 2012, and decreased with time. The RS of fertilizer, manure and control plot was 10.4 ± 0.6, 10.5 ± 0.6 and 10.6 ± 0.5 Mg C ha-1 year-1 in grassland, and 6.4 ± 1.1, 9.8 ± 0.9 and 6.7 ± 0.5 Mg C ha-1 year-1 in cornfield respectively. RS was smaller cornfield than in grassland in all plots except manure plot. On the other hand, annual OMD in the fertilizer, manure and control plots were 4.6 ± 0.5, 5.4 ± 0.4 and 4.8 ± 0.8 Mg C ha-1 year-1 in grassland, and 5.5 ± 0.9, 8.1 ± 1.2 and 6.5 ± 1.0 Mg C ha-1 year-1 in cornfield. OMD in cornfield tended to be higher than grassland ($p<0.1$). There was no significant difference in OMD among plots of grassland, but in cornfield OMD was significantly higher in manure plot than in fertilizer and control plots, probably due to the large amount of manure application in the cornfield compared to grassland. Annual CH4 emission ranged from -1.2 to -0.2 kg C ha-1 year-1 in grassland and -1.5 to -0.6 kg C ha-1 year-1 in cornfield. Both land uses were net CH4 sinks. There was no significant difference in CH4 emission between both land uses and among the plots.

In grassland, peak of N2O flux was observed after second harvest with the increase of soil NO3- concentration. This might be due to mineralization of supplied fresh OM with high soil temperature, and nitrification and denitrification. Peak of N2O flux in cornfield was observed in all plots in June, and it was higher than that in the grassland. Soil NO3- concentration also increased in all plots at the same time. Small peak of N2O flux was observed in all plots just after plowing in November 2012, and decreased with time. Based on N2O-N/NO-N ratio, the small N2O peak was caused by denitrification. The annual N2O emissions in the fertilizer, manure and control plot were 1.9, 1.5 and 2.3 kg N ha-1 year-1 in grassland, and 5.7, 6.4 and 5.7 kg N ha-1 year-1 in cornfield, respectively. N2O emissions in cornfield were higher than in grassland ($p < 0.01$), but there was no significant difference among plots in both grassland and cornfield.

Results of this study suggest that conversion of grassland to cornfield decrease RS while increases OMD and N2O emission, and the effect of land use change had a significant effect on N2O emission compared to fertilizer or manure management.

Keywords：*grassland, cornfield, organic matter, CO2,CH4,N2O,chemical fertilizer, manure*

P3-35

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Evaluation of Effect of Clean Agriculture in Upland Field in Toya and Iwamizawa, Hokkaido Japan

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Increase of concerns about environmental pollution from agriculture leads to an expectation of development of clean agriculture in the world. Clean agriculture in Hokkaido has been developed since 1993. The clean agriculture aims to construct sustainable agriculture with proper fertilization based on soil analysis, and effective usage of manure. It is known that manure application maintains soil functions and contributes to mitigate CO2 emission through soil C sequestration. Agricultural management closely related to greenhouse gas emissions. Excess application of chemical fertilizer and short term manure application enhances N2O emission. However, the effect of long-term manure application on N2O emissions has not been studied well. Objectives of this study are to evaluate the effect of long term manure application in the clean agriculture on soil fertility and greenhouse gas emissions.

This study was conducted in Toya and Iwamizawa regions in Hokkaido. Clean agriculture has been conducted about 15 years in the two regions. Soil type is volcanic ash soil and alluvial soil, respectively. Mean annual temperature is 6.5 and 7.6 °C; annual precipitation is 870 and 1163 mm; cropping system is four or five crops (soybean, wheat, potato, beat etc.) rotational and single crop (onion) cultivation, respectively. Soils were sampled from top 0-20 cm depth at three replicates before and after fertilizer application in Toya and Iwamizawa, respectively, in 2012. In Toya, 34 fields managed by clean agriculture were chosen, with reference data before clean agriculture started in 2001 to 2003. In Iwamizawa, 9 fields were chosen for conventional and clean-agriculture managements, respectively.

Fresh soil samples were stored at 5 °C in the laboratory and were used to analyze pH, electrical conductivity (EC), water extractable soil organic carbon (WESOC) and NO3- in 1:5 water extraction, and NH4+ in 1:5 KCl extraction. Soil samples were also air-dried and sieved through 2 mm sieve. Air dried samples were used to analyze TC and TN, available N by hydrothermal extraction, available P (Truog), maximum P retention, exchangeable cations, cation exchange capacity (CEC).

Air dried soil samples of Iwamizawa were also used for incubation study examining CO2 and N2O production rate. Incubation was conducted under the soil moisture condition of 40 % and temperature of 25°C. A 15g of wet soil made from air-dried sample was incubated in a 140ml bottle for 24 h, and CO2, N2O and NO concentrations of the air in the head space of incubation bottle were analyzed. The incubation was repeated 14 days.

In both Toya and Iwamizawa, many of soil properties changed by clean agricultural management. In Toya, pH, exchangeable cations, CEC, increased significantly. In contrast, available N and available P decreased significantly. There was no difference in TC content before and after clean agriculture (2.53% and 2.56%, respectively). There was a relationship between manure C application rete and TC change rate (TCafter ? TCoriginal). And we found a significant negative correlation between TC change rate and TC content before clean agriculture. It is indicate that manure application rate and TC content play an important role for the soil C sequestration. In Iwamizawa, pH, available P, exchangeable cations increased with clean agriculture, however, there were no differences in TC content, available N, NH4+ and NO3- between clean and conventional agriculture. And the yield in clean agriculture was the almost same as in conventional agriculture despite of small amount of chemical fertilizer application in clean agriculture. Generally, crop productivity is lower in low-input organic farming system compared to the conventional farming system in which inorganic fertilizers are applied. This result suggests that adequate supply of mineral N by mineralization of organic matter maintained plant growth. Incubation study showed cumulative CO2 production from the soil samples clean and conventional agriculture were 216 and 214 mgC kg-1 14 days-1, and cumulative N2O emission were 8.3 and 7.3 mgN kg-1 14days-1. There were no significant differences in both CO2 and N2O productions between clean and conventional agriculture. Long term application of manure in clean agriculture increased the values of several kind of soil properties especially pH and exchangeable cations in both regions, and maintained productivity by supplying mineral N mineralized from manure to soil, but influenced greenhouse gas emissions.

Keywords：*Clean agriculture, greenhouse gas emission, organic matter, soil fertility*

P3-36

[IDS9] Key Processes and Factors to Mitigate Land Degradation

The Research on Soil Physical Properties of Eucalyptus Plantation in Rare Earth Tailings Area

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Soil anti erodibility is important to the development of soil and water conservation. It is the important content of the soil erosion, At present, most studies focused on the Loess Plateau, studies on the Southern Red soil is less, more less for the soil anti erodibility of Eucalyptus plantations on rare earth tailings mining area. This study chosen one year old, two year old ,four year old Eucalyptus and open space for the control as the research object on rare earth tailings mining area in Ganxian country ,Jiangxi Province. Analysised and studied the factors affecting the anti erodibility and gave a more comprehensive assessment of rare earth tailings mining area after vegetation retoration.

(1)The study selected four categories and sixteen indicators to analysis by using principal component analysis, and had chosen 7 as the best indicators to reflect the soil anti erodibility on rare earth tailings mining area. They were X1、X2、X4、X7、X9、X12、X14. The soil anti erodibility equation to the area is: Y=0.603Y1+0.272Y2+0.126Y3。

(2) There are difference on soil anti erodibility between different forest age of Eucalyptus plantation on rare earth tailings mining area. Composite score on annual eucalyptus of anti erodibility were higher than two years old eucalyptus,four years old eucalyptus and open space, soil anti erodibility index were: two years old eucalyptus > annual eucalyptus > four years old eucalyptus > open space.

(3) Selecting sixteen indexes and soil anti erodibility index to correlation analysis,we found that aggregate , water stable aggregates and clay indexes were significant or extremely significant correlation to soil anti erodibility index. Dispersion and structure coefficients were significantly correlated to soil anti erodibility index. ＞0.25mm aggregate destruction rate, dispersion coefficient and dispersion rate were negatively correlated to soil anti erodibility index. ＞0.5mm water stable aggregate content and ＞0.25mm water stable aggregate content were significantly correlated. Dispersion coefficient and dispersion rate of microaggregate class were negatively correlated to soil anti erodibility, aggregation degree and structure coefficient were significantly correlated. ＜0.05mm clay content, ＜0.001mm clay content of inorganic clay class and structural particle index were significantly correlated, while organic matter was not obviously correlated.

(4) By analyzing the correlation between the physical and chemical properties of soil ,roots and microbial with soil anti erodibility, we can draw that the bulk density,organic matter, bacteria and fungi content were the factors to soil anti erodibility on rare earth tailings mining area, while soil porosity, aggregate saving chance, pH value,N、P、K content and characteristics of roots were not significantly correlation.

(5) With the principal component filter out X1(x1), X2(x2), X4(x3), X7(x4), X9(x5), X12(x6), X14(x7) this indicators as independent variable, to soil erodibility index y as the dependent variable, soil erodibility model equation in the rare earth tailings mining area is : y=0.309x1+0.038x2-0.161x3-0.643x4+0.491x5-0.0328x6+0.129x7+41.637

The equation derived factors significantly related to and the model fits well.

Acknowledgement:The work reported here has been funded by IPNI (Jiangxi-29) and the National Natural Science Foundation of China (31260194）,(30960312),（31360177）and National Science and Technology Support Project (2012BAC11B06),The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Rare Earth Tailings ；Soil Anti-Erodibility ； Eucalyptus Plantation ；Principal Component Analysis*

P3-37

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Comparison of the Effect of Manure Application on Soil Co_2 Emission from Managed Grassland and Cornfield in Southern Hokkaido, Japan

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Carbon (C) mineralization of crop residues and manure is an important process for regulating carbon dioxide (CO_2) emissions into the atmosphere and for releasing nutrient elements essential to crop growth. The location of crop residues in soils appears to influence C mineralization processes. Many studies have shown that residues incorporated into the soil decompose faster than those placed on the soil surface, while a few have reported that incorporation of residues have no effect or reduce C mineralization. However, the effect of manure application practices (e.g. surface application versus incorporation) on C mineralization is less reported. In this study, soil CO_2 emissions from manured and non-manured plots were measured in a managed grassland from 2005 to 2009 and from 2010 to 2012 in a cornfield converted from the grassland in southern Hokkaido. The objective of this study is to compare the effect of manure application on soil CO_2 emission from managed grassland and cornfield.

The study site was located at the Shizunai Experimental Livestock Farm of Hokkaido University. Three experimental plots were set up in 2005, one for treatment with chemical fertilizer (F plot), another with both cattle manure and chemical fertilizer (MF05 plot) and the other with no fertilizer or manure (CT plot). In November of 2009, the study field was converted from grassland to cornfield, and F plot was divided into two plots, one for treatment with fertilizer (F plot) and the other with both manure and fertilizer (MF10 plot). Beef cattle manure was applied on surface at the rate of 34-46 Mg fresh matter (5.8-8.0 Mg C) ha^{-1} yr^{-1} in grassland, and incorporated into soil at the rate of 40-49 Mg fresh matter (6.7-8.9 Mg C) ha^{-1} yr^{-1} in cornfield. CO_2 fluxes from soil with roots were measured by the static closed chamber method in 2-30 day intervals, and considered as soil respiration (RS). CO_2 fluxes were also measured in the root-excluded plots which were established in CT plot of grassland and in all plots of cornfield, and considered as heterotrophic respiration (RH). In grassland, RH of manure (RHm) was estimated as difference in RS between MF05 plots and F plot. Lloyd and Taylor (1994) equation was used to estimate cumulative CO_2 emission.

In grassland, 5-years average of annual RS were 11.3±0.7, 15.8±2.7 and 11.3±1.2 (mean±s.d.) Mg C ha^{-1} yr^{-1} in F, MF05 and CT plots, respectively, and RH were 4.2±0.2, 8.7±2.3 and 4.3±0.2 Mg C ha^{-1} yr^{-1} in F, MF05 and CT plots, respectively. On the other hand, in cornfield, RS had no significant difference from RH, and the average of RS and RH was 6.3±0.7, 9.4±1.0, 8.8±1.0 and 6.2±0.8 Mg C ha^{-1} yr^{-1} in F, MF05, MF10 and CT plots, respectively. RH in both grassland and cornfield was significantly larger in MF05 and MF10 plots than in F and CT plots. RHm in the MF05 plot of the grassland where manure was top-dressed increased year by year from 1.9 to 6.3 Mg C ha^{-1} yr^{-1}, while RHm in the MF05 and MF10 plots of the cornfield where manure was incorporated was smaller than in grassland. However, the RHm in cornfield tended to be larger in MF05 plot (2.0-3.8 Mg C ha^{-1} yr^{-1}) than in MF10 plot (1.7-3.2 Mg C ha^{-1} yr^{-1}), but there was no significant difference. There was a time effect on RHm. Ratio of cumulative RHm to cumulative manure C application rate in MF05 plot increased linearly with year ($y = 0.27 + 0.073x$, $R^2 = 0.90$, $p < 0.05$) to 63% in grassland, and showed no significant relationship with year in cornfield (0.55±0.02%). In MF10 plot of cornfield, the ratio increased linearly ($y = 0.11 + 0.074x$, $R^2 = 0.99$, $p = 0.07$). This result indicates that decomposition rate of manure in the first year was higher in grassland (34%) than in cornfield (19%). Furthermore, the decomposition rate was estimated as 15, 19, 16 and 10% from the second to fifth year in grassland, and 13 and 14% in the second and third year in cornfield.

Keywords：*carbon dioxide, manure, decomposition, soil respiration*

P3-38

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Key Processes in Land Degradation and Restoration: The Role of Biological Diversity

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Land degradation typically is associated with the loss of vegetation cover and a decline in the biological assemblages and rhizosphere communities of soil fauna and microorganisms. This loss of biological integrity impacts on the physico-chemistry of soil, for example through changed organic matter status and altered chemical speciation. There is clearly a breakdown of the linkage between ecological diversity and key soil processes such as nutrient mobility and availability, decomposition and water retention and percolation. This introduces something of a chicken-and-egg debate in terms of which is the key driver of degradation and restoration of functionality. Does biological diversity determine or depend upon a certain soil quality In terms of soil ecosystem services, it is shown that very few studies have demonstrated a beneficial role of biodiversity. A lack of fundamental knowledge undermines efforts in both biological conservation and restoration.

This paper investigates the interplay of plant roots and soil faunal assemblages in modifying soil biogeochemistry.
Organic matter from litter, exudates and sloughed detritus in the rhizosphere provide the template for biological activity in the soil. Essential recycling processes are mediated by the rhizosphere and drilosphere (earthworm burrows). In natural forests through to agricultural ecosystems, more biodiversity, more faunal biomass and more stored carbon exists belowground than above the surface. Plant root systems are substantially altered by earthworm activity, which also mediate the mobility of nutrients and trace elements in soil. Soil macrofauna subsequently has a profound effect on soil processes; Darwin (1881) recognised the vital role of earthworms to mankind but their functionality in relation to nutrient and trace element mobility and chemical speciation is little explored. There are more than 178 species of endemic earthworms in New Zealand (mostly in the family Megascolecidae), although most have disappeared from human-modified landscapes to be replaced by 19 species of introduced European Lumbricidae. Despite this, understanding the causal reasons and the potential loss of soil functionality due to missing native plant and earthworm species is limited to speculation.

Elucidation of the fundamental ecological processes that govern pathways and fluxes of trace elements though soils is an obvious goal for the immediate future that will provide conceptual advances in our understanding of landscape management and the provision of soil ecosystems services. There is a remarkable deficit of knowledge of trace element biogeochemistry that otherwise would justify and underpin efforts to conserve native biota and protect the environment, providing credence to ecological restoration and diversification of agricultural, urban and other human-modified landscapes. An important goal is to understand how native plants and endemic earthworms regulate biogeochemical cycles, functionality and ecosystem services. This is likely to have significant implications both to biodiversity conservation and topical environmental issues.

Keywords：*ecosystem services, biodiversity, functionality, soil ecology, earthworms*

P3-39

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Regional Assessment-Oriented Mechanistic Modeling and Multi-Site Monitoring of Water, Carbon, and Nitrogen Dynamics in Agricultural Soils Across Japan

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Applying organic matter to agricultural soil is one of the key practices to maintain soil fertility for a long time and to mitigate land degradation in view of not only on-farm agricultural problems but also off-farm regional to global scale environmental issues. Recently, organic matter application is considered as an effective option to mitigate global warming by sequestrating carbon in soil. However, this practice may have a trade-off effect on aquatic as well as atmospheric environment by enhancing nitrate leaching and nitrous oxide emission through mineralization of applied and accumulated organic nitrogen. The environmental nitrogen load mainly occurs at field scale due to local agricultural activity but spreads out into regional aquatic and global atmospheric environment. Moreover, the trade-off effect is so complicated that it should vary largely with local conditions of soil, crop, fertilization, temperature, precipitation, etc., and it may drastically change with time over several years or decades. This study was conducted to develop a comprehensive mechanistic model that can predict long-term water, carbon, and nitrogen dynamics through soil profile at an arbitrary field in an agricultural watershed under present or future climate conditions. Such model is necessary for determining best management scenarios for minimizing environmental load to aquasphere and atmosphere.

A national scale research network for long-term monitoring of water, carbon, and nitrogen dynamics in agricultural soils was developed containing nine experimental stations across Japan. The research fields include three land use types (upland, orchard, grassland); four Soil Groups (Sand-dune Regosol, Andosol, Yellow soil, Gray Lowland soil); six organic matter types (cattle slurry, cattle manure compost, crop residue, swine manure compost, rice straw compost, green manure); and a variety of crops. The agricultural soil-profile physical properties database, Japan (SolphyJ) was developed based on national-scale soil monitoring data from 1979 to 2003 in order to prepare soil-profile physical parameters that are required for developing regional assessment-oriented mechanistic models (Eguchi et al, 2011). The LEACHM model (Hutson, 2005), a numerical code based on the Richards' equation for water, convection-dispersion equation for solutes, and carbon nitrogen turnover and interaction processes (Johnsson et al, 1987), was modified and parameterized (Asada et al, 2013) in particular for organic carbon turnover based on original (Coleman et al, 1996) and modified Rothamsted Carbon model (Shirato et al, 2004) and unsteady nitrate adsorption experiments using

Andosol columns (Miki et al, 2009). Predictability of the modified and parameterized LEACHM was validated with the measured data of several stations for water content or cumulative drainage, leached nitrate concentration, total soil carbon content, total nitrogen content, etc., without numerically fitting the predicted values to measured ones.

Long-term field monitoring at different stations showed that applying livestock excreta-derived organic matter in addition to conventional chemical fertilizer generally led to increase in environmental nitrogen loads of nitrate leaching and nitrous oxide emission although it also increased crop yield. Higher nitrate leaching and nitrous oxide emission were observed for swine manure compost plots and for coarse-textured soil plots. Monitoring data also showed that alternative use of livestock excreta-derived organic matter with decreasing chemical fertilizer generally resulted in decrease in leached nitrate concentration. For crop residue, in an upland field of Andosol, it was demonstrated that crop residue incorporation caused increase in crop yield, increase in soil carbon, and decrease in leached nitrate concentration regardless of increase in surplus nitrogen. This indicates that crop residue incorporation is effective to reduce environmental load to aquasphere and atmosphere in association with maintaining soil fertility. The modified and parameterized LEACHM was able to express the difference in nitrate concentration between plots of chemical fertilizer and organic matter; cattle and swine manure composts; cattle slurry and cattle manure compost; Andosol and sandy soil; etc., with reasonable predictability sufficient for regional assessment. This model was also applicable to predict long-term total carbon and nitrogen contents in surface soil. The developed LEACHM model can be used with SolphyJ database for predicting water, carbon, and nitrogen dynamics in various agricultural soils in an arbitrary watershed in Japan where local agricultural activity data are available.

Keywords：*nitrate leaching, carbon sequestration, nitrous oxide emission, modified LEACHM, SolphyJ*

P3-40

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Biogeochemical Processes of River Sediments Control a Spatio-Temporal Variation of Nutrient Concentration at River Mouths in the Lake Hachiro Watershed, Japan

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[Introduction] River delivers nutrients such as N and P to river mouths from the watersheds. These nutrients can control primary production in rivers and lakes. In general, most phosphate in rivers is associated with particulate form and can be deposited in river mouths and lakes as sediments. Phosphate absorbed by ferric oxyhydroxides are released from sediments at anoxic condition and increase bioavailability in water body. Lake Hachiro in Akita prefecture, Japan is an eutrophic lake and blue-green algae is generated during every summer. Its water quality improvement is an urgent task. One of the characteristic in the Lake Hachiro watershed is that the concentration of phosphorus in natural streams is relatively high compared to other natural streams in Japan. Previous study revealed that the lake water qualities in summer had a large spatial heterogeneity and phosphate and chl.a concentrations were higher in the southern part of the lake. These spatial patterns of the lake water qualities may be reflecting the characteristics of rivers entering to the lake. However, the trend of spatio-temporal variation of nutrients from rivers entering to the lake and its mechanism are still unknown. Our hypothesis was that sediments in river mouth were different to reflect watershed's characteristics such as geology, soil, and land use type etc. Fraction of phosphorus and denitrification potential in sediments are also differnet among rivers and may control spatial DIN and DIP concentration.
[Aim] We focused on the dynamics of DIN and DIP concentration at river mouth which is an interface of land and lake water. The present study was conducted to elucidate spatio-temporal variation of DIN (NO3 and NH4) and phosphate (PO4) concentration and their control factors at river mouths of 5 main rivers entering to Lake Hachiro.
[Materials and Methods] Study sites were at river mouths of 5 main rivers (MTN, BBM, IKW, TYK, BFM) entering to Lake Hachiro at Akita prefecture, Japan. Surface and bottom (about 10 cm from the riverbed) river water was sampled once a month from May in 2012 to April in 2013. River sediments were also collected from the surface of the riverbed at the same time of the water sampling. Dissolved gases in stream water were collected to measure N2O and CH4 concentration. Denitrification potential (DP) of sediments was determined by the acetylene inhibition technique. Sediment incubation was also conducted to evaluate the effect of temperature (10, 25 °C) and oxic or hypoxic conditions on PO4 and DIN release from the sediments. Fractionation of sediment phosphorus (soluble and loosely bound P, Al-P, Fe-P, reductant soluble P, and Ca-P) was also determined at each sample site.
[Results and Discussion] Riverine PO4 concentrations had a large spatio-temporal variation, which increased from summer to autumn at the southern three rivers (IKW, TYK, BFM). PO4 concentrations in bottom water tended to be higher than that in surface water, which indicated a part of PO4 was released from the riverbed during summer and autumn. In contrast, NO3- concentrations were not different among rivers and decreased during summer likely by denitrification, causing lower DIN/DIP ratios in river water. Higher dissolved CH4 concentrations in the bottom water indicated the riverbed was under anoxic condition in summer at the southern three river mouths. The results of the sediment incubation clearly demonstrated that DP was higher in the southern three river's sediments and that PO4 and NH4 were released from the sediments at 25 °C with hypoxic condition, especially from the southern three river's sediments. Fe-P contents in the sediments positively correlated with PO4 concentration in the river water. Riverne PO4 and Fe concentrations also tended to have a positive correlation. Therefore, Fe-P in the river sediments had a large impact on the river water and would result in the spatio-temporal variations of PO4 concentration in river mouths in the Lake

Keywords：*eutrophication, watershed, phosphorus, nitrogen, denitrification, sediment*

P3-41

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Effect of the Use of Pam (poliacrylamide) in Clay Soils to Prevent Erosion in The Valley of Mexicali, Baja California, Mexico

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The Colorado River is the lifeblood of the Mexicali Valley (MEXICO) and Imperial Valley (USA), It is only source of irrigation and drinking water. Mexico as 1,850 MM3 to 206,000 ha, the origen the soil is aluvial,classification of soils in the Mexicali Valley, Xerosol : Arid zones slight organic matter surface layer is clear, below it may be accumulation of clay minerals and / or salts, such as carbonates if irrigation is good have good yield; Yermosol is por in organc matter in water and adequate fertilization are capable of high agricultural production. general characteristics of soils; Most soils in the Mexicali Valley is very fertile. Young alluvial soil (geologically) native conditions. Bajo MO Lowest Total N (N-N-org & inorg) Very saline (up to CE> 30.0 dS / m common) Very productive after recovery salt (sodium).

Water is essential for the existence of a gram of biomass vida.Producir supposed spend between 100 and 1000 g of water (1g 0.1 to 1 liter water.) The amount of water required for the process fotosinteticoes small, approximately 0.01 %. Over 90% of the water entering the root system is apparent to the air as water vapor.

Mexicali Valley and Imperial Valley is same basin, and have similar condition, but the economic situation is different. The salton Sea continues exist because of the drainage water from agricultura in Imperial Valley and Coachela Valley as well as flow forom agricultural drainaje and untrated an partially treated sewage from the Mexicali Valley. Because of drainage and its impact on the Sea. Approximately 15 to 20% of delivered water ens up as surface runoff water. Runoff Water from irrigated field contains great amounts of silt, pesticides and nutrients. TheTotal Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards. Several methods exist to reduce teh amount of sedimet produced in the normal course of agricultural operationes including TMDL

In this paper specifically discuss the Mexicali Valley, do not forget that similar conditions we may consider the results for both valleys.

The work took place in a clay soil of the experimental field of the Institute of Agricultural Sciences UABC. The work took place in a clay soil of the experimental field of the Institute of Agricultural Sciences UABC

at two points of the plot take soil samples (0-30 and 30-60 cm), performing lab work: applying 4 treatments and three replicates of 0, 5, 10 and 15 parts per million (ppm) of PAM determining: Percentage of saturation (% Sat), electric conducividad (EC), Potential Hydrogen (pH) and Total Dissolved Solids (TSS), making a total of 144 determinations.

The analysis was performed based on comparison of means; resulting in the lower water requirement to saturate are treatments 3 and 4 (10 and 15 ppm of PAM), without significantly altering the pH, EC, so as to save water is recommended treatment 3 or 4. It is very important to mention that is a start working in the Mexicali Valley to apply to prevent erosion polyacrylamides Loss Pack and nutrients as well as water-saving irrigation; suggestion for producers is to work with universities to find solutions to problems that exist as we know it is the loss of soil.

Keywords：*erosion, polymer, percent saturation.*

P3-42

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Artificial Macropore Installation in Degraded Soils for Enhancing Vertical Infiltration to Restore Soil Environment

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Soil is largest carbon storage body in all terrestrial medium such as vegetation and the atmosphere. However, these days, soils could not show its function as water storage layer or culture medium for plant, because of climate change or rough management. At these conditions, soil layer is hard and infiltration is poor, preventing water and air intrusion. Organic matter is accumulated at the surface soil, suffering from erosion and decomposition. Traditional counter measure to enhance infiltration is cultivation, turn over. It makes soil layer softer and agricultural jobs easier. However, it may also break soil aggregates and make soils drier, which would be a cause of erosion and decomposition of organic matter. In this study, artificial macropores are introduced in soils for purposing enhancing infiltration without cultivation. Fibrous material was inserted so that it reinforced the macropore structure. Moreover, capillary force caused by fibers drag the surface water into the deeper profile of the soil prior to saturation. Capillary force caused by fabric introduced vertical transport, while micropore (matrix) enhanced horizontal flow. It makes it possible effective infiltration than empty macropores.

Column experiment showed artificial macropore was effective and reduced surface runoff for rainfall intensity of 2, 4, 20 mmh-1 but not for 80mmh-1. At the field experiments, soil moisture sensors installed at 10, 30, 50cm depth effectively responded rainfall, showing artificial macropore successfully introduce surface water into soil profile.

One year later after the artificial macropore installation, field survey was conducted for organic matter in soils and plant biomass. The amount of plant biomass showed double number and there were significant carbon increment in soils. Artificial macropore successfully introduced surface water and organic matter into soils, which could also stimulate plant vegetation. The introduced technique has advantages for its following natural process, low cost and simple structure.

Keywords：*soil, macropore, infiltration, carbon storage*

P3-43

[IDS9] Key Processes and Factors to Mitigate Land Degradation

The Coupling Effects of Water and Fertilizer on the Camellia Oleifera Growth and Fruition

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Camellia (Camellia oleifera Abel) is one of four woody edible oil species in the word, and also the most important edible oil tree in the low hilly area of south China. The test is on the basis of camellia balanced fertilization, studying the influence of camellia growth- fructification by coupling of N,P2O5,K2O,H2O searching the demand law of water and fertilizer on camellia growth, getting the best cultivated plan, and providing the basis theory for the high quality and efficiency development of sustainable camellia. Research conclusions are as follows:

(1) There are significant effects on the camellia growth- fructification by fertilizer and water, and the effect is different in both of single factor and the coupling between two factors.

(2) The effect of main coupling factors is different on the growth and physiological indexes of camellia, and it has a certain rule between water and fertilizer requirement. Some correlation is found between growth and physiological index, The nutrients promoting effects primarily on the growth of camellia, the affection size of leaf area and yield as for N > Water > P2O5 > K2O; water promoting effects primarily on the Camellia physiological indexes, the affection size of camellia SPAD and photosynthesis as for Water > P2O5 > K2O > N.

(3) There are coupling effects between water and fertilizer factors on camellia growth and physiological index. When the other two factors for zero level, there exists fertilizer coupling effects on camellia spring length from N and P2O5, P2O5 and K2O; N and P2O5, P2O5 and H2O respectively have coupling effects on camellia leaf weight; P2O5 and H2O, K2O and H2O have coupling effects on camellia SPAD; the camellia photosynthetic is effect coupled by N and H2O, and the camellia stomata conductance has significant coupling effect from N and P2O5, K2O and H2O.

(4) The use levels of fertilizer and water in the process of camellia to gain maximization growth- fructification are not identical, nutrient and water have the same importance to camellia growth, a reasonable ratio of fertilizer and water can make the best camellia growth. This experiment has get a mode which has the largest proportion of accelerating effects on the yield of camellia, and we make it as the best cultivation mode of camellia, and the respectively code value of fertilizer and water factor as: N = 0.91, P2O5 = 0.65, K20 = 0.97, H2O = 0.98, in order to appropriate the actual production, The use levels of fertilizer and water will be determined as : the urea 0.36 Kg/plant, the phosphate fertilizer 0.49 Kg/ plant, the potash 0.44 Kg/ plant, the irrigation water 30Kg/plant.

Acknowledgement:The work reported here has been funded by National Natural Science Foundation of China (30960312)、（31360177）and National Science and Technology Support Project (2012BAC11B06),The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Camellia oleifera; Water and Fertilization Coupling; Vegetative Growth; Photosynthesis; Fruition*

P3-44

[IDS9] Key Processes and Factors to Mitigate Land Degradation

The Effects of Soil Water Retention for Meadow Degradation at Wugong Mountain

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Soil water retention is an important physical properties of soil, means the performance for receiving and maintaining soil moisture. In this paper, we took field capacity,Capillary water, and saturated water to reflect the soil's water holding capacity .We used methods to contrast different degraded grassland plots for carrying out the situation about soil capillary water and saturated water. The results showed that: field capacity, capillary water and saturated water at 0-10cm soil are much larger than the other normal grassland degraded grassland, grassland degradation larger mild, severe and moderately degraded grassland is relatively small, and three different degraded grassland difference between small and heavily degraded grassland to a minimum in 10 -20cm soil layer, Each soil water holding capacity and soil properties are closely related, mainly due to bulk density, organic matter and nitrogen of these three factors. Research can provide a scientific basis for mountain meadow degradation of soil hydrology ecological effects.

Acknowledgement:The work reported here has been funded by National Natural Science Foundation of China (30960312) 、（31360177）and National Science and Technology Support Project (2012BAC11B06),The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Water Retention；Meadow Degradation；Wugong Mountain*

P3-45

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Soil and Water Loss Sensitivity Evaluation Based on Gis in Yudu County

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Yudu is one of top areas most affected by soil and water loss in Gannan region.Severe soil and water loss has led to degradation of land. It greatly restricts local economic development and affects people's lives. This paper aims to provide an analysis and evaluation of soil and water loss sensitivity in Yudu by establishing a soil and water loss sensitivity evaluation system, adopting GIS technology to generate graphs of sensitivity distribution for rainfall erosivity, soil texture, slope and aspect factor an vegetation type of each single factor.The result shows that soil and water loss sensitivity is widely distributed in Yudu which has provided a basis for regional ecological construction and soil erosion control.

Acknowledgement:The work reported here has been funded by National Natural Science Foundation of China (30960312) 、（31360177）and National Science and Technology Support Project (2012BAC11B06),The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Yudu county;GIS;Soil and water Loss;Sensitivity*

P3-46

[IDS9] Key Processes and Factors to Mitigate Land Degradation

Spatial Distribution of Soil P and its Correlation with Soil Acidity in Mountain Meadow of Wugong Mountain

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Phosphorus is one of the essential elements for the plants growth. According different altitudes (the altitude range from 1600-1900metres) and different soil depths in mountain meadow of WuGong Mountain in JiangXi province to set the sites, analysed the spatial distribution of soil total P content and the available P content, and the correlation between soil P and soil acidity. The main research results were as follows: (1)Wugong Mountain the same soil layers of different elevation of soil available P content showed the vertical distribution of the law. With the elevation gradually increased, the total P content and available P content increased gradually, showing a clear upward trend, the range of variation in soil total P and available P were 3.71-17.78 mg/kg-1and 0.46-1.37 g kg-1 respectively. Available P content have spatial correlation with total P content ;(2) There were no significant difference in pH along the altitudes and soil depths. The soil total hydrolytic acidity and soil exchangeable acidity depths have significant difference along altitudes; (3) there were significantly positive correlations between soil available P and soil total hydrolytic acidity and soil exchangeable acidity. This research can reveal the spatial distribution of soil P and the correlation between available P and soil acidity, as well as for a guidance of vegetation restoration in mountain meadow ecosystem.

Acknowledgement

The work reported here has been funded by The National Natural Science Funds (31360177), (31260194),(30960312) and IPNI (Jiangxi-29); National Key Technology R&D Program of the Ministry of Science and Technology (2012BAC11B006); Department of Education Science and technology project in Jiangxi Province (GJJ10107); The environmental protection department science and technology project in Jiangxi Province (JXHBKJ2012-7) and The young teacher development plan of visiting scholars in Universities in the special fund.The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Mountain meadow; soil available phosphorus; total hydrolytic acidity; exchangeable acidity； Active a*

P3-47

[IDS11] Nanotechnologies in Environmental Soil Science

Use of Fertilizer Loaded Nanoclay-Polymer Composites (ncpcs) for Better Nutrient Recovery in Different Soils

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A leaching study was conducted to show the effectiveness of fertilizer loaded nanoclay-polymer composites (NCPCs) over conventional fertilizer in terms of P and mineral N concentration in the leachate and their cumulative recoveries from three different soils viz., Alfisol, Inceptisol and Vertisol. In the present study three types of NCPCs (I, II and III) synthesized from kaolinite, mica and smectite dominated nanoclays, respectively, were selected and loaded with DAP and urea fertilizer solutions. From this study, it was found that the concentration and cumulative recoveries of P and mineral N from NCPCs treated soils were higher and hence higher use efficiencies than conventional fertilizers. Further, it was found that among the three, NCPC III (based on smectite dominated nanoclay), showed better performance than other two NCPCs. The present study suggested that the NCPC loaded with DAP and urea endowed with slow release properties of P and N, which would find application in agriculture and horticulture. Moreover, nanoclay-polymer composites doped with smectite type of clay had better slow release property among the clays selected in present study.

Keywords：*Controlled release; nanoclay-polymer composite (NCPC); clay type, DAP, urea*

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[IDS11] Nanotechnologies in Environmental Soil Science

Preliminary Study on Self-Assembly Behavior of Soil Organo-Mineral Complex：Self-Assembly of Glycine-Montmorillonite

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Soils are among the most complex biological materials on earth. The elucidation of the processes involved in the formation and development of these biogeochemical interfaces in soil is essential to gain a mechanistic understanding of soil functions. Self-assembly is the spontaneous association of an ensemble of molecules into one or more supramolecular structures, driven by multiple noncovalent interactions. Here, we tested the self-assembly behavior of soil organo-mineral complexes. Analysis of organo-mineral complexes using Fourier transform infrared (FTIR), Thermogravimetric Analysis (TGA) and X-ray diffraction (XRD) confirmed that glycine was self-assembled onto montmorillonite. Also, the XRD demonstrated that glycine molecules did not significantly intercalate the Al-Si layers of montmorillonite and was bound primarily on the edges and outer planar surfaces of montmorillonite.

Keywords：*soil organo-mineral complex self-assembly behavior glycine montmorillonite*

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[IDS11] Nanotechnologies in Environmental Soil Science

Probing In-Situ Chemical Reductive Defluorination Of Perfluoroalkyl Compounds in Groundwater Impacted By Aqueous Fire Fighting Foams

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Perfluoroalkyl substances (PFASs) have been extensively used as commercial and industrial products such as wetting agents, lubricants, corrosion inhibitors, stain-resistant treatments, flame retardants, and aqueous fire-fighting foams (AFFFs) due to their unique high surface activity, thermal and acid resistance, and hydro- and lipophobic properties. Among PFASs, perfluorooctanoic acid (PFOA) and perfluorooctanoic sulfonate (PFOS) have received the greatest attention due to the frequency of detection in soil, water, humans, and wildlife at the highest concentrations and appear to negatively impact immune and thyroid systems and potentially be carcinogenic and bioaccumulative. Fire-fighting training with AFFFs for more than 30 years at military bases has resulted in PFOA and PFOS concentrations in groundwater as high as 6,570 μg/L and 2,300 μg/L for PFOA and PFOS, respectively. The 2009 USEPA Provisional Health Advisory values for protecting drinking water are 0.4 μg/L for PFOA and 0.2 μg/L for PFOS. There are almost 600 military sites where groundwater is likely contaminated with PFOA and PFOS, thus, there is an urgent need for in-situ remediation strategies. The high stability of these compounds, due to multiple C-F bonds, has resulted in most conventional techniques being ineffective including biological degradation, standard oxidation and reduction especially under ambient conditions. Recent work has shown that heat-activated persulfate oxidation (S2O82, E°=2.1V) can be effective at degrading PFOA, but not PFOS, which will be present if PFOA is present.

We hypothesized that PFOS is conducive to reduction, thus, we assessed the potential of dithionite (S2O42-, E°= -0.66 V), sulfide, nanoscale zero valent bimetals Fe°/Pd° (Fe°, E°= -0.447 V) and microscale Mg°/Pd° (Mg°, E°= -2.37 V) to defluorinate PFOA and PFOS in aqueous systems. Sodium dithionite (Na2S2O4) and sulfide which are inexpensive and safe reducing agent are conducive to in-situ injection and have been used for in-situ dechlorination. Fe° has been extensively studied and accepted as an attractive approach for remediation of persistent organic compounds given it is inexpensive, readily available, and has minimal environmental risk. Nano-particles have greater surface area, thus enhanced reactivity potential and palladization serves to catalyze the defluorination reaction by enhancing iron corrosion. The use of Mg°/Pd° has additional potential advantages such as a higher reduction potential, reduced development of a passivation layer on the metal surface due to the higher solubility of Mg-oxides compared to Fe-oxide, and Mg°/Pd° can be applied to both under aerobic and anaerobic conditions. The PFOA and PFOS were quantified by high performance reverse phase liquid chromatography tandem electrospray ionization mass spectrometry. The amounts of Pd loading were measured by inductively coupled mass spectrometry after acid digestion. However, analysis of fluoride using both ion chromatography and F-specific electrode was challenging due to adsorption of fluoride to Mg-oxide and Fe-oxide.

Our preliminary work with both dithionite and sulfide at concentrations 50 mg/L to 2,500 mg/L and temperatures approaching 90 °C did not alter either PFOA or PFOS over a 7 day period. Fe°/Pd° degraded 30 % of PFOA and 15 % of PFOS in 7 days. The removal PFOA and PFOS increased with increasing Pd loading and Fe amount. Mg°/Pd° degraded 35% of PFOA and 15% of PFOS in 48 hours. Both of them have something commons that the effect of cosolvent and temperature did not enhance to degrade PFOA and PFOS since they inhibited the sorption of PFOA and PFOS to bimetals. However, it is obvious that Mg°/Pd° degraded PFOA and PFOS faster than Fe°/Pd°. For the future works, we will focus on determining reductive reaction mechanisms and degradation pathways (identify metabolites), optimal working conditions, and potential interferences for developing a strategy for in-situ employment.

Keywords：*PFOA; PFOS; Defluorination; Zero-valent magnesium; Zero-valent iron; Palladium*

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[IDS11] Nanotechnologies in Environmental Soil Science

Implementation Nanoclays Extracted from Two Soils with Different Mineralogy Class to Removal of Heavy Metals Contaminants

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Nanoparticles are extensively used in many different industrial and environmental fields. Different soils due to their origin and genesis comprise different amounts of clay fraction which at least in one dimension is at nano scale. Smectitic and allophonic soils are among the most important soils containing nanoclays in high amounts. Nanoclays due to their type, amount and their extensive surface area, cause many chemical and physical reactions with the surrounding environment and play an important role in soil properties. Twelve samples from five pedons located in three different areas around the Karaj County, Iran, were analyzed for physicochemical and mineralogical properties. The studied samples were fractionated for clay and nanoclay separation. Clay fraction was separated by sedimentation method after removal of cementing agents. Several iteration of centrifugation were carried out for separation nanoclays in sufficient amounts. The capability of nanoclays for removal of cadmium, lead and copper at different concentrations and constant pH were investigated and compared with the results obtained for total clays fraction. The results implied that the rate of absorption were different for the studied heavy metals depending on the elements and soils. In all samples including Andic and Non-Andic soils the absorption rate were increased by increasing heavy metals concentrations. Also absorption rate showed steeper increasing slope in nanoclay samples as compared to total clay samples. Although, between the studied metals cadmium was the lowest adsorbed metal by total and nanoclays but its adsorption was linearly increased by increasing concentration. While, about lead and copper the adsorbed amount nearly borders to total applied concentrations which demonstrates their more competitive ability regarding cadmium. In most samples of non-Andic soils, the adsorption rate of the studied metals was: Cu> Pb> Cd and in soils with Andic properties the accordance was: Pb> Cu> Cd.

Keywords：*Nanoclays, soil pollution, clay mineralogy*

P3-51

[IDS11] Nanotechnologies in Environmental Soil Science

Potential of Urea-Aluminosilicate Slow-Release Nanocomposites for Controlling Nitrous Oxide and Ammonia Emissions

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N inputs from fertilizers increase NH4+ and NO3− soil concentrations and may increases the soil emissions of the greenhouse gas (GHG) as NH3 and N2O. Urea is the main N source for crop production in Brazil. The nitrogen loss by ammonia volatilization is one of the main factors for low efficiency of N-urea applied on the soil surface. Moreover, N2O produced through nitrification and denitrification processes in the soil is one of main source of anthropogenic N2O emissions. GHG emissions can be suppressed by addition of aluminosilicates minerals to N-fertilizer. However information on how urea−aluminosilicate slow-release nanocomposites might affect volatilization, nitrification and denitrification processes in the soil is limited. Zeolite minerals are crystalline hydrated aluminosilicates of alkali or alkaline-earth metals, structured in three-dimensional rigid crystalline network, formed by the tetrahedral AlO4 and SiO4, which come together to compose a system of canals, cavities and pores at nanoscale. These minerals are characterized by the retaining and releasing water and exchange cations without changes in structure. Other hydrated layered silicates clay minerals, like bentonite, are able to exchange cations, and intercalate neutral molecular species between the interlayer regions by interaction with structural water. In order to follow the gaseous N emissions and dynamics of the soil mineral N in which soil was amended with nanocomposites and standard N-sources three studies were conducted: a greenhouse-potted, a field and a laboratory experiment. Three different species of aluminosilicate were used: bentonite, clinoptilolite and stilbite. Nanocomposites were prepared at three ratios (w w−1 basis) of aluminosilicate/urea: 1:1 (50% urea), 1:2 (66% urea), and 1:4 (80% urea). All treatments applied at the level of 100 kg ha-1 of N on soil surface were compared with ammonium nitrate, urea and an unfertilized soil control. Ammonia volatilized was captured by an absorber with foam soaked with 0.5 N H3PO4 and covered by a politetrafluoroetilene tape. Brachiaria brizantha grass and corn were cultivated respectively in the greenhouse and field experiments. Both in the greenhouse-potted and in the field aluminosilicate and urea mixture reduced 50% the losses by volatilization observed with pure urea. The main action of aluminosilicates in partial reduction on NH3 loss was due its clay high cation exchange capacity retains urea hydrolysis formed ammonium in the soil exchange complex, avoiding the volatilization. The reduction in ammonia losses by volatilization and the increased efficiency of N utilization when urea is used together with aluminosilicates was demonstrated in both greenhouse and field experiments. These results indicate that aluminosilicates minerals are able to improve the efficiency of nitrogen use, contribute to increasing N uptake through the control of retention of ammonium ion. Due the promising results in reducing losses by volatilization, the aluminosilicates were tested for formation of a new fertilizer formulation by extruding the mixture of urea powder with them. The preparation consisted of three steps: mixing, extrusion, and drying. The materials were extruded in a twin-screw extruder. Unlike zeolites, bentonite could effectively be processed by extrusion, due to its plasticity. So the urea-betonite-extruded materials were converted into pellets (3 mm X 5 mm), and dried at room temperature. Urea-zeolites materials remained in the form of powder mixture without aggregation. The aerobic laboratory incubation experiment consisted of 500 mL hermetic pots with 100 g of soil. Initially soil was kept at field capacity and treatments were applied. To assure the N2O fluxes after seven days of incubation, soil moisture was increased until soil saturation. GHG fluxes were estimated by photoacoustic infrared multi-gas monitoring system. Mineral N content of the soil was extracted with 2 M KCl in a 1:10 (soil:extractant) ratio. Ammonium-N and NO3–N contents of the extracts were determined by flow injection analysis. Nanocomposites helped to keep ammonium in soil and also minimized soil nitrate formation, which helps lower the risk of increased N2O emissions. Results suggest that N release rates, as indicated by NH4-N and NO3-N, were related to GHG emissions. The challenge is meeting crop demand yet reducing GHG emissions by selection the adequate ratio of N and aluminosilicate nanocomposite.

Keywords：*zeolite, bentonite, N2O, NH3, GHG, clay minerals, nanotechnologies*

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[IDS11] Nanotechnologies in Environmental Soil Science

Fourier Transformer Infrared Spectroscopy and X Ray Diffraction in the Characterization of Organo-Phosphate Fertilizers Obtained by Humifert Process

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Introduction

The Humifert process has been developed to improve the use of phosphate rock reserves and low-grade ore. In addition, the Humifert process may utilize organic matter to obtain an organo-phosphate fertilizer. The Humifert process (Sternicha 1980) involves a reaction between phosphate rock and organic matter in a bench reactor, with nitric acid, produced in site by reaction of nitrous oxides and water. So, the apatite grains from the phosphate rock are partially dissolved, releasing PO43-, which can associate with organic phases present and/or transformed during the nitric reactions. Then, the generated organo-phosphate fertilizer is more soluble than natural phosphate rocks, but less soluble than traditional fertilizer.

However, there are few information about P associations and/or transformations and the influence of organic materials used in this process. The objective of this study was to characterize the Humifert products by Fourier Transform Infrared spectroscopy (FTIR) and X-ray diffraction (XRD) regarding to their chemical characteristics, including associations between inorganic and organic phases.

Materials and method

The Humifert compounds were manufactured in a bench reactor. They were done three kinds of compounds: PR- igneous phosphate rock from Angico dos Dias, Bahia, Brazil (9% P), SS- sewage sludge from treatment of domestic sewage sludge; and PRSS- mixture of PR and SS. Raw materials (500g) were prepared and received the equivalent of 20% of their weight in distilled water. The mixtures were submitted to reaction with gaseous nitric acid. It had been used different reaction times (0, 2, 4, 6, 8, 10 and 12 hours), to better understand the transformations that occur in the mixture.

FTIR spectra were obtained using a Perkin Elmer Spectrum 1000 spectrometer. Samples were prepared as KBr pellets (1 mg sample/ 100 mg KBr). Spectra were carried-out from 4000–400 cm-1 with 64 scans and a resolution of 4 cm-1.

XRD analysis for were conducted using a Philips diffractometer with CuKα radiation on powdered samples from 2θ of 3 to 60o.

Results and discussions

FTIR spectra, which included isolated materials (PR and SS) and their mixture (PRSS), showed a strong band at 1384 cm-1 only after Humifert reactions, even in short reaction times. Literature suggest that this band could be a new organo-phosphate compound formed by Humifert process (Toledo et al. 2005; Silverol et al 2007; Silverol, 2010). However, the same band is also found in isolated materials submitted to process, demonstrating that this band could not be related with phosphate rock or phosphate groups.

Due their appearance in both organic matter and phosphate rock, the band at 1384cm-1 has been signed as nitrogen compounds, whose nature is still unknown.

XRD analysis revealed that for PR, Humifert process transforms partiality apatite grains during time reaction (from 2h to 12h) and diffractograms suggested that some apatite could be transformed to brushite type materials (CaHPO4.2H2O) and/or some inorganic nitrous compounds. For SS, few changes has been observed after reaction. The signal of quartz has remained preserved, and discrete changes were observed in clay minerals, probably caused by hydration promoted by Humifert reactions. The PRSS reaction showed the disappearance of some apatite peaks and the appearance of new peaks, which could be brushite and/or nitrous compounds associated with phosphorus.

Conclusion

The results indicate that the synthesis of brushite type materials in Humifert process maybe is not dependent of the presence of organic matter. The Humifert process shows as an alternative method to manufacture organo-minerals fertilizers. However, it is necessary detailed characterization to understand the transformations of phosphorus and organic matter.

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Keywords：*alternative fertilizer; phosphate rock; organic matter; apatite; FTIR; XRD;*

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[IDS11] Nanotechnologies in Environmental Soil Science

Evaluation of Nanoclay Polymer Composites Loaded with Urea and Nitrification Inhibitors on Nitrification in Soil

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By free-radical aqueous solution copolymerization reaction between partially neutralized acrylic acid and bentonite (8 and 10 wt %) as principal raw material with a crosslinker and an initiator, the superabsorbent nanoclay polymer composites (NCPCs) were synthesized. These NCPCs were swollen in aqueous solution of urea and nitrification inhibitors for nutrient loading to act as a release carrier of urea. The structure and micrographs of the prepared NCPCs were characterized with Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), scanning electron microscopy (SEM), scanning electron microscopy energy dispersive X-ray (SEM- EDX) and transmission electron microscopy (TEM). The effects of factors such as the amounts and types of the bentonite on the water absorbency of the nanocomposite were also investigated. The results showed that the acrylic acid monomer was successfully intercalated into the bentonite layers and banded together with them. The bentonite layers were exfoliated and basically dispersed in the composite on a nanoscale after the polymerization. Results showed that urea, bentonite and nitrification inhibitors incorporated into the superabsorbents was by Fourier infrared spectroscopy and energy dispersion spectroscopy. The water absorbency of pure poly (acrylic acid) was higher than NCPCs. The optimum absorbency of the pure polymer and nanocomposite (8 % commercial bentonite) in distilled water was 177 and 132 gg-1, respectively. It could be observed that cross-linked AA/AM/bentonite-urea displayed the coarse surface, which greatly increased the contact area of the water and polymer, and could facilitate the permeation of water into the polymeric network, but decreased water absorbency trend was observed with increasing clay content, which was more in the case of nanobentonite. Evaluation of nitrification inhibition ability of different samples of NCPCs comprising dicynadiamide (DCD), Schiff base and neem oil were done in both the soil and aqueous system, where the N release rate from NCPCs was lower as compared to urea. It was observed that the release rate in water was the highest during the first 7 days, and then reaches a plateau. The soils fertilized with NCPCs and control (urea) were incubated at 28 °C and 50 % water-holding capacity for a period of 120 days and percent nitrification inhibition was found highest in Schiff base containing NCPCs. To determine the potential effect of combination of NCPCs and nitrification inhibitor, on the transformation of urea nitrogen and subsequent nitrate leaching, column study was performed to evaluate the leaching of ammonium N (NH4-N), and NO3-N forms from selected urea-based controlled-release NCPCs (C10D3N, C10S3N, C10N3N) and urea. The leachates marked no NH4+ and NO3- ions in NCPCs. This product with excellent slow release and water-retention capacity, being nontoxic in soil and environment-friendly, could be especially useful in agricultural and horticultural applications.

Keywords：*Nanotechnology, clay polymer, slow release fertiliser, nitrification*

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[IDS11] Nanotechnologies in Environmental Soil Science

Development of Nano-Clay Polymer Composites for Controlled Release of Metribuzin in Soils

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The Clay-polymer nanocomposites offer a wide variety of application in agriculture.Apolymerjudiciously combined with an active agent releases it from the material in a pre-designed or controlled manner. The combination of superabsorbent polymer, which can hold a large amount of water with agrochemicals in a single formulation to regulate efficient water and agrochemical release, is a good option. So in the present study a series of nano-clay polymer composites (NCPCs) were synthesized using nanoclays from two sources (commercial which contain about 60-70% nano-clay and pure nano-bentonite) at three concentrations (8, 10 and 12%) with three levels of metribuzin loading (2, 3.5 and 7.5%). Free radical aqueous solution copolymerization reaction was carried out by partially neutralized acrylic acid and acrylamide using a crosslinker and a free radical initiator. NCPCs prepared were characterized by using instrumentation (FTIR, XRD and SEM) and for water absorption capacity. The various characterization methods suggested graft copolymerization between clay and polymer leading to formation of NCPCs. The water absorption capacity of the NCPCs found to be decreased with incorporation of clays into polymer matrix which further decreased with increased clay concentration. The effectiveness of metribuzin loaded NCPCs were evaluated under controlled laboratory condition and compared with commercial metribuzin in terms of release both in water and soils (Inceptisol, Ultisol and Vertisol). In both the soil and aqueous system, the release of metribuzin from NCPCs was lower as compared to commercial metribuzin formulation. Inaqueous system the cumulative metribuzin release was maximum (81%) from the NCPCs containing 8% clays and 2% metribuzin which correspond to the lowest half-life values (t¬1/2¬) of 14 to 17 days. On the contrary, NCPCs containing 12% clays and 2% metribuzin showed the higher t1/2¬ values of 25-51 days. Similar trend was also observed for the studied soils. Amongst the soils release in Ultisol found to be higher than rest of the soils. In all the NCPCs release of metribuzin was slower than commercial metribuzin formulation, so it could be used for control release of metribuzinin soils tailored to different crops/varieties.

Keywords：*nanotechnology, slow release pesticide, metribuzin, clay-polymer*

P3-55

[IDS11] Nanotechnologies in Environmental Soil Science

Adsorption of Arsenic (iii) and Heavy Metals by Nano-Composite of Fe and Mn Oxides

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A nano-composite of Fe and Mn oxides was synthesized with the oxidation of Fe2+ and Mn2+ in an alkaline solution and the adsorption capacity of the composite for arsenic (As) and heavy metal was tested. Magnetite (Fe3O4) and birnessite (NaMn4+Mn3+O4 1.5H2O) were identified as the mineral constitute of the composite with X-ray diffraction (XRD) and transmission electron microscope (TEM). The adsorption of As (III) was tested at the composite dose of 1 g L-1 and 1 mg L-1 As (III). The kinetic test revealed that the oxidation of As (III) occurred in a very short time (less than 30 minutes) and followed by adsorption to magnetite surface. The adsorption of As (V) to the composite was relatively constant at pH 3 - 6 but it was dramatically decreased with increasing pH at alkali condition. The adsorption capacity for lead (Pb), nickel (Ni), copper (Cu), cadmium (Cd) and zinc (Zn) from aqueous solution was tested at the composite dose of 2.5 g L-1, the metals of 10 mg L-1 and the solution pH 4.5 - 5.3. Ninety four % of Pb, 98% of Ni and Zn, 97% of Cd and 99% of Cu were removed from the solution after 2 hour reaction. The results of the adsorption experiment indicate that the composite of magnetite and birnessite is an effective adsorbent for both anionic and cationic contaminants.

Keywords：*Fe-Mn oxide, heavy metals, arsenic, adsorption, synthetic material*

P3-56

[IDS11] Nanotechnologies in Environmental Soil Science

Removal of Strontium from Soil and Groundwater by Birnessite Type-Manganese Oxides

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The purpose of this study is to compare the sorption properties of micro-sized and nano-sized manganese oxides (Mn oxides) for strontium. The micro-sized Mn oxide was synthesized via Mn2+ oxidation with oxygen under alkaline condition. On the other hand, the nano-sized Mn oxide was prepared by the hydrothermal method followed by heat treatment at 600 oC for 2 h. The material characterization of two synthetic Mn oxides was carried out with XRD (powder X-ray diffraction), EDS (energy-dispersive X-ray spectroscopy), and BET (Brunauer-Emmett-Teller) surface area measurements. XRD and EDS elemental analyses showed that both micro-sized and nano-sized Mn oxides were birnessite-type sodium manganese oxides. SEM images showed micro-sized and nano-sized Mn oxides had thin plate- like shape and wire-like shape, respectively. In order to examine the sorption characteristics of the manganese oxides, batch isotherm tests were carried out. The results showed both micro-sized and nano-sized manganese oxides showed high affinity for strontium. These birnessite-type manganese oxides could be excellent sorbent/ion exchangers for removing strontium from groundwater.

Keywords：*Strontium, Nanomaterial, Radioactive species, Sorption, Manganese oxide*

P3-57

[IDS11] Nanotechnologies in Environmental Soil Science

Sources, Distribution, Environmental Fate and Ecological Effects of Nanomaterials in Wastewater Streams

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Engineered nanomaterials (ENM) are manufactured, as opposed to being an incidental by-product of combustion or a natural process, and they often have unique or novel properties that emerge from their small size. These materials are being used in an expanding array of consumer products and, like all technological developments, have both benefits and risks. As the use of ENM in consumer products becomes more common, the amount of these nanomaterials entering wastewater stream increases. Estimates of nanomaterials production are in the range of 500 and 50,000 tons per year for silver and titanium dioxide (TiO2) alone, respectively. Nanomaterials enter the wastewater stream during the production, usage, and disposal of nanomaterial-containing products. The predicted values of nanomaterials range from 0.003 (fullerenes) to 21 ng L−1 (nano-TiO2) for surface waters, and from 4 ng L−1 (fullerenes) to 4 μg L−1 (nano-TiO2) for sewage treatment effluents. Therefore, investigating the fate of nanomaterials in wastewater streams is critical for risk assessment and pollution control. This study aims to firstly, identify the sources of nanomaterials reaching wastewater streams, then determine their occurrence and distribution, and finally discuss their fate in relation to human and ecological health, and environmental impact.

Keywords：*Nanomaterials, wastewater, ecotoxicity, environmental fate, aquatic system, management*

P3-58

[IDS11] Nanotechnologies in Environmental Soil Science

Layered Silicate for Removal/retrieval of Harmful Metal Cations

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Many selective adsorbents have been developed for removing various heavy metal cations from water. However, selective adsorption of harmful metal cations on layered silicates are less explored. Recently, layered silicates such as magadiite ($Na_2Si_{14}O_{29}\cdot 9H_2O$) and kanemite ($Na_2Si_4O_9\cdot 5H_2O$) have growing interest due to their catalystic and adsorptive properties. This study deals with magadiite and kanemite for selective adsorption of heavy metals in the excess presence of Na^+. Adsorption capacity of magdiite for Cu was estimated approximately 220meq per 100g. Removal efficiency was estimated more than 90% at below 30ppm in the Cu adsorption experiment. Very high selectivity of magadiite for Cu^{2+} was obsereved in competitive adsorption with Zn^{2+}. The adsorption experiment for Sr^{2+} on kanemite was conducted, indicating that the adsorption capacity of kanemite for Sr^{2+} was approximately 342meq per 100g. The adsorption isotherms of magadiite and kanemite fit better to Langmuir adsorption model than to Freundlich one. Despite of excess presence of Na^+, magadiite and kanemite showed a high adsorption capacity for $Cu^{2+}$and Sr^{2+} respectively. Therefore, magadiite and kanemite are expected to be an highly potential adsorbent for specific harmful metals like Cu^{2+} ,Sr^{2+}.

Keywords：*heavy metals, layered silicate, magadiite*

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[IDS11] Nanotechnologies in Environmental Soil Science

Partial Exfoliation of Na-4-Mica on K Exchange Reaction

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Exfoliation of Na-4-mica has been suggested to take place during cation exchange reaction although any solid evidences have been not presented yet. This work focused on characterizing exfoliation of Na-4-mica in dimethyl sulfoxide (DMSO) solution on K+ exchange reaction. Because the presence of hydronium ion results in decrease of electrostatic repulsion among interlayer cations, urea molecules were introduced into the interlayer space to replace interlayer water molecules. Intercalation of urea molecules into mica resulted in an increase of basal spacing from 1.21 to 1.45 nm, accompanying significant increase in diffraction intensity. Characteristic IR absorption bands were appeared at the frequencies of 1,668 and 1,627 cm-1, assigned to NH2 bending modes of urea. Incorporation with urea molecules did not affect the crystal morphology such as shape and thickness. Exchange reaction of urea-incorporated mica with K+ in DMSO solution led to an enhancement of the dispersity evaluated by UV-Vis scattering to indicate the exfoliation of Na-4-mica. The reaction also led to decrease of basal spacing from 1.45 to 1.34 nm, accompanying a remarkable reduction of overall diffraction intensity and considerable changes in morphology. Slicing and tearing of platelet crystal into thin flakes and reassembling of exfoliated layers into irregular platelets were observed. The transparent suspension showed Tyndall light scattering indicating the presence of exfoliated nanoplates. This study shows that exfoliation of Na-4-mica on cation exchange reaction takes place by electrostatic repulsion of interlayered large cations, in particular K+ and Cs+.

Keywords：*exfoliation, Na-4-mica, cation exchange reaction*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

A Kinetic Approach for Remediating Ptes in Sewaged Soils Using Novel Biotechnology

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In a completely randomized field experiment, a novel biotechnology was successively practical to remediated PTEs in a sewaged soil ecosystem. The technology was applied in two stages, first bioremediation with a biochemical remediative amendment composed of probentonite (Bentonite, rock phosphate, Thiobacillus sp. and phosphate dissolving bacteria) and second phytoremediation with canola, Indian mustard or black nightshade hyperaccumulator plants in association with mycorhyzea. Results indicated that the application of this novel biotechnology reduced the zinc equivalent value in the experimented sewaged soil from initially 630 to ta safe level less than 200. The effect of canola hyperaccumulator plant in general far exceeded that of the other two experimented plants; however, the differences between their efficiency were not that great. Inoculation with either mycorrhyzae (AM) or Thiobacillus sp. significantly enhanced PTEs uptake by the tested hyperaccumulator plants. From a kinetic prospective, the application of the combined novel biotechnology exhibited superior remediative action compared to the application it single remediative amendment in minimizing Zn equivalent value to the safe level. The different mechanisms that took place during the bioremediation process of in the studied sewaged soil were discussed.

Keywords：*Bioremediation, Zn equivalent, Kinetic models, PTEs, sewaged soils.*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Microwave-Enhanced Reduction of Cr (vi) in Contaminated Soil

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Chromium slag is a primary cause of soil pollution. In China, more than 20% of the hyper-chromium contaminated soil and groundwater arise from the long-term stacking of chromium slag , the soil where chromium slag deposited has been polluted seriously. Chromium exists in environment in two common oxidation states, Cr (III) and Cr (VI). Chromium (III) occurs naturally, while Cr (VI) is generally produced by industrial processes. Hexavalent chromium Cr (VI) is a known carcinogen and mutagen and can be acutely toxic, it is mobile in both aqueous and subsurface environments. In contrast to Cr (VI), trivalent chromium Cr (III) is relatively innocuous and functions as a micronutrient for humans and animals, and it is much less mobile in the environment. Therefore, it is necessary to remediate the soil contaminated by Cr (VI). One of the most common ways to dispose of the chromium slag is to reduce Cr (VI) to Cr (III), which is less toxic and can be relatively easily removed or fixed. In recent years, microwave (MW) radiation has attracted great attention in environmental remediation field, especially for soil remediation. Interesting reports have appeared on the application of MW heating technology for remediation of soil contaminated by organic pollutants and heavy metals. Soil can be heated rapidly and selectively by MW, and the pollutants in the soil were desorbed, degraded or stabilized. MW technology has shown great potential for the remediation of contaminated site of chemical industry due to its non-selective for the pollutants, high heating rates and great control of the treatment process. The present study describes a new method for reducing Cr (VI) by MW radiation combined with granular activated carbon (GAC).

Since organic matter widely exists in soil under either oxic or anoxic condition, and the reduction of Cr (VI) by these electron-rich organics has been considered as the predominant mechanism for the attenuation of toxic Cr (VI) in surface soils, even though the reduction rate was relatively low, the reduction of Cr (VI) by organic matter was investigated in our study firstly. Then MW radiation combined with GAC was used to reduce Cr (VI) to Cr (III). The main conclusions are drawn as follows:

(1) Cr (VI) could be reduced by soil organic matter (SOM) when the soil organic content was measured as 2.75%. Cr (VI) was reduced fast at the beginning state, its concentration in soil decreased from 100 mg/kg-1 to 31.73 mg.kg-1 in the first 3 days, almost 70% of Cr (VI) was reduced to Cr (III). Then the reduction rate decreased, and the concentration of Cr (VI) in soil gradually got a plateau. After 60 days, the reduction rate of Cr (VI) could reach 95%. At a certain SOM concentration, the reduction rate of Cr (VI) decreased with the initial Cr (VI) concentration, but the reduction amount was increased.

(2) MW radiation posed a great reduction effect for Cr (VI) in the soil when GAC was used as reducing agent, and about 85% of the Cr (VI) could be reduced in 1-3 min at the MW power of 700 W. GAC dosage was the most important impact factor for the reduction process, the effects of radiation time and MW power were minute. Cr (VI) in the soil could be largely reduced by MW radiation, even at high initial concentrations. When the initial concentration ranged from 7.34-610.48 mg kg-1, more than 75% of Cr (VI) could be reduced in 3 min.

(3) If Cr (VI) was treated only by SOM presented in the soil, several ten days was needed to reduce 85% of Cr (VI). But only 1-3 min was needed by MW radiation combined with GAC to get the same reduction effect. MW enhanced reduction of Cr (VI) showed great efficiency, which is of fleetness and high performance. MW technology combined with GAC can be considered as an alternative remediation approach for soils contaminated with high concentration of Cr (VI) in abandoned chemical industry sites which should be treated quickly and developed for commercial and residential use.

Keywords：*Soil remediation; Microwave radiation; Cr (VI); Reduction; Granular activated carbon; organic matter*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Accumulation and Migration of Heavy Metals in Soils of Rostov-On-Don City

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The researches were conducted in the territory of the largest city of the South of Russia - Rostov-on-Don. Objects: ekranozems - the asphalt sealed soils and chernozem ordinary carbonate covered with steppe vegetation (fallow) and under the trees (forest plantation). The accumulation and distribution of priority pollutants in the profile of urban soils Zn, Pb, Cu, Co, Ni, added to the soils mainly together with motor transport exhaustion and due to work of industrial enterprises, was investigated.

First of all, it should be noted that the content of all these elements in the parent rock exceeds background values. It may indicate the cumulative effect of the accumulation of heavy metals, having effect even on the parent rock. But another explanation is possible: this fact shows the loess loams specific character. The published data show that the loess loams and clays are abounding in micronutrients. It is also shown by the accumulation factors, calculated by us as a ratio of the content of the element in the genetic horizon to its concentration in the parent rock. For surface horizons these coefficients have a value being more than unity only for zinc and lead, therefore, only in respect of such elements we can say with confidence about anthropogenous character of their accumulation in the soil.

For cobalt, nickel and copper the accumulation factors in the surface horizon are less than unity, that indicates the absence of anthropogenic pollution of soils by these elements. Depthwise distribution of cobalt is characterized by relative accumulation of this metal in B2, BCCA or C horizons that proves cobalt capacity to migration inside the profile with formation of its maximum at a level of carbon-bearing barrier. Nickel tends to accumulation in the middle part of the profile.

Copper is relatively inactive element in soils, its ions are easily precipitated by sulfides, carbonates and hydroxides and are combined with humic acids. Variation of profile content of copper in soils is not great. The relative increase is observed in the middle part of the profile, where in the native chernozems there are processes of slight innate argillization. It probably causes the sorption of copper on the newly formed argillaceous material.

Increase of the Approxible permissible concentration (APC) for zinc is observed in all researched soils. Therefore, here we are faced with the consequences of pollution of surface horizon of soil that had taken place before asphalt laying. The source of pollution the chemical plant for production of paint and varnish coating, in particular, zinc oxide, up until recently located about a kilometer from the place of the cut making. Uniformly decreasing character of zinc accumulation in the cuts made in the forest plantation and fallow, also indicates the anthropogenic origin of zinc of surface horizons, because these cuts were made in the eastern part of the city. It should be noted that zinc migration to lower horizons is limited by sorption concentrating of the element by means of complex formation with humic acids. It may, in its turn, lead to enrichment of surface accumulative horizons by this element.

In Rostov-on-Don accumulation of lead was observed along the major highways. Our researches showed that there are two profile maximum in the lead content regardless of the type of soil. They are, at first, the surface horizons, the accumulation of which is connected with atmosphere pollution by vehicle exhaust gas. Although increased lead concentration in the top soil is traditionally explained by accumulative activities of the plants, but the size of the accumulation within the limits of MAC as well as the nature of the soil cover or its absence indicates its anthropogenic origin of this phenomenon. The second profile maximum is referred to BCCa horizon or parent material, that is caused by binding of lead with carbonates. It can be concluded that lead moves in the soil profile. Evaluation of soil pollution degree with heavy metals were also carried out according to index of overall soil pollution $Zc = \Sigma Kc - (n-1)$. Calculation showed that the level of soil horizons pollution in all researched profiles is permissible, except Au horizon. Here, the degree of pollution is evaluated to be moderate (Zc = 19,9)

Keywords：*heavy metals, sealed soils, urban area, chernozem*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Field Scale Phytoremediation Experiments on a Former U Mining Site

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Soil and water pollution by heavy metals and radionuclides (HM/R) is a major concern in many areas of the world, influencing the health of local populations, the use of the natural resources and the environmental equilibrium. In particular, soil, surface water and groundwater are likely to get an important input in different of these persistent pollutants, compromising the biosphere including humans on large areas. Bare soil or heaps are furthermore more likely to erode through the action of wind and precipitation, causing an eluviation of soil parallel to a spreading of contaminants in the air and water phase.

In this context, the present work aims at investigating the potential of phytoremediation at field scale on an area of the former uranium mining in East Thuringia, Germany, which is mainly influenced by acid mine drainage (AMD). On this area, a low grade uranium ore leaching dump was situated, which was later removed during the remediation process of the site. Now, an AMD-influenced substrate remains that is moderately contaminated with HM/R and characterized by very low nutrient content, low organic carbon and acidic pH.

The development of convenient methods for phytostabilization and phytoextraction combined with an application of microbial, plant- and soil technologies are in the focus of investigations. One aim of application of the optimized technologies is the immobilization of the HM/R in the soil substrates and a minimization of the transfer into the system soil-water-groundwater. The success of the new developed and applicated technologies is evaluated by measurement of mass transport of U, heavy metals and rare earth elements (REE) as chemical analogues of the trivalent actinides in the system soil-water-biota.
Plant experiments with Triticale, Helianthus annuus, Brassica juncea and Sorghum bicolor were performed revealing the influence of biological additives (mycorrhiza, HM-resistant
streptomyces) and soil amendment strategies (increasing pH and organic matter) on biomass productivity and plant tolerance to heavy metals.
The addition of mycorrhiza and streptomyces (MS) had a significant effect on biomass of Triticale and Sorghum bicolor. Furthermore, the microbial amendment of mycorrhiza and streptomyces (MS) decreased the bioavailable parts of HM/R (e.g. Ni, Sr, U) in soil in comparison to untreated polluted soil (control, C) with all studied plants. During the field studies temporal changes in the bioavailable fraction of U (mobile + specifically adsorbed) from 2009 - 2011 in the control soil (C) and in the microbial amended soil (MS) could be monitored. Here, the content of bioavailable uranium increased up to 400% in the unplanted and untreated soil (C). Without planting and soil amendments, also an increased release potential of Cd (+ 13%), Co (+ 25%), Cu (+ 200%), Ni (+ 10%) and SEE (+ 44%) was observed.
Finally, in lysimeter experiments it was figured out, that the different soil improvement strategies, addition of MS and of calcareous top soil (MIX) resulted in a reduction of the concentration of contaminants in the seepage water, as well as of the seepage water rates and loads, thus decreasing the risk of groundwater contamination.

Keywords：*Phytoremediation, Amendments, Bioavailability, Triticale, Sorghum, Seepage water*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Phytoremediation in Mining Activities

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There are a large number of sites worldwide polluted with trace elements as a result of human activities. Extraction of metals from ore minerals usually results in large amounts of tailings which often contain elevated concentrations of potentially harmful elements such as As, Cd, Cu, Pb and Zn. Tailings usually provide an unfavourable substrate for plant growth because of their extreme pH, low organic matter and nutrients, high concentrations of trace elements and physical disturbance, such as bad soil structure, and low water availability. Heavy metal contamination has also been a serious problem in the vicinity of mine sites due to the discharge and dispersion of mine-waste materials into the ecosystem. The presence of vegetation reduces water and wind erosion, which may decrease the downward migration of contaminants into the groundwater and improve aesthetical aspects.

This review about phytoremediation, particularly in mining activities, will start with an overview of behaviour (trace elements uptake, accumulation and translocation from roots to shoots) of different populations of plants growing spontaneously in mines. Plants growing on naturally metal-enriched soils are of particular interest, since they are genetically tolerant to high metal concentrations, have an excellent adaptation to this multi-stress environment. For example, the native mine spoil ecotype of Agrostis capillaris plants can grow on acid soils with high burdens of potentially toxic trace elements due to efficient restriction of uptake and translocation of As, Cu, Pb and Sb. In contrast, a commercially A. capillaris variety that has not evolved under these extreme soil conditions is unable to prospect because of the high accumulation of these trace elements in roots and shoots. Therefore, the conservation of the genetic diversity of these metallophytes is of enormous importance for the future development of efficient plants for phytoremediation purposes.

Much less information is available on metal uptake by natural vegetation in neutral to alkaline abandoned mining sites with high metal burdens. Investigations on the natural vegetation simultaneously adapted to high soil carbonate and high metal availability can be important for both the fundamental knowledge on metal uptake and tolerance mechanisms and for the characterization of germplasm for phytoremediation of large areas of near neutral to alkaline mine spoils. Recent studies of plant efficiency in phytoremediation, especially in phytostabilization, of metal contaminated soils in Mediterranean area will be presented.

South American countries are rich in valuable ore deposits and mining activities that have quickly developed all over the continent. In general, the environmental impact of mines in Europe and North America has been evaluated in detail. In contrast, data on impact assessment of the mining activities in South America countries are still very poor. Native farmers living downstream of the copper mine have frequently observed unidentified toxic effects in natural vegetation and crop plants and some health problems of inhabitants and cattle downstream of the mines. Finally, an overview of accumulator species described in the literature for Latin America as well from the author research group will be presented.

Keywords：*mining activities, heavy metals, soils, phytoremediation*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Effects of Particle Sizes of Rock Phosphate on Heavy Metals Uptake by Lolium Prenne, L in Pb-Zn Mine Soils

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Phosphate-based minerals that adsorb, chelate, or complex heavy metals in soils were greatly concerned as effective heavy metals immobilizing materials. Effects of particle sizes of rock phosphate on immobilizing heavy metals in Pb-Zn mine soils by a greenhouse experiment was conducted. Rock phosphate was added to a Pb-Zn mine soil with four different particle sizes, D97<101.43 μm (UP), D97<71.12 μm (P1), D97<36.83 μm (P2) and D97< 4.26 μm (P3) (the diameters of 97% of the particles were less than 4.26 μm.), and 2 rates (2.5% and 5%). Lolium prenne, L. were grown in the treated soils. Addition of rock phosphate (RP) decreased metal contents in both roots and shoots significantly. Pb contents in shoots decreased by 19.59%-37.80% by different particle sizes at the rate of 5%, and Zn contents in shoots reduced by 13.47% -13.75 %, Cu in shoots was reduced by 16.82%-32.61%, and Cd in roots reduced by 31.03%-74.23%, all of which reaching the lowest level at smallest particle size P3 treatment. The results indicated that, RP can reduce the phytoavailability of Pb, Zn, Cu and Cd in soil significantly by immobilization and the effects strengthened with the decrease of particle size and increasing the rate of addition.

Keywords：*Particle size, rock phosphates (RP), immobilization, heavy metals, Pb-Zn mine soil*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Determining a Constituent Release Index from Overburden Material Using Laboratory Weathering Experiments

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The Appalachian coal industry has been successful in developing technologies to identify, handle, treat, and isolate potentially acid-forming overburden materials during coal mining to reduce or eliminate acid mine drainage. However, the techniques used to predict acid mine drainage potential have not been tested for total dissolved solids (TDS) prediction; therefore, new techniques may need to be devised. Current recommendations to blend acidic and alkaline overburden can lead to handling plans that actually increase TDS release, which may be toxic to benthic macroinvertebrates and fish at levels exceeding the maximum contaminant level of 500 mg L-1. Our objective was to develop quick laboratory methods for predicting TDS release from overburden materials in the Appalachian region by comparing two extracting solutions and one digestion technique to Acid-Base Accounting (ABA) parameters, Virginia Tech leaching columns, and University of Kentucky field studies. Forty-one overburden samples were collected from surface mines in West Virginia, Virginia, and Kentucky. Ground samples were mixed with a dilute nitric acid (HNO3 0.016 M) solution or Ethylenediaminetetraacetic acid (EDTA 0.5 M) solution, and shaken for up to one week to simulate weathering. Microwave digestion (USEPA Method 3051) using nitric acid and hydrochloric acid was performed to provide the upper limit on TDS release. Supernatants were extracted and filtered to be analyzed for pH, electrical conductivity (EC), cations (Al3+, Fe3+, Mn2+, Mg2+, Ca2+, P, Na+ and K+) by Inductively Coupled Plasma- Optical Emission Spectroscopy, as well as anions (Br1-, Cl1-,NO31-, PO43-, and SO42-) by Ion Chromatography. ABA parameters, which measure percent sulfur (% S) and neutralization potential (NP), were compared to results from our weathering tests. Results showed that predictions of TDS from the ABA were similar to the actual release of constituents in our weathering study. Samples highest in percent sulfur and NP released the highest concentrations of elements, including Fe, Al, and Mn, and Ca, which are primary elements of concern in acid mine drainage. Samples with lower sulfur and NP contents released lower quantities of TDS. Samples mixed with dilute HNO3 released two to six times more constituents than samples shaken with EDTA. Of the 41 samples, 60% were significantly correlated to the leaching columns at Virginia Tech, with Ca2+ being the most highly correlated constituent.

Keywords：*acid mine drainage, total dissolved solids, weathering,*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Rehabilitation of Acidic Mine Tailings for Biofuel Production: From Biosolids to Biochar Amendments

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Back in 2006, Natural Resources Canada initiated, through a consortium with various academic and industrial partners, a research program on the rehabilitation of mine tailings for biofuel production. The research demonstrated the feasibility of establishing energy crops on mine tailings using a thick cover of papermill biosolids. This system might also represent an economical way to integrate biochar into a rehabilitation plan for impounded tailings at the mine scale because biochar could potentially be generated on site as a by-product of biofuel production. This presentation first discusses how 6 years of the current practice with biosolids covers affect metal mobility and stability in the amended tailings, and then summarizes preliminary laboratory tests conducted to evaluate the alternative use of biochar and their potential to mitigate metal leaching in these tailings.

A sampling campaign was conducted in 2013 to revisit field plots from an oxidized, acidic Cu/Ni mine tailings (pH 2.5), which have been cultivated for the last 6 years with canola, corn or sunflower crops established in a thick (1 m) cover of papermill biosolids. The 0-15 cm layer of tailings below the cover was sampled for chemical and mineralogical analysis, along with a control of unamended tailings for comparison. While no direct accumulation of total or water-extractable organic C was found in the tailings below the cover, the nutrient (nitrate, Ca and K) contents increased in the amended tailings. Compared to the control, an increase of up to 1.5 pH unit was also measured in the tailings underneath the organic cover, and was associated with a significant reduction of the most mobile (water-extractable) pool of Cu and Ni, the two main contaminants of concern. Water-soluble Fe and Al concentrations dropped by ~2 orders of magnitude, likely due to precipitation of Fe- and Al-oxyhydroxides. Fe- and Al-oxyhydroxides can act as a sink for metal contaminants. Mineralogical characterization by scanning electron microscope is underway to refine these results.

In the laboratory, two experiments were done to determine changes in metal mobility in the presence of biochar. The three wood-derived biochars used had distinct chemical properties and had low liming potential (≤3.3% CaCO3 eq.). A 2-month leaching experiment was conducted on the same Cu/Ni tailings mixed with 5 wt. % biochars. The columns were leached with water at intervals, and the leachates were monitored for dissolved metals, organic C and pH. In parallel, 24-h batch sorption experiments were carried out on the three biochars adjusted to pH 4.5, to test their relative sorption capacity for Cd, Cu, Ni and Zn under acidic conditions. Compared to the control, the input of biochar led to an increased loss of dissolved organic C in the first two leaching events but no evidence for metal mobilization with DOC was found. After 2 months, a pH increase of 0.3 unit and a reduction of Cu and Ni concentrations in the leachates by more than 50% compared to the untreated tailings was observed with the biochar that had the greatest liming potential and showed the most advance stage of pyrolysis. In the batch sorption experiments, the amount of metal sorbed by the three biochars at pH 4.5 varied from 5-35 % of the 3 mmol added metal per kg biochar. Sorption seemed to be due to specific interactions between the metal and biochar.

In conclusion, preliminary results suggest that the metal attenuation noted in the short term following biochar input may be mainly due to liming potential rather than metal sorption properties, which were low under highly acidic conditions for these fresh biochars. Further studies are needed to evaluate these properties for other types of biochars, to identify other mechanisms responsible for metal sorption, and to assess how weathering can alter these properties in the long term. The thick biosolids cover approach resulted in an overall improvement of the “soil health” in the underlying 0-15 cm tailings but the thickness of the cover poses the issue of biosolids availability and transport costs. It is proposed that a more sustainable system for the long term would be to use a reduced amount of biosolids mixed with biochar.

Keywords：*acidic mine tailings, biosolids, biochar, metal mobility, metal leaching*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Salt Migration and Salinity Exposure to Plants in Reclamation

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Soil salinity is one of the major issues that can substantially impact the success of oil sands reclamation. Proper design of reconstructed soil profiles may reduce upward salt migration from the underlying saline materials. In this study, a complete randomized block design column experiment was carried out to examine how the texture (fine textured overburden vs. coarse textured tailings sand) and capping thickness (0, 20, 50 and 100 cm) under different water balances (water addition that is 80% vs. 120% of actual evapotranspiration) will affect salt accumulation in the rooting zone and plant growth in the presence of saline groundwater. We expect that fine textured soils will allow more salt migration to the rooting zone via capillarity than coarse textured soils and will need thicker capping layers to prevent salt accumulation in the rooting zone from reaching harmful levels for plants; in drought conditions, intensive evaporation from saline groundwater can bring salt into the rooting zone even with a common capping thickness under current reclamation prescriptions; in rainy conditions, salt leaching may occur most of the time, however, water table fluctuation after watering may also affect upward salt migration ; and data on critical thicknesses of capping materials needed to minimize the risk of upward salt migration under different water balance conditions can be obtained. Results from this study will provide guidance for preventing salinization in soil profile reconstruction for oil sands reclamation in the future.

Keywords：*Soil salinity, Oil sands reclamation, soil texture, capping thickness, water balance*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Phytostabilization Aided with Pig Slurry and Marble Wastes Successfully Reclaims a Bare Mine Soil

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Tailing ponds pose environmental hazards, such as toxic metals reaching to waters through wind and water erosion and leaching. These abandoned mine sites contain materials of high Fe-oxyhydroxides, sulphides, sulphates, and elevated contents of trace elements. As a consequence, soils remain bare. A reclamation strategy to reclaim a bare tailing pond to reduce hazards for environment and human health was established in southeast Spain based on the concept of aided phytostabilization. Marble waste (6.7 kg m-2), raw pig slurry (4.3 L m-2), and the solid phase of pig slurry (7.0 kg m-2) were applied as amendments along 2011. Thirteen plant Mediterranean native species were planted or seeded in spring 2012 for phytostabilization. Various soil physicochemical properties, together with soil microbial biomass and activity and the exchangeable fraction of trace elements (As, Cd, Cu, Pb and Zn) were measured for two years (2012-2013), before the application of the amendments and every six months after this application. The number of plant individuals of each present species and vegetation cover was recorded at each sampling date, also collecting plant samples to assess the accumulation of trace elements by different tissues of each species. Results showed that aggregates stability, pH, organic carbon, total nitrogen, caption exchange capacity, available phosphorus, exchangeable potassium, microbial biomass carbon, basal soil respiration and several enzyme activities increased with the application of the amendments and development of vegetation, while the exchangeable fraction of trace elements drastically decreased (90-99%). The vegetation cover increased from nil to 67% after two years, with the presence of 17 different plant species, 15,400 individuals ha-1, and a Shannon biodiversity index value of 1.23. Most plant species did not transfer trace elements to the aerial tissues, and trace elements concentrations were in all cases below toxicity limits for vegetation and cattle. Thus, the strategy followed here based on the application of marble waste to increase pH and immobilize trace elements, and pig slurry as a source of organic matter and nutrients, together with the development of vegetation to immobilize trace elements in roots and rhizosphere and retain soils, has resulted positive to decrease the availability of trace elements, improving soil quality and fertility. This is promising in areas with quarries of carbonate material (limestone, dolomite, marble) and extra production of organic residues such as pig slurries, since these residues can be used as amendments to reclaim bare main soils with no cost but for transportation, turning into by-products. Once the soil quality of mine tailings was improved, the development of vegetation was favoured, promoting the integral reclamation of the area. Not only the vegetation introduced with planting or seeding was able to grow, but also new species spontaneously colonized the soil increasing the vegetation cover and biodiversity of the area.

Acknowledgements: This work has been funded by the European Union LIFE+ project MIPOLARE (LIFE09 ENV/ES/000439).

Keywords：*contamination, trace elements, tailing pond, phytostabilization, amendments*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Environmental Assessment of Coal Mine Wastes for in-Pit Disposal of Tailings

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Open cast mining activities produce significant amount of spoils and tailings which need to be deposited to get access to a coal vein. Spoils and tailings can be returned to the mine by in-pit disposal. In-pit disposal of tailings refer simply the process of backfilling of open pit with tailings, which is very attractive to mine operator because of cost benefit and structural stability. However, characterization of tailings should be carefully conducted due to the potential for groundwater contamination around the pit. The major problems caused by tailings are the generation of acid mine drainage, release of saline water and mobilization of heavy metals and metalloids from the breakdown of residual sulfide minerals.

The objective of this research is to assess environmental impacts of in-pit disposal of tailing, especially in relation to the geochemical properties of coal mine rejects and tailings. In addition, potential release of salts and trace elements depending on the mode of disposal was tested. Physicochemical properties of coal mine rejects and tailings investigated include particle size, surface area, pH, electrical conductivity (EC), acidity, total element concentrations and serial batch leaching tests. Statistical analysis using correlation matrix, principal component analysis (PCA) and cluster analysis was performed. Correlation matrix showed that Se-particle size, Fe-S, S-SO42-, EC-acidity, EC-SO42- and SO42—acidity were strongly correlated, which indicates that pyrite is a major mineral controlling salt chemistry in coal tailings. The first component of PCA mainly explains acidity and related salts and the second component mainly addresses trace element concentrations. Based on PCA and cluster analysis, samples required special considerations in in-pit disposal of tailings could be identified. Kinetics of serial leaching showed good agreement with PCA score of samples. Therefore, tailings can be grouped in relation to their environmental risk and managed accordingly when they are disposed in pit.

To reduce environmental risk of in-pit disposal, tailings can be co-disposed. Co-disposal of coarse and fine tailings will reduce the volume of total wastes and produce a more stable deposit. Salt and metal adsorption results showed that benign fine tailings have metal sorption capacity and controls leaching of salts and metals when they are disposed together with tailings having high salts and metals. Column leaching results showed that leaching of salts and metals can be controlled by mode of tailings disposal. Especially, benign tailings placed in the bottom of column could reduce leaching of trace elements by sorption. Hydraulic conductivity of tailings can be used to control water infiltration through the tailings deposited in pit. If tailings with low hydraulic conductivity are placed on the top of the pit, it will prevent water infiltration, thereby reducing reaction of tailings with water. If tailings with low hydraulic conductivity are placed on the bottom of the pit, it will prevent seepage water to flow to ground water.

In summary, for in-pit disposal of tailings geochemical properties of tailings should be assessed first and disposed by layering in pit depending on their properties to reduce environmental risk.

Keywords：*tailings, in-pit disposal, co-disposal, coal, backfill*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Microbial Removal of Toxic Metals from a Heavily Polluted Soil by Means of a Heap Leaching System

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Soil heavily polluted with toxic heavy metals (mainly Cu, Zn, Cd) was subjected to microbial cleanup in an experimental heap specially constructed for studing this process. The heap was located on an impermeable geomembrane, had the shape of a truncated pyramid and contained about 104 tons of soil collected from the horizon A of an agricultural field located near a huge dump consisting of mining wastes. The soil was highly acidic (with an initial pH of about 3.7), was preliminarily crushed to minus 2.5 cm and the toxic metals were present mainly as the relevant sulphides. The soil was inhabited by different microorganisms, including some acidophilic chemolithotrophic bacteria.

The heap possessed systems for irrigation and aeration and was surrounded by ditches to collect the drainage heap effluents. The treatment of the soil heap was carried out by means of interrupted irrigation with leach solutions containing diluted sulphuric acid (to maintain pH in the heap within the range of about 2.8 - 3.0, i.e. relatively suitable for the growth of the acidophilic chemolithotrophs and relatively not very destructive towards the soil structure) and ammonium and phosphate ions to maintain the microbial growth. The treatment was carried out for a period of about three years during different climatic seasons. As a result, the residual contents of the toxic metals in the heap were decreased below the relevant permissible levels. After the end of leaching, the soil was subjected to some conventional melioration procedures such as liming, grassing, moulching, addition of fertilizers and animal manure and periodic plouging and irrigation to increase its quality to levels suitable for agricultural utilization.

Keywords：*toxic metals, acidophilic chemolithotrophs, heap leaching*

P3-72

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Potential Environmental Impact of the Amendments Application in Sulfide Mine Wastes from Sao Domingos: Assay of Simulated Leaching

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Ore exploitation in Sao Domingos mining area (Portuguese Iberian Pyrite Belt) both from gossan and massive sulfides generated large volumes of tailings composed of different types of mine wastes. The dumps composed of roman and modern slags, smelting ashes, and brittle pyrite and blocks of pyrite, still have, in different proportions, sulfide-rich materials which produce acid drainage. The acid mine drainage is a serious environmental problem due to the extremely acidic conditions and, consequently, chemical elements dispersion to adjacent areas. The amendments application, which can make a Technosol in an attempt to create different soil functions, can be a valuable technique that can reduce elements concentrations in the leachates and contribute to the area rehabilitation. This study aimed to evaluate the effect of different amendment mixtures and application rate on the reduction of cations and anions dispersion by leachates, over thirteen months, from sulfide-containing tailings.

Composite samples of the sulfide mine wastes (total fraction: MW), containing mainly crushed pyrite and smelting ashes from Sao Domingos mine area were used in microcosm assays under controlled conditions in greenhouse. The amendments applied were mixtures containing distinct organic/inorganic wastes from: green agriculture (plant remains+strawberry substrate; AgrW), Arbutus unedo L. and Ceratonia siliqua L. fruit spirits distillation (ArbW and CerW); rockwool used for strawberry crops (RW). Limestone rock wastes (LRW) were used at 55 Mg/ha. Eight treatments were made (n=4): control; MW+LRW+Amendment AgrW+ArbW+RW at 30, 75 and 150 Mg/ha; MW+LRW+Amendment AgrW+CerW+RW at 30 and 75 Mg/ha; and MW+LRW+Amendment AgrW+ArbW+CerW+RW at 30 and 75 Mg/ha. All treatments were kept at 70 % of water-holding capacity and monitored for thirteen months.

Initial mine wastes (fraction <2 mm) and organic/inorganic wastes were characterized (classical characterization and multielemental concentration). Materials from all the treatments were collected (<5 cm depth) after one, four, seven and thirteen months of incubation and used to obtain simulated leachates (DIN extraction using a solid:water ratio of 1:10 (m/V) and shaking for 24 h). The leachates were analysed for pH, electrical conductivity (EC), Al, As, Ca, Cu, Fe, K, Na, Mg, Mn, Pb, PO4, SO4 and Zn.

Mine wastes presented extreme characteristic as very low pH (~2) and fertility and large total concentrations (g/kg) of Al (58.1), As (1.1), Cu (2.1), Fe (107.3), Pb (11.7), S (65.3) and Zn (1.1). Considering the volume of tailings composed of sulfide mine wastes, large quantity of contaminants can be leached in each rainfall.

After one month of incubation, the acidity of the simulated leachates from treatments with amendments decreased by the LRW application (3.8<pH<5.1). However, after four months, the pH of these leachates decreased (2.4<pH<2.9) to values close to the

control due to the continuous generation of acid drainage and carbonates dissolution. During the experiment, EC values were high, independently of the amendment and dose, and no significant differences were observed among treatments (1.9-5.2 mS/cm depending on the treatment and sampling period).

A significant reduction of the anions and cations concentrations in leachates was observed with amendments application. However, in general, no significant differences were observed among type and application rate of the amendments. The great reduction, between 17 and 99 % compared to the control, occurred after one month of incubation for As, phosphate, sulfate and some cations (Al, Cu, Fe, K, Na and Zn). Until the end of the experiment, all the amendments still reduced the dispersion of As, Fe, Na, sulfate and phosphate (7-99 % of reduction) compared to the control (mg/kg, As: 17.7-26.7; Fe: 3185-5417; Na: 5.6-50.6; PO4: 32.8-60.3; SO4: 37915-85518). The amendments efficiency in the Pb reduction was only observed up from four months (mg/kg, Amended treatments: <detection limit-3.5; Control: 2.9-22.6).

The higher concentration of Ca, Cu, Mg and Mn in leachates from amended treatments, compared to the control, can be a consequence of the existence of remains of the nutrient solution (for strawberries cultivation) in the rockwool and also from carbonates dissolution. This fact can be an advantage in the phyto-rehabilitation processes of these mine wasters. The Technosols conception using the tested amendments can be a suitable technology for the environmental impact reduction of the sulfide mine wastes. Other agro-industrial wastes with higher neutralizing capacity and time persistence should be tested in order to improve the efficiency of the produced Technosol.

Keywords：*Organic amendments , DIN method, Technosol , Trace elements*

P3-73

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Adsorption of As(iii) and As(v) from Soil Using Acid Mine Drainage Sludge (amds) Mortar as a Blocking Adsorbent

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Arsenite and arsenate adsorption were investigated with acid mine drainage sludge (AMDS) mortar as a blocking adsorbent. AMDS mortars were synthesized by mixing with AMDS, cement, sand, and various additives. The AMDS as main constituent was charactirized by XRD and XRF. Moreover, final products, three types of AMDS mortars were characterzied by SEM-EDS, FT-IR, PZC, and TCLP. The present investigations on the adsorption of As(III) and As(V) on AMDS mortar in batch experiments offer fundamental information in terms of adsorption kinetics, pH effects, and adsorption isotherms. The results show that the As(III) adsorption isotherm data were well described by Freundlich isotherm model however the As(V) adsorption isotherm data were fitted to the Langmuir isotherm model. The maximum adsorption capacity of AMDS mortar 1, 2, and 3 for As(III) using Langmuir model were 16.64, 14.49, and 20.62 mg/g, respectively and for As(V) were 29.59, 27.32, and 31.35 mg/g, respectively. Moreover, the kinetic results indicated that adsorption of As(III) and As(V) fitted well with the pseudo-second order kinetic model. Under the PZC (point of zero charge) (pHi < 12.6) condition, average adsorption efficiency of As(III) and As(V) were 33% and 87%, respectively using AMDS mortar 3 at pH from 3 to 11. In the column experiments, the results revealed that soluble arsenic was not eluted in the columns with AMDS mortars. Thus, the synthesized AMDS mortars could be used as effective low cost blocking adsorbent for adsorption of arsenic in soil.

Keywords：*Acid mine drainage sludge (AMDS), AMDS mortar, arsenic, cement, blocking adsorbent*

P3-74

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Phytoremediation of Pb Polluted Soil by Kenaf Assisted with Pgpr

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To study the impact of Pb on the growth of, as well as Pb accumulation and translocation in, the economic plant kenaf (Hibiscus cannabinus), a series of pot experiments were conducted. Moreover, a Pb resistant plant growth promoting rhizobectrium (PGPR) DBM1 (Arthrobacter sp.) was innoculated to the kenaf's rhizosphere and its plant growth promoting (PGP) ability for kenaf under Pb stress was investigated to reveal the feasibility of phytostabilization in Pb polluted soil using heavy metal tolerant plant kenaf assisted with PGPR. Results showed that both Pb stress and bacterium inoculation had significant influences on the growth of kenaf. Specifically, kenaf had high resistance to Pb, which was proved by its successful colonization and development in the treatments of 400 and 800 mg Pb/kg-1. The Pb tolerance ability of kenaf could be attributed to the restriction of Pb in the roots and the inhibition of its translocation to the shoot（TF<1）. The growth of kenaf was inhibited when Pb concentrations reached 1 600 mg.kg-1 in soil. Inoculation of DBM1 effectively increased biomass and chlorophyll contents of kenaf. The PGP effects were more remarkable in high Pb stress indicating that the PGP characteristics of DBM1 may be stress-induced. We concluded that, in remediating soils severely contaminated by Pb, phytostabilization using kenaf combined with PGPR could be considered for getting high biomass production and meanwhile restraining its translocation to the shoot.

Keywords：*kenaf; plant growth promoting rhizobacteria; phytostabilization; lead*

P3-75

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Remediation of Cu-Contaminated Soils with Modified Bentonite

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There are three polluted soils. One is copper contaminated soil（R1） collected from mining areas of Daye city, Hubei Province, and the other two are artificial-polluted red soil（R2） and yellow brown soil（R3） which are contaminated with exogenous copper. The remediation of the Cu-contaminated soils is carried out with modified bentonite which modified with diethyidithiocarbamate (DTC). The different forms of Cu in soils are analyzed with the modified European Reference Materials Bureau (Community Bureau of Reference, BCR method) sequential extraction procedures. And the effects of materials dosages, temperature, pH and content of water in soils on the Cu form transformation in soils are considered.

The results stated that: The modified benotinite was beneficial for the passiviation of Cu in soils. When the modified benotinite was added into the soils, the content of soluble and reduced Cu decreased largely, and the oxidation and residual Cu increased highly. With the increase of modified bentonite dosage, the content of soluble Cu in the soils gradually reduced, otherwise, the residual Cu increased gradually as followed : R3>R1>R2. As the temperature increased, the Cu passivation effectiveness of modified bentonite was not very significant. When the pH and the content of water in soil increased, the passivation ability of modified bentonite strengthened, and the content of water in soils varied, the content of different forms varied.

Keywords：*Benotinite; Modification; Soils; Remediation; Heavy metal*

P3-76

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Removal of As(iii) and As(v) Using Acid Mine Drainage Sludge Coated Sand (amdscs) in Aqueous Phase

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In this study, arsenite and arsenate sorption were investigated with acid mine drainage sludge coated sand (AMDSCS). AMDSCS was synthesized and was tested for their efficacy in removing As(III) and As(V). Batch experiments were conducted to quantify the isotherm, kinetic, and pH effects on the adsorption of As(III) and As(V). Both As(III) and As(V) adsorption isotherm were well described by Langmuir model. The maximum adsorption capacity of AMDSCS for As(III) and As(V) using Langmuir model were 1.60 mg/g and 1.50 mg/g, respectively. Moreover, the kinetic study indicated that adsorption of As(III) and As(V) fitted well with the pseudo-first order kinetic model. Under the PZC (point of zero charge, pHi < 9) condition, adsorption efficiency of As(III) and As(V) were 98% and 98%, respectively using AMDSCS at pH from 2 to 8. Consequentially, AMDSCS is efficient material for adsorption of both As(III) and As(V). The results demonstrated that AMDSCS could be used as an effective low cost adsorbent and it could be applied for arsenic contaminated soil and groundwater remediation.

Keywords：*Acid mine drainage sludge coated sand (AMDSCS), arsenite, arsenate, adsorption, adsorbent*

P3-77

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Effect of Different Machinery and Rolling Times on the Microbial Activity of Reclamation Soil in Coal Area

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This experiment sets up the simulation experimental area based on the Natural Science Foundation of China, simulating the main types of reclamation in coal mine area.Regarding construction waste, fly ash and coal gangue as filler material, NT855 - B280 crawler dozer and DongFeng EQ3060 dump truck as reclamation machinery, simulating 5 times rolling(1,3,5,7,9 times), in order to explore the change rule of soil microbial quantity and respiratory capacity under different construction machinery and rolling times,and to find the optimal processing conditions. The result shows that: 1)In soil microbial community, Bacteria is the maximum one, which is about 70%, followed by actinomycetes, and the quantity of fungus is minimum; 2)In the land reclamation, the effect of microbial quantity and respiratory capacity under crawler bulldozers is less than that under dump trucks; 3)With the increase of rolling times, the change of microbial quantity and respiratory capacity is invert 'V' type, and they reach a peak when rolling 3 times under dump trucks and 5 times under crawler bulldozers; 4)The correlation between microbial quantity and respiratory capacity is very significant positive($P<0.01$), the correlation coefficient is 0.818; the correlation between bacteria, actinomycetes quantity and respiratory capacity is positive($p<0.05$), the correlation coefficient is 0.658 and 0.763 respectively; the correlation between fungi quantity and respiratory capacity is smaller, the correlation coefficient is 0.42; 5)Adopting the combination of"crawler bulldozers×rolling 5 times "and "dump trucks×rolling 3 times", the soil microbial activity is the strongest and nearest to the nature soil.

Keywords：*Construction machinery; Rolling times; Reclamation soil; Microbial quantity; Respiratory capacity*

P3-78

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Reclamation of Coarse Textured Soils Following Oil Sands Mining - Implications of Topsoil Placement Depths to Microbial Community Structure and Function and Plant Available Nutrients

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Open pit mining in the Athabasca Oil Sands Region of Alberta, Canada is one of the largest localized industrial disturbances requiring reclamation - exceeding 750km2. Government regulations mandate reclamation to an equivalent capability of the predisturbance state, returning major ecosystem processes once mining activities have ceased. Expensive handling costs and scarcity of topsoil resources necessitates judicious management and application of capping materials. Soil microbial ecology plays an integral role in soil reclamation by mediating nutrient availability and organic matter decomposition. This study compares soil reclamation materials by evaluating placement depths within the context of microbial community structure and function, as determined by phospholipid fatty acid (PLFA) analysis and community level physiological profiles (CLPP), respectively. Seven treatments encompassing two topsoil depths of forest floor mix (FFM) and peat mineral mix (PMM), and two subsoils were measured on the Aurora Capping Study. Preliminary analysis suggests greater soil respiration rates in FFM and natural analogues (NAT) than in PMM treatments with no difference attributable to subsoil or placement depth. Nutrient profiles in the top 10 cm indicate greater availability of total inorganic N in PMM than FFM or NAT, while FFM and NAT have comparable availability of N P K S. Non-metric multidimensional scaling reveals profound discrepancies in plant available macro and micro nutrients between topsoil substrates and placement depths ($p<0.001$) with shallow FFM application most closely resembling the natural analogue. We hypothesize that under these conditions, shallow FFM applications create an adolescent environment capable of supporting endogenous microbial communities. Nutrient and microbial community profiles could contribute to future work: assessing restoration trajectory in newly reclaimed sites; and providing an indicator of reclamation success when filing for government certification.

Keywords：*soil, microbial community, nutrients, reclamation, oil sands, coarse texture, mining*

P3-79

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Biosorption Mechanisms Involved in Immobilization of Soil Cu/pb by Bacillus Sp. Dbm Leading to Their Reduced Uptake by Rice in a Multi-Metal Contaminated Soil

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Mechanisms of soil Pb and Cu immobilization and assisting phytostabilization with rice by Bacillus sp. DBM, a heavy metal tolerant PGPR (Plant Growth-Promoting Rhizobacteria) isolated from a heavy metal contaminated soil, were investigated. Adsorption and desorption experiments with living bacterial cells as well as dead cells revealed that both extracellular adsorption and intracellular accumulation were involved in the removal of Pb(II) and Cu(II) ions from the liquid phase. Of the sequestered Pb and Cu, 8.5% and 14.7% were held by physical entrapment within the cell wall, 43.3% and 33.2% were held by ion exchange, 9.7% and 14.8% were complexed with cell surface functional groups or precipitated on the cell surface, and 38.5% and 37.4% was accumulated intracellularly. Complexation of Pb2+ and Cu2+ with carboxyl, hydroxyl, carbonyl, amido, and phosphate groups were demonstrated by FTIR analysis. Precipitates of Pb5(PO4)3OH, Pb5(PO4)3Cl and Pb10(PO4)6(OH)2 that formed on the cell surface during the biosorption process were identified by XRD analysis. TEM-EDS analysis confirmed the presence of the Pb precipitates extracellularly but without Cu precipitates formed. Incubation with Bacillus sp. DBM significantly decreased the Pb and Cu concentration of the weak acid soluble fraction of a heavy metal contaminated soil, resulting in a reduction in Pb and Cu bioavailability, while the amount of Pb and Cu in the organic matter bound fraction increased by 71% and 106%. Results of pot experiments showed that concentrations of heavy metals in rice shoots significantly decreased by 16.45% for Pb and 13.57% for Cu combined with the increase in the rice growth of 29.47% for roots and 18.89% for shoots in the treatment inoculated with Bacillus sp. DBM compared to untreated control. Our study suggests that several biosorption mechanisms contribute to soil Pb and Cu immobilization by Bacillus sp. DBM. The ability of Bacillus sp. DBM to reduce the bioavailability of soil Pb and Cu and the growth promoting for rice make it potentially useful for bacteria-assisted phytostabilization of multi-heavy metal contaminated soil.

Keywords：*Bacillus sp.DBM, biosorption mechanism, heavy metal speciation, rice, phtostabilization*

P3-80

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Affects of Wastewater Discharges from Mining Areas on Soil Heavy Metal Pollution and Enzyme Activities in Northern Hunan Province, Central South China

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Hunan province, Central South China, is a well-known nonferrous metal base in China. Mine exploiting and processing there, however, often lead to heavy metal pollution of farmland. To study the effects of mining activities on the soil environmental quality, four representative paddy fields, the HSG, SNJ, NT and THJ, in Y county, northern Hunan province, were investigated. It was found that the streams running through the HSG, SNJ and NT are severely contaminated due to long-term discharge of untreated mineral wastewater from local indigenous mining factories. The stream at the HSG, for example, is brownish red in color, with high concentrations of Cu, Zn, Cd, Fe and Mn. The concentrations of Cu, Zn and Cd in all the stream water of the HSG, SNJ and NT exceed the maximum allowable levels of the Agricultural Irrigation Water Criteria of China. Correspondingly, the HSG, SNJ and NT are heavily polluted by Cu, Zn and Cd due to the long-term irrigation with the contaminated stream water. In comparison, both stream water and paddy fields of the THJ, far away from mining areas, are not contaminated by any heavy metals and hence regarded as a control in this study. The rice grain produced at the HSG, SNJ and NT has a high risk of Cd contamination. The rate of rice grain produced in the four paddy fields in Y county with Cd exceeding the safe level (Cd, 2 μg g-1) specified by the Rice Quality and Safety Criteria of China is 90%; that with Cd exceeding the toxic level (Cd, 1 μg g-1), called as the Cd Rice, reaches 50%. Cd content in the rice grain is positively significantly correlated with that in the paddy fields, especially with the content of diethylenetriaminepentaacetic acid (DTPA) - extracted Cd, suggesting that the heavy metal pollution of paddy fields has already posed a high risk to rice safety and human health. Soil enzyme activities and microbial biomass are significantly inhibited by the heavy metal pollution of the paddy fields. Microbial biomass C and N (MBC and MBN) at a severely contaminated site of the HSG are only 31.6% and 64.4% of the controls; the activities of dehydrogenase, urease, catalase, acid and neutral phosphatase and sucrase are only 25.2%, 49.3%, 52.4%, 94.7%, 53.2% and 87.8% of the controls. These microbial parameters are mostly negatively significantly correlated with the contents of Cu, Zn, Cd and Ni in the paddy fields, suggesting the toxic effects of the heavy metals on microbial processes. Both the Principal Component Analysis (PCA) and Cluster Analysis (CA) indicated that DH activity and MBC are the most sensitive to the heavy metal pollution and could be used as eco-indicators of the environmental quality of the paddy fields in the study areas.

Acknowledgements: This work was supported by the National Natural Science Foundation of China (No. 41130526).

Keywords：*Heavy metal pollution; Paddy fields; Soil enzyme activity; Mining areas*

P3-81

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Heavy Metal Pollution of the Paddy Fields in the Mining Sites and Their Effects on Microbial Biomass in Hunan Province, Central South China

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Hunan province is located in Central South China and abundant in mineral resources. It is a well-known base of nonferrous metals. The mining activities widely occurring in the province, however, have posed threat to paddy fields in the areas. In this study, 37 soil samples of the paddy fields distributed in four towns of Y county, northern Hunan province, were collected. The content of total and DTPA - extracted heavy metals in the samples were analyzed; meanwhile, microbial biomass carbon (MBC) and microbial biomass nitrogen (MBN) were assayed. The results are as follows: (1) The contents of Cu, Zn, Pb, Cd, Co, Ni, Cr in the soils are 36.43 mg kg-1, 267.41 mg kg-1, 21.39 mg kg-1, 3.22 mg kg-1, 18.42 mg kg-1, 29.52 mg kg-1 and 40.25 mg kg-1 on average, respectively. The soils in the areas are commonly polluted by Cu, Zn, Pb and Cd, especially heavily polluted by Cd, with the highest value reaching 10.55 mg kg-1. In almost 100% of the soil samples, Cd content exceeds the recommended safe value specified by the Soil Environmental Quality Criteria of China. Moreover, there are positive significant correlations between each two of Cd, Cu, Zn, Pb and Ni, suggesting their similar sources, possibly related to anthropogenic activities. (2) The contents of DTPA-extracted Cu, Zn, Pb, Cd, Co, Ni and Cr in the soils are 9.98 mg kg-1, 29.30 mg kg-1, 0.84 mg kg-1, 0.3 mg kg-1, 2.53 mg kg-1, 0.11 mg kg-1 and 7.05 mg kg-1 on average, respectively, suggesting their high toxic risks to the rice soil system. The contents of DTPA-extracted heavy metals are mostly significantly correlated with their total contents in the soils, implying that the availability of heavy metals is mainly controlled by their total contents in the soils. (3) MBC and MBN of the soils vary greatly from site to site. MBC ranges from 238.94 - 1186.86mg kg-1, respectively; MBN from 64.83 - 10.49 mg kg-1. Both MBC and MBN are negatively significantly correlated with the contents of Zn, Pb, Cd, Co and Cu. This fully suggests that microbial processes are highly inhibited by the toxic heavy metals.

Acknowledgements: This work was supported by the National Natural Science Foundation of China (No. 41130526).

Keywords：*Heavy metals; Paddy fields; Microbial biomass; Mining sites; Soils*

P3-82

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Evaluation of Limestone -Based Remediation Technique in Sediments Affected by Mining Activities

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Acid mine drainage (AMD) is a big environmental problem caused by sulphide deposits mining and is responsible for the pollution and degradation of soils and waters. AMD may lead to high concentrations of dissolved metal(oid)s, together with high levels of sulphate and low pH. Over the past few decades many remediation technologies were applied to deal with the contaminated soils and waters. Among remediation techniques, chemical immobilization by means of soil amendments has been investigated as a valuable alternative technique for a wide range of contaminated sites. Limestone filler is a good selection in remediation processes, because of its low permeability and low solubility, due to its high degree of physical-chemical stability and because is a non-toxic material showing high finely divided calcium carbonate. In addition, the use of this amendment could revalorise residues, reducing costs.

The aim of this work was to assess the suitability of limestone-based technology in sites contaminated by heavy metals from mining activities.

Portman bay is situated close to the mining region of La Union. The entire area around the bay was subject to mining from the time of the Roman Empire to 1991. These wastes mainly consisted in ore materials (galena, pyrite and sphalerite), phyllosilicates, in addition to siderite, iron oxides and sometimes alteration products such as jarosite, alunite, kaolinite and greenalite. These materials have suffered a concentration process by floatation with sea water and as a result of the discharge; the whole of the bay has filled up with wastes which also extend into the Mediterranean Sea. In 2007, a recuperation project was developed and financed by the Spanish government. In the first step of this project, the complete physical, chemical and mineralogical composition of sediments, both in surface and at depth was carried out. In addition, the chemical and isotopic characterization of waters together with ecotoxicological assays was made. Two experimental areas were selected and technosols were developed as follows: original sediments from the bay, sediments mixed with limestone filler in a 1:1 proportion, gravel to avoid capillary and natural soil to allow plant growth. Considering that this experience gave favourable results, a new experiment was developed in order to optimise the proposed methodology and reduce recuperation costs. Four sediments, considered representative of the whole bay, where selected and mixed with limestone filler at 3 percentages: 10, 20, 30%. The technosols were then submitted to different humidity/dryness cycles simulating the usual rain conditions in the zone and percolates were analysed.

The pH and the electrical conductivity was determined in obtained percolates, together heavy metal concentration. The Zn content was determined by flame atomic absorption spectrometry. The Pb, Cd and Cu content was determined by electrothermal atomization atomic absorption spectrometry. The As content was measured by atomic fluorescence spectrometry using an automated continuous flow hydride generation spectrometer.

In sediments A, C and D percolation assay results suggested that untreated material showed acidic pH, high EC values and high trace elements content. When these sediment is mixed with 10%, 20 and 30% of limestone filler, pH is neutral and soluble trace element content diminishes, being <dl when limestone percentage was 20%. Sediment B corresponds to black sand, that is, washed steriles. All percolates showed neutral pH and low trace elements content. Filler influence is not as important as in sediment A because sea currents washed the most reactive and toxic materials.

The obtained results suggest that the use of limestone filler constitutes an excellent option in sediments polluted by trace elements, because of risk for human health or ecosystem does not exist after the intervention. In addition, the designed experience allows stabilizer proportion to be optimized and may suppose a big cost-saving project in areas affected by mining activities.

Keywords：*Acid mine drainage; limestone filler; remediation project.*

P3-83

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Assessment of the Suitability of Limestone-Based Remediation Technique in Sediments Contaminated by Heavy Metals after a Pilot-Scale

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A lot of soils around the world are contaminated by heavy metals, mainly due to waste deposits, mine activities, chemical escapes, or fall-out from atmospheric emissions, generating adverse effects on human health, food quality, soil ecology and the environment. In response to these negative effects, a variety of technologies to remediate soils affected by heavy metals have been developed. Among them, in situ immobilization is a non-intrusive and cost effective alternative, that transforms the highly mobile toxic heavy metals to physico-chemically stable forms, reducing their mobility and environmental risks. Chemical immobilization by means of soil amendments has been investigated as a valuable alternative technique for a wide range of contaminated sites. A number of natural or synthetic materials, such as phosphate rocks, zeolites, municipal biosolids, red mud or carbonates have been tested in order to evaluate their ability to immobilize toxic trace metals. Limestone filler is a good selection in remediation processes, because of its low permeability and low solubility, due to its high degree of physical-chemical stability and because is a non-toxic material showing high finely divided calcium carbonate content. In addition, the use of this amendment could revalorise residues, reducing costs.

The objective of this work was to evaluate the effectiveness of a immobilization technique in sediments contaminated by heavy metals as a results of mining activities.

The study area was Portman bay, located close to the mining region of La Union and subjected to mining from the time of the Roman Empire to 1991. Wastes from mining activities mainly consisted in ore materials (galena, pyrite and sphalerite), phyllosilicates, in addition to siderite, iron oxides and sometimes alteration products such as jarosite, alunite, kaolinite and greenalite. These materials have suffered a concentration process by floatation with sea water and as a result of the discharge; the whole of the bay has filled up with wastes which also extend into the Mediterranean Sea. In 2007, a recuperation project was developed and financed by the Spanish government. In the first step of this project, the complete physical, chemical and mineralogical composition of sediments, both in surface and at depth was carried out. In addition, the chemical and isotopic characterization of waters together with ecotoxicological assays was made. Two experimental areas were selected and technosols were developed as follows: original sediments from the bay, sediments mixed with limestone filler in a 1:1 proportion, gravel to avoid capillary and natural soil to allow plant growth. After the remediation technique was applied monitoring of experimental areas is done monthly in 18 sampling points, where sediment and water samples were collected and analysed.

The pH and the electrical conductivity were determined, together heavy metal concentration. The Zn content was determined by flame atomic absorption spectrometry. The Pb, Cd and Cu content was determined by electrothermal atomization atomic absorption spectrometry. The As content was measured by atomic fluorescence spectrometry using an automated continuous flow hydride generation spectrometer. In addition, Microtox bioassay was applied in order to study ecotoxicity of collected water samples.

Sediments before the remediation technique showed acidic pH, high EC values and high trace elements content. The obtained results after the immobilization showed that sediment samples showed neutral pH (average value of 8,3) low electrical conductivity (1.32 dS m-1) and low trace elements concentration, in some cases below the detection limit.

When water samples obtained in the piezometers were evaluated the results obtained suggested that these samples correspond to rainfall waters and werew characterised by neutral pH and trace elements concentration below the detection limit. In addition, none of them were sensitive for the selected bioassay

Them we can conclude that the use of limestone filler constitutes an excellent option in sediments polluted by trace elements, because of risk for human health or ecosystem does not exist after the intervention. In addition, the designed experience allows stabilizer proportion to be optimized and may suppose a big cost-saving project in areas affected by mining activities.

Keywords：*limestone filler; technosol; in situ immobilization; AMD.*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Effects of Various Amendments on Heavy Metal Stabilization in Acid and Alkali Soils

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Recent studies using many amendments for heavy metal stabilization on soil were conducted. And the researches have grown more popular in various fields for finding new materials. But, the studies accounting for the use of appropriate amendments considering soil pH remain incomplete. The aim of this study was to investigate the effects of soil pH on the efficiency of various amendments. This study was conducted to investigate the impact of soil pH on amendments effects. So, both acid soil and alkali soil contaminated with heavy metals were collected near mine abandoned agricultural land. Three types of amendments were selected considering different amelioration mechanisms; organic matter, lime stome and iron, and added with different combination. For determining the changes in the extractable heavy metals, water soluble, Mehlich-3, TCLP and SBET method were examined for chemical assessments. For biological assessments, soil respiration and root elongation of bok choy (Brassica campestris L.) were determined. It was revealed that lime stone reduced heavy metal mobility for acid soil by increasing soil pH and iron was good at stabilizing heavy metals by supplying adsorption sites for alkali soil. Organic matter did not show definite results; however, it induced better biological indicators.

Keywords：*Acid soil, Alkali soil, Amendments, Bioavailability, Heavy metals, Stabilization*

P3-85

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

An Antimonate-Reducing Bacterium Isolated from Sb-Contaminated Sediment

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Antimony (Sb) is considered a non-essential element and toxic to most living organisms at elevated concentrations. Except for the bioreduction of Sb(V) to Sb(III) which was suggested from Sb methylation studies, the information on the ability of microbes to reduce oxidized Sb species as a terminal electron acceptor in anaerobic respiration has not been thoroughly studied so far. The objective of this study were to isolate and characterize Sb(V)-reducing bacteria from the sediments contaminated with Sb in Korea, including investigation on the phylogeny of this bacterium strain.

The sediment used in this study was collected from the water outlet of an Sb-oxide factory in Korea. For the enrichment experiment, a sediment sample of 50 g was placed in 500 mL of 5 mM HEPES buffer solution (pH = 7.0) in serum bottles. Then, the serum bottles were purged by argon gas for 30 minutes and shaken at 100 rpm in a water bath incubator for an hour. The inoculums were incubated at 30 oC in 2 days before being injected into a minimal medium containing 5 mM Sb(V) and 10 mM acetate. The enrichments were incubated for 4 days at 30 oC and subcultured twice. Subsequently, the third transfer culture was serially diluted and inoculated onto the agar petri dishes containing anoxic minimal medium(AMM), 1.5% (w/v) purified agar, 5 mM Sb(V) and 10 mM acetate. The agar plates were incubated in an anaerobic chamber. Some colonies were selected for 16S rRNA sequencing, gram staining and TEM photographing. For the isolated bacterium, growth experiment and phylogenetic analysis were conducted.

An Sb(V)-reducing microorganism, temporarily named JUK-1, was isolated. JUK-1 is a Gram-positive, endospore-forming, and rod-shaped bacterium. It occurs individually or in pairs. The cells are 0.6 to 0.8 μm in diameter and 1.2 to 1.7 μm in length. It reproduces through binary fission. JUK-1 is motile by polar or subpolar peritrichous flagella.

JUK-1 reduced Sb(V) to Sb(III) during its growth while the pH of the medium increased and the redox potential decreased continuously. A part of Sb(III) precipitated as white bio-minerals in the AMM medium. Growth did not occur when either Sb(V) or acetate was absent. Optimal growth of JUK-1 occurs at 30 oC and in a minimal medium at initial pH 7.7. The phylogenetic analysis of the partial 16S rRNA sequence (1440 bp) of JUK-1 showed that this bacterium strain belongs to the α-Proteobacteria, Sinorhizobium/Ensifer group, and according to G+C content of DNA, it seems to belong to the genus Sinorhizobium (100% bootstrap value).

The results indicated that this novel Sb(V)-reducing bacterium altered redox state of Sb and thus global cycling of the element. Microbial reduction of Sb(V) to Sb(III) and subsequent formation of precipitate may be applied to development of in-situ stabilization technique for Sb-contaminated soil, sediment and groundwater.

Keywords：*antimonate-reducing bacteria, Sinorhizobium sp., antimony, sediment, isolation, antimony reduction*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Bioremediation of Heavy Metal Contaminated Mine Impacted Soil Using Plant Extract

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An indigenous plant extract was used to produce calcite from Canavalia ensiformis as effective biomaterial, and its ability to form under stable conditions was compared to that of purified commercially available urease. X-ray diffraction and scanning electron microscopy were employed to elucidate the mechanism of calcite formation from the crude plant extracts. The results revealed that urease in the plant extracts catalyzed the hydrolysis of urea in liquid state cultures and decreased heavy metal amounts in the contaminated soil. The heavy metal amounts were decreased in the leachate from the treated mine soil; 55.4% of Pb, 35.6% of Cu, 33.6% of Mn, 32.0% of As, and 25.6% of Fe, respectively. The procedure described herein is a simple and beneficial method of calcite biomineralization without cultivation of microorganisms or further purification of crude extracts. This study suggests that crude plant extracts of Canavalia ensiformis have the potential to be used in place of purified forms of the enzyme during remediation of heavy metal contaminated soil.

Keywords：*Calcite precipitation; Heavy metal removal; Mine impacted soil; Plant extracts; Soil remediation.*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Bacterial Community Structure Analysis for a Heavy Metal Contaminated Mine Impacted Soil Remediation Process

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Acid mine drainage occurrence is a serious environmental problem by mining industry, it usually contain high levels of metal ions, such as iron, copper, zinc, aluminum, and manganese, as well as metalloids of which arsenic is generally of greatest concern. It causes mine impacted soil pollution with mining and smelting activities, fossil fuel combustion, and waste disposal. The polymerase chain reaction coupled with denaturing gradient gel electrophoresis (PCR-DGGE) has been widely used to determine microbial community structure and species richness in a variety of environmental matrices. Previous studies commonly showed the naturally occurring microbial communities from soil samples after routine chemical or microbial analyses, and use of PCR-DGGE to analyze microbial communities of mine impacted soils has been largely unexplored. Therefore, we report the molecular characterization of the microbial diversity and composition change of the mine impacted soil or waste ore taken from the site during bioremediation processes are presented. To evaluate the stability of DGGE patterns in remediated mine soils in comparison with before or after plant extract treatment, a number of soil samples with time interval in the mine impacted soil were compared using PCR-DGGE of 16S rDNA. This analysis showed that some bacterial strains in the treated mine soils were maintained throughout the treatment process and were, therefore, stable under the mine impacted soil treatment conditions. The results considerably extend the knowledge of the diversity of microorganisms in heavy metal contaminated soil environments. Use of treated mine soils to determine long-term changes in bacterial community structure via PCR-DGGE appears to be a potential candidate for addressing microbial community dynamics for particular bioremediation processes.

Keywords：*Mine impacted soil; Bioremediation; Bacterial community analysis; PCR-DGGE*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Stabilization of Heavy Metals in Agricultural Polluted Soil Using Various Amendments

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Heavy metals contamination in soil is a major globally and one of the most serious environmental problem nowadays, especially accumulation in agricultural soils. Because of heavy metals' toxicity and profusion, it can cause serious consequences to ecological environment as well as human health through poor quality of agricultural products. To date, there are many solutions have been administered to mitigate the toxicity of heavy metals in soil. Remediation method based on chemical stabilization using inexpensive amendments and plants to restrict harmful aftereffect upon polluted soil is now widely applied, it is also based on the principle that heavy metal is easily accumulated by plants as well. Absorption efficiency of amendments including three individual kinds (steel slag, lime, acid mine drainage- AMD sludge) and one combined mixture (lime plus AMD sludge) was assessed using Lettuce (Lactuca sativa L.) and compared with non treated soil- control sample. Experiments were also divided into 2 parts on which a half was kept in original while the other was added cover (collected near soil sampling area) to all samples for testing the effectiveness of clean cover soil on extractability of metals. Evaluation of the redeemable metal fraction and trace elements bioavailability were determined via sequential extraction using Wenzel method for As and Tessier method for other cationic metals. Obtaining results show addition of amendments significantly decreased the burden of heavy metals in soil; in which steel slag represented as the most efficient treatment in reducing concentrations of Cd, Cu, Ni, Zn meanwhile lime was the most sufficient with As and Pb. Compared with non-treated soil, uptake by lettuce of Cd, Cu, Zn by adding steel slag and uptake of As, Pb by addition of lime were reduced 76%, 74%, 73%, 75% and 69%, respectively. In particular, the role of cover soil, which showed great influence and astonishing results in immobilization of heavy metals, is incontrovertible. Compared with samples without cover soil, the remaining samples exposed database about the heavy metal concentrations in plants 0.58- 6.29 times lower. Besides assessing performance of treatments in reducing metabolic efficiency of heavy metals from polluted soil into plants, this study also evaluate effectiveness of amendment in providing clean agricultural productions based on calculation of plant biomass. By indentifying the net weight of edible crop parts, crops planted in lime and steel slag added soil for acceptable biomass, in turn were 14.47 grams and 12.66 grams with no cover soil sample, 20.16 grams and 13.79 grams on soil samples with cover layer.

Keywords：*stabilization, amendments, heavy metals accumulation*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Detailed Remediation Study in Heavy Metals-Contaminated Site around the Abandoned Myeongbong Au Mine in Korea

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The purpose of this study is to suggest a basic data in order to drive an economic and effective remediation method planning of heavy metals contaminated soil around the abandoned Myeongbong Au mine in Korea. Detailed environmental geochemical survey of agricultural soil, and stream water and groundwater was conducted to investigate the source, the level and covered area of soil contamination. The principal contamination source was originated from the mine tailings and waste rocks, and effluents of mine waters to the stream of the mine area. The content of As in stream water and groundwater is mostly below the permissible level except for the mine water of 0.78 mg/l As and drilled groundwater of 0.11 mg/l As. A total of 1,124 surface soil (0-30 cm in depth) and subsurface soil (30-60 cm) samples were analyzed for As, Cd, Cu, Pb, Zn and Hg following the Korean standard soil analysis method. The level of heavy metals in 626 (55.7 %) and 119 (10.6%) soil samples were over worrisome level and countermeasure standard, respectively. A total of 54 soil samples were collected vertically from 18 holes of 1m, 2m, and 3m in depth. At the depth of 1m, the level of As, Cd, Cu and Zn in 23 and 7 samples were over worrisome level and countermeasure standard, respectively. At the depth level of 2 m, that in 21 and 2 samples over worrisome level and countermeasure standard, respectively. At 3m level, that in 14 and 4 samples were over worrisome level and countermeasure standard, respectively. The soil depth of study area was about 3 to 4 m, and soil contamination occurred in all depths within 3 m. The most contaminated site occurs over the reclaimed mine tailing site, and the level of As and Cd in all depth of 1, 2, and 3 m was over the countermeasure standard and that of Pb over worrisome level. The contaminated area by As and Cd over the countermeasure standard was 81,046 m2 and 2,525 m2 (maximum As level was up to 5,534 mg/kg), respectively, and that over worrisome level was 336,138 m2 and 6,233 m2, respectively. The contaminated area by Hg over worrisome level was 2,525 m2. The increasing order of contamination degree was As, Cd and Hg. It is suggested according to the topographic relief that most heavy metals -contaminated soil site be remediated with clean soil capping and dig and dump method, and partly with some limestone and steel slag for stabilization. Approximate budget for remediation project will be estimated as more than 8 million US dollars.

Keywords：*Myeongbong Au mine, Heavy metals-contaminated soil, Worrisome level, Countermeasure standard*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Heavy Metals Contamination and Remediation Method around the Abandoned Seoseong Au-Ag-Pb-Zn Mine in Korea

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The purpose of this study is to investigate the contamination levels of heavy metals in agricultural soils around the abandoned Seoseong Au-Ag-Pb-Zn mine in Korea, and to suggest a basic data for an economic and effective remediation method planning of the contaminated soil. The principal contamination source of soil was originated from the mine tailings, and the surveyed area was mostly farmland and paddy field of 623,750 m2 in area. A total of 902 surface soil (0-30 cm in depth) and subsurface soil (30-60 cm) samples were analyzed for As, Cd, Cu, Pb, and Zn following the Korean standard soil analysis method. The area of 200,882 m2 was contaminated with heavy metals over worrisome level; As(62,203 m2 in area), Cd(89,422 m2), Pb(160,821 m2), Zn(91,003 m2) and Cu(15,665 m2). The size of contaminated area was in the order of Pb, Zn, Cd, As and Cu due to the production activity of Pb and Zn ores at the mine. The increasing oder of contamination in surface soils is Pb, Cd, Zn, As and Cu, and that in subsurface soil Pb, Zn, As, Cd and Cu. A total of 120 soil samples were collected vertically from 40 holes of 1m, 2m, and 3m in depth. At the depth of 1m, the contamination level of the above metals in 2 and 4 holes were over worrisome level and countermeasure standard, respectively. At the depth 2 m, that in 1 and 5 holes over worrisome level and countermeasure standard, respectively. At 3m level, that in 1 and 5 holes were over worrisome level and countermeasure standard, respectively. The most contaminated site occur on the landfill site of No. 4 mine dump and the level of As, Cd, Cu, Pb and Zn in soils from holes of 2 - 4 m depth was over the countermeasure standard (Maximum value of Pb was upto 65,371 mg/kg). It is suggested according to the topographic relief that most heavy metals -contaminated soil site be remediated with clean soil capping, and dig and dump method partly with some limestone and steel slag for stabilization. Approximate budget for remediation project will be estimated as more than 6 million US dollars.

Keywords：*Seoseong Au-Ag-Pb-Zn mine, Heavy metals -contaminated soil, Remediation*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Heavy Metals Contamination and Remediation Method around the Abandoned Namkyeongsang Au-Ag-Pb-Zn Mine in Korea

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The purpose of this study is to investigate the contamination levels of heavy metals in agricultural soils around the abandoned Namkyeongsang Au-Ag-Pb-Zn mine in Korea and to suggest a basic data for an economic and effective remediation method planning of the contaminated soil. The principal contamination source of soil was originated from the mine tailings and waste rocks, and the size of surveyed area was 249,281 m2. A total of 536 surface soil (0-30 cm in depth) and subsurface soil (30-60 cm) samples were analyzed for As, Cd, Cu, and Pb following the Korean standard soil analysis method. The area of 21,123 m2 was contaminated with heavy metals over worrisome level ; As(5,794 m2 in area), Cd(1,258 m2), Pb(12,706 m2), and Cu(1,365 m2). There was no contaminated area over countermeasure standard. A total of 81 soil samples were collected from 27 holes of 1m, 2m, and 3m indepth. Heavy metals content in most soil samples collected from the depth of lower than 1m were below the permissible level. It is suggested according to the topographic relief that most heavy metals -contaminated area be treated first with clean soil capping because there are several suitable uncontaminated clean soil covers around the site. The recommended second method will be dig and dump to maintain the relief of the agricultural soil cover, and the ideal remediation method will be first and /or second method mixed with stabilization method in some contaminated areas. Approximate budget for remediation will be estimated as more than 4.5 million US dollars.

Keywords：*Namkyeongsang Au-Ag-Pb-Zn mine, Heavy metals-contaminated soil, Remediation*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Effects of Soil Amendment and Uncontaminated Soil Covering on Yield And Heavy Metal Accumulation of Brassica Campestris Var. Chinensis in Heavy Metal Contaminated Soil

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Soil around mine area can be highly contaminated with heavy metal. Because food crop can absorb that heavy metal, the soil contamination of heavy metal can affect to human health. Therefore, the current study was conducted to cultivate safer food crop production by reducing heavy metal accumulation and to increase production. The experiment conducted in field in Danyang-gun, North Chungcheong province near by Eugene mine. Amendments (lime, steel slag, acid mine drainage sludge) were treated as heavy metal stabilizer and uncontaminated soil was covered. Bok choy (Brassica campestris var. chinensis) was cultivated in the field. As, Cd, Pb, Zn in the contaminated soil in the field over standard. Because of that they became target elements. The bok choy on the soil that lime was treated had the highest concentration of all elements. Steel slag and acid mine drainage sludge had similar efficiency. The plot where uncontaminated soil was covered on amendment treated soil had higher efficiency than amendment treated soil without uncontaminated soil. Average weight of bok choy on lime treated soil was lower than the one on control soil, but the one on steel slag and acid mine drainage sludge was higher than the one on control soil.

Keywords：*heavy metal, stabilization, AMD sludge, lime, steel slag, Brassica campestris var. chinensis*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Mining Area Soil Reclamation in Korea

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Despite being an important economic activity, mining causes substantial damage to the environment. In Korea, it has been widely recognized since the late 20th century that reclamation is required, "To return the mined area to an acceptable environmental condition and allow such lands to achieve their optimum economic value." According to the Ministry of Trade, Industry and Energy of the Republic of Korea (KMoTIE), Korea currently has approximately 5,396 mines, including 2,166 metallic mines, 400 coal mines, and 2,830 nonmetallic mines. More than 85% of these mines are now closed and may be sources of environmental pollution. In particular, metal mining and refining facilities at abandoned metal mines have been left unattended, with mine tailings and ore waste being released. The national survey of mine damage revealed that 950 mines out of the 2,089 abandoned metal mines require soil reclamation, which can restore this land. As public awareness of the adverse effects of toxic elements on animal and human nutrition has increased, interest in developing guidelines and remediation technologies for mitigating toxic element-contaminated ecosystems has also increased. The national survey of KMoTIE states that arsenic (As) is the most common inorganic soil contaminant in mine areas, and mine sites show complex situations with pollution by both As and metals. In Korea, as most contaminated soils are located in agricultural areas, one may assume that remediated soils would typically be reusable. Thus, low-cost, low-input technologies are required for the remediation of contaminated agricultural soils and community acceptance. Mine soil reclamation began in 2006 in Korea with the promulgation of the "Mining Damage Prevention and Restoration Act". It is the first regulatory document specifically designed for the reclamation of damaged mine area. To date, 52 mines (1,569farmland, 274 ha) were reclaimed mainly using soil covering and/or replacement with stabilization. Applied mine soil reclamation technologies include simple covering without stabilization (SC, 15.20% of total remediated farmland), simple replacement without stabilization (SR, 2.05% of total remediated farmland), covering with stabilization (CS, 52.89% of total remediated farmland), and replacement with stabilization (24.85% of total remediated farmland). The thickness of covering soil layers ranged from 30~50 cm on both covering and replacement, but 40 cm was typically applied. To stabilize As and heavy metals in soil, two common amendments were applied; namely, limestone and steel making slag. These amendments were applied alone or in combination according to soil and contamination characteristics. After reclamation, comprehensive maintenance programs are required for 5 years to monitor stability and durability of the reclamation by evaluating soil contamination levels in surface soil (<30 cm) and crops. Based on the monitoring results, covering and/or replacement with stabilization decreased public exposure and reduced metal contamination levels in food, water, ingestion soil, and dermal exposure. There are several major challenges in mine soil reclamation in Korea. First, in relation to laws and regulation, the regulation of contaminants in Korea is based on the total contaminant concentration. However, knowledge of the total concentrations of trace elements in soil provides very limited information regarding their behavior, fate and potential risk. Second, technologies to simultaneously treat As and metal contaminants are lacking. The successful stabilization of multi-element contaminated sites depends on the combination of critical elements in the soil and the choice of amendment. Chemical mechanisms in amended soil, ecological consequences and potential remobilization processes are only partially understood and require long-term studies. Finally, covering with imported soil is a rapid and simple (but expensive) solution, but the guest soil may be difficult to obtain. Thus, alternatives (such as benign materials) are required. To facilitate mine soil reclamation in Korea, several measures can be taken. First, more diversified reclamation goals should be established reflects the land uses and local characteristics. Second, rehabilitation guidelines or best practices environmental management for mining that can easily be understood and implemented by people responsible for restoration should be developed as soon as possible. Finally, research into important fields, such as restoration planning, environmental risk assessment, and assessment criteria for the success of restoration technologies should be conducted.

Keywords：*Mine soil, Reclamation, Stabilization, Covering, Replacement, Amendment*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

A Study on Manufacturing Asbestos Removal Equipment of Soils and its Field Applications

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Asbestos is one of the commercial terms given to a group of six fibrous hydrated silicate minerals which occur in sufficient quantity and quality to be mined and processed for industrial and commercial applications. It is well known that asbestos is a group of fibrous minerals often associated with the development of pulmonary interstitial fibrosis (asbestosis). In general, there are two families of asbestos, both serpentine group and amphibole group. The former includes only chrysotile, and amphibole group is composed of actinolite, amosite, anthophylite, crocidolite, and tremolite. Because of its fibrous characteristics, asbestos related diseases including asbestosis pulmonum, lung cancer and malignant mesothelioma can be occurred in occupationally exposed individuals. Thus, lots of studies for environmental assessment of asbestos caused by natural and anthropogenic sources were undertaken and prohibited usage of asbestos and related materials. As a result, most of countries including Korea have banned all use of asbestos and extraction, manufacture and processing of asbestos products. However, various countries still have environmental problems due to asbestos exposure derived from previous usage of asbestos for industrial materials, roof covering materials of individual house and asbestos mining and milling process, and so on.

In Korea, there are over 40 abandoned asbestos mines and 250 naturally occurring asbestos (NOA) areas. After closing the mines, lots of fibrous materials including asbestos were left around the mines without a proper environmental remediation work, and eventually influenced in agricultural areas as well as residential areas. In addition to NOA areas, friable asbestos on the surface of weathered rocks contained asbestos-related minerals were distributed around the areas due to wind and precipitation, which are one of the most important sources of asbestos-related environmental problems.

The objectives of this study, therefore, are to develop a proper removal equipment of fibrous materials including friable asbestos in soils, and to find out best working conditions of the equipment in field. For the basic concepts, friability of asbestos was used for removal asbestos from soils. After manufacturing the equipment, best working conditions of the equipments were examined on the basis of three major factors, revolution numbers of brush, inhalation velocity of friable asbestos, and moving velocity of the equipment. As results of laboratory experiment, the best working conditions of the equipment were 200rpm of rotation for brush, 3m/s of inhalation velocity and 0.1m/s of moving velocity of the equipment, and applied under various working condition in field. Friable asbestos samples from three types of land usage including playground soils of elementary school contained 0.5% of asbestos, orchard soil with 0.25% of asbestos, and farmland soils with 1.0% of asbestos were collected, and then measured friable asbestos concentrations before and after remediation work used the equipment with 20 times' removal trials. In comparison to asbestos contents in soils adapted before and after remediation work using the equipment, over 50% of asbestos in the soils were removed. In addition, the airborne asbestos contents from the soils were 18.414f/cc, 12.668f/cc and 104.310f/cc for playground, orchard and farmland, respectively. This study also examined the proper water contents of soils for application of the equipment and concluded that asbestos contaminated soils with less than 10% of water contents is quite enough to removal asbestos using the equipment. Furthermore, the best removal trials for the equipment adapted asbestos contaminated soils were 10 times as considering economic efficiency. Therefore, it can be concluded that the manufactured equipment for removal asbestos in asbestos contaminated soils by natural and anthropogenic sources is well developed and applied to various types of land usage. This study also recommended that decreasing method for water content of soils using heating system and more efficient disturbing method for the surface area of the asbestos contaminated soil using plowing system are needed to additional facilities.

Keywords：*Asbestos removal equipment, Fibrous materials, Soil remediation, Friable asbestos*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Release of Cd, Zn and Pb from Alkaline Soil Nearby Abandoned Metal Mine by Rainfall and the Treatment Effect of Limestone

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Vast areas of abandoned metal mines were left that were polluted by heavy metals during the last almost a century in South Korea. The most feasible approach to restore these sites is the stabilization method, which reduces the mobility of heavy metals via the stabilization agent. In this study, the leaching characteristics of the stabilization technique using limestone as a stabilization agent, was examined. The limestone was applied to contaminated soil under the condition of normal- and acidic-solution conditions (pH=5.6, 4.6, and 3.6) in a laboratory-scale column test, which were considered an acidic rainfall situation in South Korea.

Form the test results, it was observed that heavy-metal components could be released at the early stage of the supply of acidic solution even highly alkaline soil. Especially Cd and Zn components were shown the abrupt or continuous leaching characteristics with the supply of acid solutions. Because of the rain generally being slightly acidic in South Korea, it was anticipated that the Cd and Zn components may be released, and it could be caused the pollution of surrounding water systems.

Therefore, the treatment using stabilization agents, such as limestone, could obviously reduce the leaching of heavy metals from the contaminated soil and it was considered that the application of stabilization method to the heavy-metal-contaminated farmland soil as an economical and feasible way was needed to reduce the releasing of pollutants around abandoned metal mines.

Keywords：*soil contamination, heavy metals, stabilization method, acid rainfall, stabilization agent*

P3-96

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Study on In-Situ Stabilization of Heavy Metals through Activation of Indigenous Bacteria in Arable Soil

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Microbiological in-situ stabilization of heavy metals is a technique with advantages including low process cost, low energy input, and less hazardous byproducts when compared with physical or chemical treatment methods. Thus they received much attention from researchers and scientist concerned in soil remediation. This study was conducted to investigate the effects of indigenous bacteria on geochemical behavior of toxic heavy metals in contaminated arable soil near abandoned metal mines. The microbiological stabilization possibility was investigated through activation of indigenous bacteria through supplying with carbon source and sulfate in batch-type experiments. Sulfate (250 mg/L) was artificially injected at 60 days after the onset of the experiments. In the case of glucose supply, pH of solution was increased from 4.8 to 7.6 while pH was maintained at 7~8 in the lactate solution. The initial low pH in the case of glucose supply likely resulted in the enhanced extraction of Fe and other heavy metals at the initial experimental period. Lactate supply exerted no significant difference on the amounts of dissolved Zn, Pb, Ni and Cu between microbial and abiotic control slurries; however, lower Zn, Pb and Ni and higher Cu concentrations were observed in the microbial slurries than in the controls when glucose supplied. Sulfate amendment led to significant decrease in dissolved Cr and maintenance of dissolved As, both of which had gradually increased over time till the sulfate injection. Black precipitates formed in solution after sulfate amendment, and violarite (Fe+2Ni+32S4) was found in the microbial precipitates. The mineral might be conceivably formed after Fe(III) reduction and microbial sulfate reduction with co-precipitation of heavy metal(s). The results suggested that heavy metals which can be readily extracted from contaminated arable soils may be stabilized in soil formation by microbial sulfate reduction. The experimental results of bacterial control on the geochemical behavior of the toxic elements were practically applied to contaminated field site with 2m x 2m x 0.5m dimension based on the results of batch experiment. Carbon source and sulfate were injected to the field by downward injection to a total of 100 L. The supply of carbon source into contaminated field had increased the activity of indigenous microorganisms. After 117-day incubation of indigenous bacteria, weak acid-extractable As and Cd appeared to be successfully in situ stabilized in the geological media, which showed long-term stability of the stabilized toxic elements.

Keywords：*heavy metals, stabilization, indigenous bacteria, arable soil*

P3-97

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Neutralization of Acid Mine Drainage and Stabilization of Their Soluble Al by Treatment of Coal Fly Ash under Laboratory Conditions

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Acid mine drainage (AMD), produced from both surface and underground mine wastes and tailings, has discharged into the surrounding streams in mine areas of South Korea. Due to its low pH, high Al, Fe, Mn, and sulfate, it has caused serious water pollution in mine areas, showing yellow boy and aluminium whitening in streams. Coal fly ash (FA), in contrast, has alkaline characteristics and contains nutrients such as Ca, Mg, B. Therefore, the aim of this study was to investigate the effect of FA on the neutralization of AMD and stabilization of their soluble Al and Fe after treatment with FA under laboratory conditions. Mine wastes, collected from Kyeongdong mine site, were air-dried and mixed with FA (air-dried) at different mixing ratio of 0, 10, 20, 30, 40, 50% (w w-1). The mixtures were saturated with distilled H2O (16 h, water content about 35%), and the saturation extracts were analyzed for pH, EC, Al, cations, and anions. Soluble and insoluble Al species were predicted by using Visual MINTEQ. pH(1:5 H2O) of the saturation extracts from mine wastes with FA 0% was 4.3, and it increased up to pH 12.1 with the increasing mixing ratio from 10% (pH 6.89), 20% (pH 7.75), 30% (pH 8.29), 40% (pH 11.3) to 50 % (pH 12.1). This indicated that more than 20% of mixing ratio is not recommended. The concentration of Al in the saturation extracts from mine wastes with FA 0% was 25.9 mg L-1, and it decreased up to 0.80 mg L-1 with the increasing mixing ratio from 10% (0.80 mg L-1), 20% (0.42 mg L-1), 30% (0.32 mg L-1), 40% (0.34 mg L-1) to 50 % (0.09 mg L-1). The concentration of Fe in extracts also decreased from 0.15 mg L-1 to be not detected with the increasing mixing ratio from 0 to 50%. We calculated the possible Al species in extracts by using Visual MINTEQ. The main solid forms of Al were Al(OH)3, Al4(OH)10SO4, AlOHSO4, KAl3(SO4)2(OH)6. The saturation index (SI) showed that Al(OH)3 and Al4(OH)10SO4 were unsaturated with mixing ratio of FA 0%, but were supersaturated with the increasing mixing ratio from 10%. In the case of AlOHSO4, KAl3(SO4)2(OH)6, they were supersaturated already with the mixing ration of FA 0%, showing high precipitation feasibility. These results indicated that most Al species should be precipitated above the mixing ratio of 10%. The application of FA could neutralize the AMD, generated from mine wastes in Kyeongdong mine site, and reduced dramatically the concentration of toxic Al and Fe, forming precipitations of Al and Fe compounds. On the basis of these results, we recommend the FA mixing ratio of 20% to neutralize the AMD.

Keywords：*Al precipitation, AMD, fly ash, MINTEQ, neutralization*

P3-98

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

In-Situ Application of Coal Combustion Ash for Management of Acid Mine Drainage(amd) from Coal Mine Wastes in Korea

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Mine wastes were merely dumped in the mine waste dump, they has produced Acid Mine Drainage(AMD). Generally, AMD from mine wastes was acidic and retains many soluble heavy metal ions. It has discharged into a surrounding stream, it is causing a serious water pollution e.g. with aluminium whitening and yellow boy. The Coal Combustion Ash(CCA) can use stabilization material to improve the quality of contaminated water at the river near investigated mine sites because it has alkaline characteristics and contains many nutrients such as Ca, Mg, etc.. The objective of this study is to evaluate the feasibility of CCA for stabilization of AMD which produced from mine waste dump. Field test was conducted in mine waste dump of operating mine (Kyung dong corp, Korea). Field plots were constructed a four types treatment plot; 1. W (Mine waste only), 2. WC20M (Mine waste + CCA 20% (w w-1) mixture), 3. WC40M (Mine waste + CCA 40% (w w-1) mixture), 4. WC40MD ([Mine waste + CCA 40% (w w-1) mixture] + Fresh soil layer). The runoff water and leachate was collected after raining during the past two years. In this poster, it was used to average of monitoring data. It was analyzed for pH, EC and Al, Fe concentration and it was expected to precipitable chemical species of Al as estimate to saturation index(SI) by Visual MINTEQ program. The result of runoff water showed that W treatment plot was pH 5.42 but it was increased to pH 6.60, 7.37 in WC20M, WC40M. The concentration of Al and Fe in WC40MD was decreased from 0.42, 0.17 mg L-1 to 0.07, 0.06 mg L-1. In the case of leachate, pH was lower than runoff water in all treatment plot. pH in WC40M(pH 4.34) is a little higher than W treatment(pH 3.80). The concentration of Al and Fe was decreased from 47.01, 0.37 mg L-1 to 15.12, 0.12 mg L-1 by treat CCA. The EC of leachate was higher than runoff water in all treatment plot because reaction time of leachate was very longer than runoff water. The concentration of SO42- in each treatment plot was high regardless of treat CCA(more than 2000 mg L-1). Among the chemical species of Al (Al(OH)3, AlOHSO4, Al4(OH)10SO4, KAl3(SO4)2(OH)6), AlOHSO4 and KAl3(SO4)2(OH)6 was presented to precipitable species in W treatment plot. But kind of precipitable species was increased from two to four in WC20M, WC40M, WC40MD. In the leachate, Al(OH)3 and KAl3(SO4)2(OH)6) was presented to unsaturation, and it was presented to same in other plot. But AlOHSO4 was presented to supersaturation in all treatment plot without reference to treat of CCA. In conclusion, aplication of CCA to mine wastes is increase pH and decrease concentration of Al, Fe as well as probability that Al compound is change to be precipitation is increased as state of Al compound is change from unsaturated state to supersaturated state.

Keywords：*AMD, CCA, MINTEQ, stabilization,*

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[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Isolation and Identification of Bacteria Capable of Oxidizing as(iii) to as(v) from As-Contaminated Soil

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Arsenic(As) is released as the large amount to the area adjacent to the adjourned and exhausted mine. It is well known that As is toxic to living organism. The technology development for the removal of As is currently urgent in Korea. The majority of As-removing technology has been focused on the removal of As(V) by adsorption and precipitation technology, even though the major species of As is As(III). Therefore, the oxidation of As(III) to As(V) is essential prior to the removal of As. However, it depends to a large extent on the chemical oxidation of As(III) to As(V). Therefore, the microbiological oxidation of As(III) to As(V) in this study was tried and evaluated through the isolation and identification of bacteria from the soil contaminated with high concentration of As. The potential As-oxidation of the standard culture Alcaligenes faecalis was within 40 to 55% range. Based on the experimental results from the isolation of bacterial cultures capable of oxidizing As(III) to As(V) from the soil ontaminated with As, As1 and As4 colonies on the agar plate were found to have the As-oxidizing capacity. As a result, As1 and As4 have 33% and 16% of oxidation rates, respectively. The proteome analysis was performed for the As1 culture showing relatively high potential capable of oxidizing of As(III) to As(V). The As 1 culture was identified as Bacillus thuringiensis serovar finitimus YBT-020, based on 16S-rRNA gene sequencing. Compared to the untreatment, the intensity of some protein spots for Bacillus thuringiensis serovar finitimus YBT-020 was increased, as the As concentration was gradually increased from 20 ppm to 50 ppm through the use of 2-DGE(2-dimensional gel electrophoresis). At 100ppm of As, the proteins intensity was decreased, which indicates that it may be involved in the resistance to As. In addition, as the As concentration was increased, compared to the untreatment, the other protein spots in which its intensity was decreased was found. Therefore, in the further study, the proteins involved in the oxidation of As(III) to As(V) and its resistance will be characterized.

Keywords：*Isolation, Identification, Bacteria, As(III), AS(V), Oxidation, Cotamination, Soil*

P3-100

[IDS15]Advanced Technology on Soil Remediation in Mined Lands: MIRECO Symposium

Determining Soil Quality Index (sqi) for Heavy Metal Contaminated Agricultural Field

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Adverse effect of heavy metal contamination in agricultural field near at the abandoned metal mine has been awared as a citical problem in Korea not only for human health concern but also crop safety. In addition, crop production is generally decreased after remediation in agricultural field. Main objective of this research was to determine soil quality index (SQI) in heavy metal contamined agriclutural field after remediation with chemical amendments for evaluating crop productivity. Five soil chemical properties, soil pH, electric conductivity (EC), cation exchange capacity (CEC), available phospohate (P2O5), and soil organic matter (SOM) were chosen as minimum data set (MDS) with principle component analysis (PCA). Among 5 factors, available phosphate showed the lowest percentage (38%) for the optimum range in terms of crop productivity comparing to other properties (58% for soil pH, 42% for EC, and 60% for OM, 72% for CEC). Based on PCA analysis, SQI was calculated with weighting method. Calculated SQI in agricultural filed remediated with three different chemical amendments, lime, steel slag, and acid mine drainage slude, was 56, 48, and 46 respectively. Overall, steel slag can be used as chemical amendment for remediation in heavy metal contamined agricultural field considering crop safety and management of available phosphate is necessary to increase crop yield.

Keywords：*Heavy metal, Remediation, Amendments,Soil quality index, Minimum data set*

P3-101

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Portable X-Ray Fluorescence Spectrometry for Elemental Soil Characterization

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Proximal sensing technologies are rapidly gaining popularity as a key component of soil characterization. Already, collected pedons in the United States are subjected to visible near infrared diffuse reflectance spectroscopy (VisNIR DRS) scanning at the National Soils Laboratory in Lincoln, NE. In doing so, a spectral library of each soil horizon or depth is created; data which can be parsed to predict a number of different soil properties (e.g., soil organic carbon, clay mineralogy, etc.). Portable x-ray fluorescence (PXRF) spectrometry is a similar non-destructive, proximal sensing technology which offers elemental quantification in-situ, in ~60 seconds. The technique requires no consumables or extensive sample preparation such as grinding or digestion. Furthermore, the advent of silicon drift detectors for contemporary PXRF spectrometers has resulted in lower limits of detection and lower error terms. Already, the US Environmental Protection Agency has a published method (6200) for the use of PXRF in characterizing soils and sediments. The USDA Natural Resources Conservation Service has recently developed a PXRF method for their new SSIR No. 51 Version 2.0 Soil Survey Field and Laboratory Methods Manual. Thus, this technology has the potential for multiple pedology, agronomy, and environmental science applications. In this paper, we argue that soil pedons should be subjected to PXRF scanning so as to create a library of elemental data by horizon or layer, in much the same way VisNIR DRS is currently used. However, we argue that PXRF elemental data can be used to successfully predict a number of other soil physicochemical properties (different from those predicted by VisNIR DRS) including clay percentage, gypsum content, calcium carbonate content, salinity, pH, and the presence/availability of plant available nutrients. Furthermore, heavy metal quantification as an indicator of anthropogenic impacts on environmental quality relative to established geochemical background levels can be determined. As with all proximally sensed data, georeferencing of the captured data allows for rapid spatial analysis showing trends in soil variability, contaminant plumes, and the impacts of humans on the environment. Summarily, we argue that PXRF should be widely employed as an accurate means of producing soil elemental data with numerous environmental, pedological, and agronomic applications.

Keywords：*Portable x-ray fluorescence, heavy metals, soil analysis, salinity, pH*

P3-102

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Micromorphology and Genesis of a Calcareous Soil Along a Catena, Southern Iran

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A catena is a transect of soils from the top to the base of a hill, perpendicular (or nearly so) to the contour lines. Soil profiles change along this sequence in accordance with conditions of drainage and geomorphic history. In order to determine the role of topography and drainage condition on soil genesis, a micrmorphological study was carried out along a catena in Kohgilouye Province, southern Iran. Yasouj Eastern Plain in Kohgilouye Province, is an ideal location for studying soils within the framework of a catenary relationship. This catena is located on relatively same parent material (mostly calcium carbonate). It has the main physiographic units along a toposequence, comprises of alluvial and colluvial fans, piedmont plain, plateau and, lowland under the influence of the water table (drainage condition). This study area was in a plain of about 2800 ha. The elevation of the area varies between 2208 and 2375 m above the sea level. Seven representative soil profiles were described and studied accurately. Thin section observations, SEM and digital microscope studies were used in this study. The major contributing soil processes can be categorized as calcium carbonate leaching, clay eluviation, and Fe-Mn oxides formation. Since the soils in this study are moderately to highly calcareous, the b-fabric is mostly calcitic crystallitic. Exceptions are soils with argillic horizons. Where it can be speckled when calcite depletion occurs as well as grano, parallel and porostriated b-fabric. The main observed pedofeature was secondary calcium carbonate as mycelium, nodules, coating and infilling in vughs and channels, as well as biogenic calcite of cytomorphic and needle-shaped types. Microcrystalline calcite nodules were widespread in almost all the B horizons with some differences in shape, size and internal fabric. Clay coatings and Fe-Mn oxides were also observed in some soils. Calcite depletion pedofeatures were the most striking aspect of the soil thin sections studied. In pedons that were located on more stable physiographic unit, a higher frequency of micritic calcite nodules was observed. The presence of needle-shaped calcite in aquic and non-aquic conditions throughout the soil profile suggests an appropriate broad range of pedoenvironmental conditions for the formation and stability of this mineral habit. The magnitude of calcite nodule that was impregnated with Fe-Mn oxides was higher in soils formed on more stable geomorphic units. Adjacent formation of needle-shaped calcite and cytomorphic calcite in some horizons may suggest the biogenic source of this mineral. Clay coatings were observed as coating and hypocoating around voids, on nodule surface, along channels and as non-oriented clay films in matrix. In most argillic horizons thin sections, clay films were cleared after a mild HCl treatment, suggesting masking of the clay coating by carbonates. Digital microscope images exhibited that calcite crystals formed in aquic condition were mostly covered by dark spots probably a combination of organic matter, Fe-Mn oxides or clay particles, while similar calcite crystals were limpid in non-aquic horizons. Precipitation of non carbonatic materials on calcite crystals may occur during dryer seasons.

Keywords：*calcium carbonate, drainage, Fe-Mn oxides, Iran, topography*

P3-103

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Soil Quality and Variability Assessment of Ultisols Derived from Sand Stone in South Western Nigeria

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The study was conducted to assess soil quality and variability of soils in experimental plots on Ultisols which has been cultivated for about four decades at the Institute of Agricultural Research Training, Ikenne , Ogun state, Nigeria for effective management. The area was divided into subs units of 200 200m2. for detailed study. Soil units were confirmed with auger holes borings and minipits. Surface and sub -surface samples were collected in triplicates within each unit and the samples were subjected to routine soil physical and chemical analyses. Analysis of variance (ANOVA) was carried out on the data and treatment means were compared using Duncan's Multiple Range Test at $P \leq 0.05$. The soils were identified majorly as Rhodic Hapludult and Typic Hapludult. The result obtained showed that the soil varied from sandy clay loam to sandy loam texture and were strongly acidic with pH values of 4.5 to moderately acidic 5.73. The soils also have low P (2.23 -4.17 mgkg-1) and low CEC (2.02 -4.67cmol/kg-1) with medium percentage of C ranged between 1.48 - 2.30. The soil was low in quality as deduced from soil properties in terms of nutrient availability and retention, but of medium quality for permeability because of sandy clay loam to sandy clay texture. The coefficient of variability shows that the silt was most variable at the surface (64.44%) followed by K (36. %), while P, CEC, BS, Na, C and pH were of medium variability (11.06-30.36%). Similar pattern occurred in the subsoil with K having very high variability of 131.82%. The overall chemical quality was low while it was high to medium for the physical parameters. The panacea to stabilize the fragile and variable properties will be a system that involves integrated nutrient management. Thus combination of proper residue management, minimum tillage, application of organic and inorganic fertilizer, legume based cropping system and short fallow will increase the soil resilience and result to sustainable land use.

Keywords：*integrated land management, soil quality, soil variability, Ultisols, long term cultivation*

P3-104

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Soil Description and Classification of Inactive Tailings after 13 Years in Tailings Deposition Area, Modada - Timika Papua

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Tailings are residue of mining material after separation of valuable substances such as copper, gold and silver elements. Separation of these elements involves crushing of parent material to become fine particles and separation of the precious elements by flotation technique. Total amount of tailings produced by the company of Freeport Indonesia (PTFI) are about 230.000 tons/day. These tailings are transported and deposited in the lowlands of Timika, Papua and confined in the two levees i.e East Levee and West Levee called as ModADA (Modified Ajkwa Deposition Area). The first research had been done in ModADA and Timika Environment Laboratory, the property of PTFI in Timika, Papua from March 2005 to July 2006. The main objectives of this research were to study the morphological, physical, chemical, and mineralogical characteristics of soil developed on tailings. The representative sampling location of soils were chosen based on differences in tailings particle size distribution from north to south around inactive tailing deposited after 13 years at the ModADA.

Dealing with the objectives, the methodology of this research will be compassed two steps as follow : soil morphological characterization and soil sampling, and also laboratory analysis of soil sampling. Results of the research showed that tailings were still under development stage to become soil. It was indicated by soil structure development with ochric epipedon on surface horizons (horizon A : ± 10 cm) without diagnostic subsurface horizons (horizon B), therefore tailings soil were classified as Entisols (A - C). Entisols are the pedologically youngest of the soils. Entisols are often formed from freshly deposited or heavily reworkd material. Horizonization is usually very weak, if present at all. Flood deposits (Fluvents) and sand dunes (Psamments) are good examples of Entisols. In ModADA, distribution of particle size tend to gradual from north to south, that were sand, loamy coarse-fine sand, and silty coarse sand. On the family category, the succession area of ModADA were clasified as Typic Endoaquent with texture class of sand, silty coarse sand, and loamy fine sand respectively. While the reclamation area of ModADA were clasified as Typic Udorthent, Aquic Udorthent, and Typic Epiaquent with texture class of sand, loamy coarse sand, silty coarse sand, and loamy coarse sand respectively.

The available micro nutrients from high to lower were Cu > Fe > Mn > Zn, and base cations were Ca > Mg > Na > K. Concentration of Cu > 600 mg/kg when total of S > 1% which tend to increase on sub horizons of silty coarse and loamy fine in sucession area, but it can be neutralized by OH- because of dissolving Ca from CaO, therefore Ca was high with deepness on sub surface horizons. The mineralogical analysis showed that quartz and feldspar minerals were the dominant, whereas clay mineral contents were very low. Process pedogenesis has been happening especially on loamy and silty particles, the particles with size were medium to very fine. That was found in the south of ModADA with time of inactive tailing deposited since 1992/1993. It showed by weak weathering of feldspar, carbonate, amphibole or piroksen minerals; chlorite to illite, montmorillonite, and inter stratification minerals; and forming of iron oxide/hydroxide.

Base on the research that the recommendation for succession area is to let land occupied by natural vegetation, while reclamation area on sandy particle in the north of ModADA suggested by giving treatment of organic matter to increase soil fertility, and chosening of vegetation types which is able to improve soil fertility and continued to forest or agriculuture vegetation. The next research will be continued in 2013/2014 to study soil development after 20 years as inactive tailing at the ModADA or area of inactive tailing deposited.

Keywords：*soil development, tailing ModADA, reclamation, succession*

P3-105

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Determination of Zones Sensible to Soil Degradation under the Effect of Water by Artificial Neuron Network

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In the semi-arid environment of northern Algeria, degradation of soil quality alluvial plain of the Lower Cheliff represents a serious threat to the sustainability of irrigation systems.

This region is the alluvial plain high agricultural production potential; soils often have structural stability to average to poor. The nature and intensity of these changes depend on many factors ie weather conditions, ground cover, the material properties and structural water conditions and during exposure to rain and irrigation.

In this work we tried to estimate the mean weight diameter of the study area in order to cartography the zone most sensible to the impact of water using artificial neurons network

Keywords：*soil degradation, mean weight diameter, artificial neurons network*

P3-106

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Pedogenic Influence of Particle Size Fractions on the Properties of Coastal Plain Sands Soils of Southeastern Nigeria

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The landscape of locations covered with coastal plain sands in southeastern Nigeria has characteristically monotonously flat terrain, high intensity rainfall and eventual annual redistribution and rearrangement of particle size fractions (psf) which is dominantly sand particles. These define a major pedoturbation process that imprints properties and characteristics of soil in the area. Therefore the objective of this study was to establish the influence of psf as a major pedogenic factor on the properties and characteristics of coastal plain sands soils of southeastern Nigeria. A total of 178 samples were collected according to genetic horizons on 30 profile pits prepared at 10 each on the upper, middle and lower slope positions. The samples were analysed for hydraulic conductivity (Ksat), pH in water and KCl, bulk density (BD), gravimetric moisture content (GMC), electrical conductivity (EC), exchangeable bases (calcium, magnesium, potassium and sodium), exchangeable acidity (EA), effective cation exchange (ECEC), base saturation (BS), organic carbon (OC), available (AvP) and total phosphorus (TP), crystalline and amorphous iron (Fe) and aluminum (Al) and particle size fractions including sand (very coarse (VCS), coarse (CS), medium (MS), fine (FS) and very fine sand (VFS)), clay and silt. Statistical analyses carried out on the data collected were Pearson's correlation ($p<0.18$ is significant at 5% while $p>0.19$ is significant at 1%) and principal component analysis. There was significant correlation respectively between VCS, MS and crystalline Fe (-0.18, 0.24) and Al (0.16, 0.26). Total sand and clay respectively significantly correlated with crystalline Fe (0.23 and 0.20) and Al (0.19 and 0.16), while silt and clay correlated with amorphous Al (-0.33, 0.20). Hydraulic conductivity correlated with clay (-0.37) and VFS (0.16), GMC correlated with clay (0.25) and MS (0.27), while ECEC correlated with clay (0.19) and MS (0.28). Depth of genetic horizon of the profiles correlated with total sand (0.19), clay (0.17) and VFS (0.18), OC correlated with total sand (0.15) and MS (0.23) while ECEC correlated with total sand (-0.19), clay (0.19) and MS (0.28). Fine sand significantly correlated with TP (0.20), amorphous Al (0.17) and EC (0.14). These correlations culminated into classification of the soil properties into 11 components with eigenvalues of 21.4 accounting for approximately 71.6% variance. Factor 1 comprising total sand, clay, amorphous Al, MS and Ksat were major determinants of the pedogenic processes, distribution and variability of coastal plain sands soil properties. Sand content and hydraulic conductivity are at the two extremes of factor 1 describing their different contributions to soil formation processes. It could be concluded that the particle size fractions play a major role in the processes of pedogenesis of coastal plain sands soils of southeastern Nigeria.

Keywords：*particle size fraction, pedogenesis, pedoturbation, soil properties, coastal plain sands*

P3-107

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Characterisation, Classification and Evaluation of Some Basement Complex Soils of Nigeria for Multipurpose Use

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Soil information is a key asset in soil management as it forms the basis for rational and proper allocation of land as soil variability is a fundamental issue in proper land use and management.

A 420ha land made of soils formed from basement complex rocks were evaluated for multi purpose use which include capability and suitability assessment for agricultural and urban land use potentials. The soils were characterized and classified for agricultural and urban land use potentials.

Results obtained showed that soil colour varied from yellowish Brown (10YR) in the dry state to 2.5YR (Dark red) in the moist state while soil texture varied from sandy loam at the surface soil to sandy clay loam in the sub soil with evidence of agrillic horizon associated with argiilluviation. The soils are low in ECEC with values <20 cmol/kg, however, percentage base saturation was high in all the soils with values>95% For most of the soil, Available Phosphorus and Total Nitrogen were below the critical levels for Nigerian soils with values that ranged from 1.87 - 25.2 for available phosphorus and 0.3g/kg - 1.2g/kg for Total Nitrogen. The soils were classified according to USDA soil taxonomy as Alfisols and Inceptisols but found to be Luvisols and Gleysols according to FAO/UNESCO soil classification. Local classification was carried out and six soil series namely Iwo, Iregun, Balogun, Egbeda, Matako and Ibadan series were found. Land evaluation showed that the soils are moderately to marginally suitable for agriculture however, they show no serious constraints to urban land use.

The soils are low in N and P and did not show serious constraints to urban land use, but caution must be exercised to avoid degradation of the soil.

Keywords：*Key Words: Basement complex soils, characterization, soil suitability.*

P3-108

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

More Important Role of Soil Phylogenetic Horizon than the Topography on Soil Microbial Biomass and Abundance in Karst Subtropical Primary Forest of Southwest China

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More important role of soil phylogenetic horizon than the topography on soil microbial biomass and abundance in Karst subtropical primary forest of southwest China FENG Shu-zhen1,2,3 HE Xun-yang1,3CHEN Xiang-bi1,2,3 LIANG Yue-ming1,2,3 LI Lei1,2,3 SU Yi-rong1,3*

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Abstract：Base on the hypothesis that slop position may affect the profile differential characteristic of soil microbe through affecting the basic physicochemical properties of soil, we determined the microbial biomass carbon (SMBC), nitrogen (SMBN) and vibration of microbial population of three different phylogenetic layers of soil leaching layer (A, 0-10cm); transition layer (AB, 30-50cm) and deposited layer (B, 70-100cm) in upper, middle and lower slop of Karst primary forest, using chloroform fumigation and Real-time PCR. The results showed that: 1) Phylogenetic layer was more important in affecting the soil nutrient than slope position. Slope position can cause the physicochemical differentiation of soil profiles in some degree. In the lower slope, the soil nutrient of layer A were significantly higher ($P<0.05$) than layers AB and B, except for the rapidly available K and volume weight. In the same phylogenetic layer, different response on slope position were observed, depending on different nutrient, without showing lower slop > middle slope > upper slope. 2) Slope position had distinct effect on SMBC, SMBN and abundance of bacteria and fungi, and showed notably interaction with phylogenetic layer. 3) From the soils, the bacterial 16S rRNA abundance ranged 1.4×1010 to 4.2×1011 copies g-1 soil and the fungal 18S rRNA abundance ranged 3.7×107 to 4.6×108 copies?g-1 soil. Soil genetic layer was shown to have a significant effect on the abundance of bacterial 16S rRNA and fungal 18S rRNA. 4) The organic matter, total nitrogen, available nitrogen, rapidly available phosphorus and K not only affected the SMBC and SMBN, but also the abundance of bacteria and fungi, as the most important factor. Thus slop position affected the profile differential characteristic of soil microbe indirectly through affecting the soil characteristics (i.e. organic matter, total nitrogen, available nitrogen, rapidly available phosphorus and K). 5) There was a positive correlation between the abundance of bacteria and fungi, and some degree of relation between the population and biomass of the soil microbe. These findings would be helpful to the further understanding on the mechanism of soil nutrient loss in karst region.

Key words：profile differentiation；slope；microbial biomass；microbial abundance

Acknowledgements: This project was supported by the Knowledge Innovation Program of the Chinese Academy of Sciences (KZCX2-XB3-10), the National Science-technology Support Plan Projects (2012BAD05B03-6),and by the National Natural Science Foundation of China (grant no. 30970538 and 31270551)

Keywords：*profile differentiation；slope；microbial biomass；microbial abundance*

P3-109

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

The Role of Soil Evolution in Erodibility of Lithogenic Sediments in Central Iran

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In order to study the impact of soil evolution in decrease of erodibility of lithic depositions in Central Iran this research was defined. The major mineral components in geological formations of Iran with arid climate are carbonates. The carbonate types of the rocks in different periods of geology change as calcite and so as dolomite ones. Soil depths and evaluations on the calcite or dolomite depositions were changed and the results of these variations are not similar to some other reported results in another climate. In a topography- geological sequence in the southern part of Yazd plain X ray diffraction analyses on the less than 1micron of soil and sediment particles were carried out for clay mineralogy. The results showed that in addition to the role of third geological period in increase of palygorskite in the soils and sediments on Yazd plain, Soltanieh and Nayband Formations from early Paleozoic and Mesozoic are effective in increasing lithogenic paligorslite in Yazd plain. Because of decreasing of palygorskite in clayey plain and increasing in eolians could be resulted it's high sensitivity in wind erosion. This mineral with lower particle size, was able to be moved farther by wind. The other major minerals with palygorskite are respectively: Illite, Chlorite and Smectite. As a result low evaluated soils of Lithic Torriorthents on Soltanieh Formation has lead to an increase in the fine dust as palygorskite clay particles. In the higher evaluated soils of Typic Haplocalcids have shown an accumulation of palygorskite in B horizon and result in a reduction of fine dust particles.

Keywords：*Central Iran, Fine dusts, Palygorslite, Soil Evolution*

P3-110

[DS1] Micromorphological Answers to Palaeopedological and Polypedogenetic Questions

Pedogenesis and Stage Weathering Vertic Haplusteps Derived from Alluvialbasaldeposits

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The objectives of the research is to studies and assessing stage of weathering and factors affecting pedogenesis of vertichaplusteps derived from alluvial basal deposits of two profiles. Located on different land system in Jenepon to Dystrict, South Sulawesi, Indonesia. Profile T1P2 located on PLU (Palu) land system while profile T3P2 located on BRA (baraja) land system. PLU land system in the form of non-volcanic alluvial fan with slope (2-8 %), relief < 2m, an alluvium and alluvial fan sediments whereas BRA land system in the form of karstic terrain, flat to wavy (2-8 %) slope , relief 2 - 10m, consists of limestone, rock, and marl. Data were collecting through field survey and mineral analysis in laboratory. Analysis mineral of sand and rock fraction using thin section method while clay mineral analysis using XRD. The result showed that there were a difference between the mineralogical composition of the parent material compare to the parent rock beneath it, indicating the presence of a lithological discontuinity by irregular contrasting texture through soil depth, contrasting sand grain size, and irregulardistribution of rock fragments. The results show that factors which most affecting the soil genesis were dry climate (<1000 mm year - rainfall), parent materials which dominate by easily weathered minerals such as feldspar and piroksin and flat topography with valley physiographic position. The pedogenesis process that occurs predominantly in the form of pedoturbasi process and the formation of secondary minerals such as montmorillonite. Soil weathering is the stage virile according to Mohr and Van Baren (1960) or cambic stage according to Tavernier and Eswaran (1972).

Keywords：*Pedogenesis, Stage Weathering, VerticHaplusteps, Alluvial Basal*

P3-111

[DS5] Soil Health: Key to Food Security

Soil Microbial Biomass and Mineralzable C and N Associated with Water-Stable Aggregates after Conversion of a Native Forest into Cultivation at Munessa, Ethiopia

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The activity and biomass of microbes can be influenced by land use/cover and its associated soil management. We conducted a laboratory experiment to determine soil microbial biomass C (Cmic) and N (Nmic) and mineralizable C (Cmin) and N (Nmin) associated with water-stable aggregates after conversion of a natural forest into cultivation on red brown soils at Munessa, Ethiopia. Soil samples (0-20 cm depth) were taken from a mixed natural forest and 26 year continuously cultivated field. Samples were air dried and fractionated into macroaggregates (> 0.25 mm) and microaggregates (0.053-0.25 mm) by wet sieving. Continous cultivation of the forest soil had resulted in significant reductions of bulk soil C and N contents as well as deterioration of soil structure. Soil microbial properties associated with water-stable aggregates were also significantly (P 0.05) reduced after cultivation, being 53% for Cmic, 32% for Nmic, 55% for Cmin and 48% for Nmin, on the average,. The proportions of total write in full first with abbreviation in brackets SOC and N contained as Cmic, Nmic, Cmin and Nmin were not significantly different between the forest and cultivated soils. In both land use types, Cmic, Nmic, Cmin and Nmin were significantly (P 0.05) greater from the macroaggregates than from the microaggregates indicating that the organic matter associated with macroaggregates is more labile than that associated with the microaggregates. The Cmic/Nmic ratio in the forest soil water-stable aggregates was higher than that in the cultivated soil indicating that cultivation had altered the composition of the microbial community. The microbial biomass and its activity associated with both the macro and microaggregates had more apparent relationship with the soil chemical properties than between themselves. Generally, the results indicate that these activities were sensitive to early changes in soil management under the rainfed area of Munesa in south-eastern Ethiopia.

Keywords：*Microbial biomass, Water stable aggregates, Mineralization, Cultivation.*

P3-112

[DS5] Soil Health: Key to Food Security

The New World Atlas of Desertification: Soil is Slipping Away……we Can Stop it!

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A new World Atlas of Desertification (WAD) is being compiled under the coordination of the Joint Research Centre (JRC) of the European Commission, in partnership with the United Nations Environment Programme (UNEP). The WAD will be available as both a published reference atlas and an online digital information portal. The new WAD will built upon recent scientific progress and is envisaged to be a pragmatic approach and an example of how to implement up-to-date concepts and robust approaches for assessing and mapping land degradation and desertification. The WAD is expected to be the foundation for better addressing desertification and land degradation mitigation in strategies that focus on food security, resource base efficiency, sustainable development and poverty reduction.

A special chapter within the Atlas is devoted to soil issues. They are dealt in an ecosystem based approach that identify soil functions and services and provides a solid background for further actions. Special attention is devoted to the availability of world's soil resources and their capacity to feed an ever-growing population that is expected to reach 9.2 billion by 2050. This means that globally the average amount of per capita agricultural land that decreased from 0.39 ha per person in 1960 to 0.21 ha in 2007 would continue to decline. Globally, agriculture is practiced on 1.5 billion ha but the distribution of cropland is extremely uneven. China and India, accounting for more than 35 per cent of the total global population, both have exploited most of their land and water resources available for agriculture. Similar situation exists throughout the Mediterranean and in particular in North Africa and the Middle East where only 5 per cent of the land is suitable for agriculture.

Farmers will have to produce 70 per cent more food by 2050 in a time when the recent data indicate that 24 per cent of all land is highly degraded and 1.5 billion people are affected. FAO warns that fifty two per cent of the land used for agriculture worldwide is moderately or severely affected by soil degradation and thirty five per cent of severely degraded land worldwide is due to adverse agricultural practices. These are disturbing data that must be quickly reversed. Yet, the world is endowed with good soils, primarily those occurring in humid climate, favorable terrain and easy access. Overall this category barely cover 3 per cent of the world's land area, and yet produce more than 40 per cent of the global food and over 90 per cent of cereals. It is a paramount priority that especially these soils are protected against any form of degradation. However, there is no substitute to sustainable land management (SLM) and any effort to ensure food security, as well as economic and social stability should consider practices that limit the release of C, restore degraded soils, and sustain ecosystem services and functions. SLM has the potential to increase yields by 30-170 per cent, increase SOC by 1 per cent in degraded soils and up to 2-3 per cent in non degraded ones, and increase water use efficiency by up to 100 per cent. The WAD offers numerous positive examples of SLM from around the world, including conservation agriculture, minimum or no tillage, Conservation Reserve Program, TerrAfrica, "Zero net land degradation" UNCCD Initiative, etc. They strongly emphasizes the needs for continued support from national and international organizations and private-public partnerships to invest in SLM as the only viable option to increase food production sustainably, mitigate climate change and meet the challenge of combating desertification.

Keywords：*WAD, soil ecosystem, function, food production, population, soil degradation*

P3-113

[DS5] Soil Health: Key to Food Security

Socio-Cultural Aspect of Soil Management for Resource and Environment Conservation: 'zabo' An Unique Indigenous System of Soil Management

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The Chakhesang tribe of Nagaland State of India has developed soil and water management system and transformed the society from food deficit to plenty by improving crop productivity, environment and resource base. The practice of shifting cultivation is prevalent in north eastern region of India, which has resulted in soil and environment degradation. The place of study is Kikruma village in Phek district of Nagaland state of India. In Naga tribes, the fertility of the soil and prosperity of the village were closely associated with the dead, whose life substance was conceived as forming a continuous cycle of reproduction, passing from men to cereals sown and then back through grains eaten or through the flesh of the animals that had eaten it, to man again. The homosapiens were under the awe of natural objects such as oceans, rivers, forest, springs etc. from the pre-historic age. Population was small in number, primitive in technology and their needs were extremely limited. With decrease in shifting cultivation cycle as a result of increase in population, the crop productivity decreased considerably, thereby necessitating the tribal people to migrate from one place to another for an easy access to food and water.

The 'Zabo' system was developed by tribal farmers due to their ingenuity and skill on hill slopes. The area on the hill top serves as catchment for rain water and is kept under natural vegetation. This area is not disturbed by cutting of forest trees or livestock grazing. The slope of this area is up to 100% or even more. Being permanently under vegetation, annual soil erosion was found to vary from 0.07 to 1.02 t ha-2, depending on the amount and intensity of rains. Compared to this, the average soil erosion from shifting cultivation areas was 36.2 t ha-2. At the end of slope, livestock enclosures are made with wood and bamboo and, are managed by a group of farmers by stocking their livestock on rotation basis. During irrigation the water from the main tank is taken to the paddy fields by passing through the livestock enclosure and it carries all dung and urine of the animals, making the fields highly fertile. Paddy and other crop fields are located at lower elevation. Application of cow dung and run-off through open cattle yard are the common methods of manuring the rice fields. Besides animal manure and farm wastes, leaves and succulent branches of Alnus nepalensis and Albizia lebbeck are also added to the fields and decomposed for soil fertility. No inorganic source of nutrients is added, making the whole system as organic farming. There is no pollution of water and environment due to fertilizer use. Some farmers practice paddy-cum-fish culture and about 50 to 60 kg of fish is obtained per ha, which is an additional source of income to the farmers. The Chankhesang tribe is socio-culturally attached with 'Zabo' system as different operations are done on community basis with participatory approach.

The 'Zabo' system of water resource development and management is an unique system of farming which has helped the society in improving soil health, crop productivity, quality of life and environment around. The paddy yields in 'Zabo' system are more than double compared to the average yields of the region and three-folds than shifting cultivation.

Keywords: *Socio-cultural, soil management, resource and environment conservation, soil health, 'Zabo' system*

P3-114

[DS5] Soil Health: Key to Food Security

Increasing Productivity through Promoting Balanced Fertilizer Use in Bangladesh

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Bangladesh is one of the populous countries of the world. Hence, food security is a major concern. The dominance of agriculture will continue in the 21st century as the nation fights against poverty and strives to raise living standard of its people through sustained economic growth. The land-man ratio in Bangladesh presents a gradually declining trend over the past few decades. To attain self-sufficiency in food and desired level of living standard it is necessary to utilize the full potential of land resources and maintain the soil productivity at a sustainable level through balanced and judicious use of inputs and management technology.

Keywords：*Keywords: soil and land resources, balanced fertilizer, sustainable productivity*

P3-115

[DS5] Soil Health: Key to Food Security

Impact of Selected Industries on Soil and Groundwater in Abia State, Nigeria

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Industrial activity remains the major source of environmental contamination worldwide. In developing countries like Nigeria, industrial growth has led to heavy contamination of soil and groundwater. We evaluated the effect of wastes from paper, paint and vegetable oil industries in two major cities of South East Nigeria on farmlands, wells and boreholes within a 50m radius of such factories. Analyses of groundwater in the vicinity of industries showed significantly elevated levels of dissolved nitrate (18 - 63 mg/L); lead (0.11 - 0.27 mg/L); zinc (42.1 - 90 mg/L), copper (0.008 - 0.29 mg/L); iron (23 - 40 mg/L) and chromium (0.16 - 0.45 mg/L), all above WHO limits allowed for drinking water. Soils impacted by industrial wastes and effluents had significantly lower pH (3.9 - 4.8), and contained heavy metal levels above the critical threshold allowed for arable soils. Paint effluent was the greatest source of metal contamination in soil- resulting in Pb, Zn, Cd, Cr and Cu levels of approximately 450, 826, 14, 132 and 260 mg/kg respectively.

Keywords：*industrial wastes, groundwater, soil contamination, heavy metals*

P3-116

[DS5] Soil Health: Key to Food Security

Influence of Conservation Agriculture Practice Systems (caps) to Soil Properties in a Sloping Oxisol in Southern Philippines

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Conservation Agriculture Practice Systems (CAPS) is a tailor-fitted approach for successful adoption and implementation of Conservation Agriculture (CA). It is a recent agronomic innovation currently gaining ground globally and tested under a sloping upland oxisol in Southern Philippines. Three main pillars of CAPS namely: 1) continuous crop rotation 2) minimal tillage and 3) continuous ground cover were used simultaneously in various cropping systems (CS). When synergistically implemented, these factors could results to sustainable food production. To date, however in the Philippines there is a dearth of scientific evidences that can support the above-mentioned claim. Hence, this study aims to test the viability of CAPS under a sloping oxisol in a typical tropical climatic agro-ecosystem. Specifically, it envisions to determine a suitable cropping combinations one that will gradually conserve and improve soil health over the long term. Different cropping systems (CS) employed as component of CAPS was established in a 23 percent sloping study site. In two cropping seasons (November 2011-November 2012) five corn-based CS, namely: CS1 (corn + Arachis pintoi), CS2 (corn + Stylosanthes guianensis), CS3 (corn + cowpea - upland rice + cowpea), CS4 (corn + rice bean) and CS5 (corn-corn) were implemented, respectively. Soil properties such as pH, organic matter (OM), Cation Exchange Capacity (CEC), NPK, C: N ratio and soil moisture content were measured and analyzed respectively. Composite sampling was done from 0-30 cm depth across treatments and replications over the course of the study period. Soil pH was improved in all treatments with associated legume components except in sole corn. OM content was influenced by CAPS with legume components observed to be comparably higher than CS5 (sole corn).CEC values which ranged from 21.4- 26.60 me/100g at the start of the cropping period increased to 23.75-33.98 me/100 g soils. NPK values differed in various CS, wherein corn intercropped with legumes generally had an increase ranging from 26-32 % while in sole corn a 46 % increase was observed. Extractable P increases in all CAPS except in CS2 (wherein P decreased by 16 %). Extractable K decreases after two seasons, except for corn + rice bean (CS4) with a slight decreased of 8 %. Moreover, the C: N ratio decreased in all CS imposed except in CS2. In the case of soil moisture content (SMC) measured through TDR, a general observation was noted that in all treatments using associated legumes soil moisture was evidently better conserved in plots with legumes relative to the conventional sole corn plot.

Keywords：*Conservation Agriculture Practice Systems, sloping upland, cropping systems,*

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[DS5] Soil Health: Key to Food Security

Sustaining Soil Health to Produce Quality Food

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The demand for safe disposal of wastes generated from agricultural and industrial activities is ever increasing and soil is considered as a sink for most of the waste-borne contaminants. As land treatment is considered as an important waste management practice, soil becomes a major source of contaminants including heavy metal(loid)s and organic compounds reaching the food chain, mainly through plant uptake and animal transfer. Indiscriminate waste disposals, and mining and industrial activities have led to significant build up in soils of a wide range of metal(loid)s including arsenic, cadmium, chromium, copper, mercury, lead, selenium and zinc and organic compounds such as pesticides, insecticides, herbicides and hydrocarbons.

Health authorities in many parts of the world are becoming increasingly concerned about the effects of soil contamination on food quality, and environmental and human health and its potential implications to international trade. For example, cadmium accumulating in the offal of grazing animals not only makes it unsuitable for human consumption but also imperils the access of offal products to overseas markets. Similarly, bioaccumulation of Cd in potato, wheat and rice crops has serious implications to local and international commodity marketing. Arsenic contamination of surface and ground waters occurs worldwide and has become a sociopolitical issue in several parts of the globe because of its adverse impact on human health. Indiscriminate use of pesticides in agricultural and horticultural production systems has resulted in the accumulation of these toxic compounds in soils, thereby reaching the food chain. For example, endosulfan, one of the most toxic pesticides on the market today, is responsible for many fatal pesticide poisoning incidents around the world. For these reasons, there is a global urgency to ensure that the level of these contaminants in foodstuffs produced complies with regulatory standards and compares well with those from other countries. Effective action in the long-term will depend on gaining an understanding of the causes of their accumulation and a proper appreciation of the issues for public health.

In addition to soil contamination, soil fertility degradation trigged by nutrient removal through plant uptake, erosion and leaching, coupled with low application of nutrients through fertilisers and organic manures/composts becomes a major constraint to achieve food security in many countries. The full yield potential of genetically improved high-yielding crops cannot be realised when soils are depleted of nutrients. For example, while the rates of adoption of improved crop varieties have been similar in Asia, Latin America, the Middle East and Sub-Saharan Africa during the last 38 years, such varieties are responsible for 66-88% of the crop yield increases in the first three regions but only for 28% in Africa. Soil fertility is the likely biophysical reason behind such difference, and therefore is the logical starting point to tackle hunger in Africa and many other countries. This paper provides case studies examining the impacts of contaminants and nutrient depletion on soil productivity.

Keywords：*Soil Fertility, Heavy metals, Nutrients, Food Security, Carbon Sequestration*

P3-118

[DS5] Soil Health: Key to Food Security

Changes in Soil Physical Health of an Eroded Land as Affected by Vegetative Buffer Strips and Vegetal Mulch Cover

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In spite of greater potential of vetiver grass technology for soil conservation, information on integration of vetiver grass strips (VGS) and vetiver mulch (VM) on soil physical health (SQphy) is scanty. Therefore, a field trial was conducted at Ikenne (6° 51'N, 3° 42' E), Nigeria, during 2007 - 2010, to study temporal changes in SQphy following application of VGS and VM on a sloping land. The 10 m (VGS10) and 20 m (VGS20) strips spacing were integrated with 2 (VM2) and 4 (VM4) t/ha of vetiver mulch as VGS10+VM2, VGS10+VM4, VGS20+VM2 and VGS20+VM4, while VGS10, VGS20, VM2, VM4, VM6 and NV were the control treatments. Soil health indicators (particle-size distribution, bulk density, water stable aggregates (WSA), pore-size distribution, soil strength, saturated hydraulic conductivity, available water content, soil erodibility and soil organic carbon) were determined and integrated to form a data set for SQphy. Storage and transmission pores (equivalent pore radius of 0.5 - 300 μm) under vetiver-mulched plots were larger than un-mulched plots. There were significant ($P < 0.01$) variations in WSA among the treatments with VGS10+VM4 provided better soil aggregation than other treatments. The macroaggregates (250 - 2000 μm) under VM6 accounted for more than 70% of the total soil mass, although not significantly different from those under VGS10+VM4. Positive and significant relationships were established between aggregate-associated carbon (Ag-C) and macroaggregates (250 - 2000 μm). The changes in SQphy over the study period ranged from -8.8% to 16.3%, where VGS10+VM4 displayed the highest quality while there were reductions in SQphy from 9 to 25% under NV. Integration of vetiver grass strips at 10 m interval and 4 t/ha vetiver mulch (VGS10+VM4) led to higher percentage increase in soil physical health than any other integrated conservation measures employed in this study. However, the benefit of higher crop yield due to improved soil physical quality was dwarfed by higher soil loss beneath the mulch cover in 6 t/ha vetiver mulch (VM6) plot.

Keywords：*Vetiver grass strips; vetiver mulch; surface hydraulic roughness; degradation; soil physical health*

P3-119

[DS5] Soil Health: Key to Food Security

Effect of Variation in Nitrogen And Potassium Ratio (n:k) in Soil on the Yield, Yield Components and Shelf Life of White Yam (discorea Rotundata P.)

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The study was carried out at the Teaching and research Farm of Ambrose Alli University, Emaudo, Ekpoma, Nigeria to determine the effect of variation of N/K ratio in soil on the yield and yield components and shelf life of white yam (Discorea rotundata P.). The site is located in the derived savanna area of Edo State, Nigeria. The composite surface soil sample from the experimental site was analysed for the physical and chemical properties before planting. The amounts of N and K in the soil were adjusted taking congnisance of what were already present in the soil. The adjusted N:K ratios were 0:0 (control), 1:1, 1:2,1:3, 1:4, 1:5, 1:6, 2:1, 3:1,4:1, 5:1 and 6:1, were fitted into a randomized complete block design with three replicates. Nitrogen was applied as urea and potassium as muriate of potash and these were band-applied. The planting materials used were seed yams (average weight of 25g). Results showed that N/K ratio with high rates of N favoured high yam number of leaves, leaf area, vine length, vine girth and vine number at 2, 4 and 6 months after planting when compared to N:K ratio with high rates of k, although no significant differences were observed in most cases. Adjusted N/K ratio 1:2 had the highest number of yam tubers per stand. The concentration of K in the yam tubers increased as the level of N in the tuber decreases and as N:K ratio increased from 2:1 to 1:6. The concentration of N in the yam tuber increased and that of K decreases as N:K ratio increased from 2:1 to 6.1. Yam tubers with high concentration of N were highly susceptible to deterioration as they had shorter shelf life. Those with high K concentration showed greater resistant to deterioration . Adjusted N:K ratio of 1:6 had the highest shelf life of 212 days (7 months 2 Day) and the yield of 9.6 tons / ha, which was the second best, and this yield was not significantly different from the highest yield of 9.86 tons / ha obtained from ratio 1:2. The least yield of 6.4 tons / ha was obtained from the control and tubers did not show any sign of deterioration but rather sprouted. Adjusted N:K ratio 1:6 is therefore suggested for efficient yam fertilization programmed for the derived savanna area of Edo State of Nigeria.

Keywords：*Variation, nitrogen, potassium ratio , yield, shelf life, white yam (Discorea rotundata P.)*

P3-120

[DS5] Soil Health: Key to Food Security

A Qualitative Comparison of a Sandy Podzol under High-Input Kikuyu-Based Pasture and Native Fynbos Vegetation

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The natural vegetation in the southern Cape region of South Africa has low productivity and grazing capacity, resulting from soils with inherent characteristics such as poor drainage, high acidity and low biological activity. The main farming enterprise is dairy production from minimum-till kikuyu (Pennisetum clandestinum)-ryegrass (Lolium spp.) pasture. Native rangeland was improved with irrigation and fertilization to establish highly productive pasture crops. Even though the benefit of minimum-till is widely known, the impact of intensive management on soil physical, chemical and biological properties and processes of these improved pastures are not known. The aim of this study was to evaluate whether 19 years of irrigated minimum-till kikuyu-ryegrass pasture had altered the quality of a sandy podzolic soil.

The study was a comparison between Podzol soils with respectively irrigated minimum-till kikuyu-ryegrass pasture and natural fynbos vegetation in an unaltered state. The latter served as the point of reference of the inherent state of the soil. Kikuyu-ryegrass pasture was managed consistently for 19 consecutive years. Jersey cows intensely strip-grazed the pasture every 28 days, and 50kg N per hectare was applied after every grazing. The soil nutrient status was maintained by annual soil analyses and fertilization according to guidelines for kikuyu-ryegrass pasture. Representative soil samples were taken in 100mm depth increments up to 300mm deep. The minimum data set of indicators for soil quality was based on the physical, chemical and biological properties. The physical properties comprised of particle size distribution, penetration resistance, water holding capacity and aggregate stability. The chemical indicators included pH(KCl), total N, extractable P, exchangeable Cu, Mn and Zn. Biological indicators involved organic C, active C, microbial biomass C and β-glucosidase, urease and phosphatase activities. Data were analyzed using a two sample student's t-test for independent samples.

Dynamic physical quality of soil (sand 87-93%; clay 2.6-6.8%) was affected by kikuyu-ryegrass pasture. Physical resistance and aggregate stability of the soil were adversely affected ($P \leq 0.05$) and could potentially hinder root penetration, but water holding capacity improved ($P \leq 0.05$).

Soil pH was higher ($P \leq 0.05$) for all layers in the cultivated pasture soil and beneficial effects of liming the kikuyu-ryegrass over 19 years according to guidelines were evident. Total N in association with organic C was improved ($P \leq 0.05$) in cultivated pasture soil as a result of organic matter buildup in the surface soil layers. Copper and Mn were raised ($P \leq 0.05$) to levels satisfactory for pasture production and would be deemed a beneficial improvement. However, extractable P and Zn were severely increased

(P≤0.05) to levels which could cause deleterious effects on ecosystem health and sustainability. Mitigating strategies to prevent P and Zn build-up to toxic levels in cultivated pasture soil are necessary and the current fertilizer guidelines should be reinvestigated to prevent further damage to environmental quality and sustainability.

Organic C, active C, microbial biomass C, total N and enzymatic activities behaved similarly. These indicators were highly stratified and had higher (P≤0.05) values in the surface layers of the cultivated pasture soil than in the virgin fynbos soil, decreased with depth until they become similar (P>0.05) in the 200-300mm layer.

Improvement of virgin soil with kikuyu-ryegrass pasture and its associated management had adverse effects on certain dynamic physical properties and chemical properties, but improved environmental conditions supporting build-up of soil organic matter levels. This was reflected by the distribution patterns, stratification and degree of organic matter indicator accumulation and enzymatic activities. Fertilizer guidelines should be strictly used to fit the farming system and in doing so the dual goals of economic and ecological sustainability should be satisfied. Beneficial effects of minimum-tillage were evident in the biological processes, but agriculturalists need to focus also on physical and chemical properties to ensure sustainability of pasture production.

Keywords：*chemical indicators, compaction, aggregate stability, soil organic matter,, microbial biomass C, total N, enzymatic activities*

P3-121

[DS5] Soil Health: Key to Food Security

Proximate Mineral Composition of Purslane (portulca Oleracea L.) in Response to Salinity

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Purslane (Portulaca oleracea) is a drought and salt tolerant annual plant which contains high amounts of beneficial antioxidant vitamins and minerals. The objective of this study was to determine the influence of salinity on mineral composition of purslane (Portulaca oleracea L.). Four salinity levels namely 0 (control), 66, 132 and 264 mM were tested. Full grown leaf and stems of purslane samples were harvested at 10 and 20 days of the saline treatment exposure. Growth of purslane plants was more suppressed under 264 mM than 132 mM. The highest mineral residue content was found in leaves exposed to the maximum salinity levels. The mineral composition was also affected by salinity levels, Na+, Mg++ and Cl- uptake and accumulation increased with increasing salinity. Ca++, K+ and Zn+ levels decreased with increasing salinity. Accumulation of Ca and Zn in leaves was higher while K+ and Na+ were higher in the stems. The relative ratio of Na+/K+, Na+/ Ca++, Na+/ Mg++, Mg++ / Ca++ and Mg++/ K+ increased with increasing salinity treatment. The findings of this study reveal that purslane can tolerant moderate salinity levels66 (132 mM) thus improving it s potential to become a key vegetable crop especially for functional food and nutraceutical applications.

Keywords：*Purslane. Salinity and mineral content*

P3-122

[DS5] Soil Health: Key to Food Security

Flush of Co2 as a Biologically Based Tool to Predict Nitrogen Mineralization from Soil

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A biologically based tool to improve nitrogen (N) management in cereal crops is currently lacking from soil testing programs, but very much needed to optimize N fertilizer inputs to be able apply enough N fertilizer to achieve high production and avoid excess application that is damaging to the environment. We are developing such a tool based on growing confidence from previous research that shows strong relationships between the short-term flush of carbon dioxide (CO2) following rewetting of dried soil and several other soil biological properties, including short-term net N mineralization and soil microbial biomass. Soil microbial biomass is an active part of soil organic matter that plays a key role in the decomposition of organic materials, nutrient cycling, and formation of soil structure. Across a number of soils with a wide range of soil organic matter concentrations, the flush of CO2 following rewetting of dried soil has been closely related to (1) the flush of CO2 following fumigation with chloroform, (2) potential C mineralization, and (3) potential N mineralization. We describe the framework for a practical decision support system to improve N fertilizer recommendations for corn and other cereals. The short-term flush of CO2 following rewetting of dried soil predicts N mineralized from soil organic matter during the growing season and from rapidly decomposable substrates (e.g. cover crops, previous crop residues, manure additions, etc.), but may need adjustment based on variations in the soluble C-to-N ratio that can predict N immobilization. Applicable results have been obtained with a large number of different soil types. Development of this simple, rapid, and robust biologically based indicator of potential N mineralization will help farmers, consultants, soil testing facilities, and scientists better promote sustainable agricultural production.

Keywords：*Carbon mineralization; Microbial biomass C; Nitrogen mineralization; Soil biological activity*

P3-123

[DS5] Soil Health: Key to Food Security

Soil Management Strategy for Enhancing Soil Quality for Higher and Better Crop Yields

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One of the most threatening factors to soil quality especially in the tropical island of Guam is the low organic matter content. Soil organic matter (SOM) is probably the most important soil quality indicator in Guam and the other islands of Micronesia. Soil organic matter is both a source and a sink of plant-nutrients. Soil organic matter also influences the formation of soil aggregates and thereby improves soil physical properties and its ability to resist erosion which is a major threat to the soils of Micronesian islands. Soil organic matter content are enhanced by effective management activities such as; manipulation of soil environment via conservation tillage practices, application of organic based fertilizers, and more effectively by land application of composted organic wastes. In our case study, preliminary results have shown that the application of composted organic wastes increased crop yield and significantly improved soil quality of severely eroded and degraded soils of southern Guam. In this study, composted organic waste was applied on soils of agricultural fields as an alternative to commercial fertilizers to provide nutrients and also to enhance the organic carbon content and improve the overall quality of these poor soils of northern Guam.

In our soil program at the University of Guam, we are evaluating the use of compost as an alternative to synthetic fertilizers. Our goal is to develop management strategies for using available resources for improving crop production while conserving resources and preserving environmental quality. In our pilot project compost is produced from wood chips mixed with animal manure, chicken litter, and other organic wastes available at the local farms. Mature compost is then applied on the field at the rate of; 0, 30, 60 and 90 tons per acre as soil amendment on the poorly behaved 'Guam soils series' of northern Guam. Corn is planted and monitored for growth performance and yield evaluation. In this presentation, the methodology as well as up to date data will be presented to illustrate the effect of land application of composted organic wastes on organic matter content and other soil quality indices.

Keywords：*Keywords: Soil Organic Matter, Soil Quality, Sustainable Agriculture, Compost and Composting, Guam.*

P3-124

[DS5] Soil Health: Key to Food Security

Comparison of Soil Nutrient Recovery after Seven-Year Fallow in Ultisol Grown to Cassava-Pigeon Pea Based Systems for Seven Years in Southeastern Nigeria

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A virgin forestland cleared in 1998 was continuously grown to cassava (Manihot esculenta Crantz), pigeon pea (Cajanus cajan) and their combinations for seven years. After these years of continuous cultivation, the land was left fallow for seven years to evaluate its natural nutrient recovery capacity in relation to the cropping systems. The experimental design was a randomized complete block design replicated three times. The study showed that the solely cassava (SC) plots were able to recover more exchangeable K and Mg. Again the values of soil pH and exchangeable acidity from these plots were also higher than those grown to solely pigeon pea (SP) and plots grown to their combinations (C+P). The plots grown to SP were able to recover more organic matter, available P, and exchangeable Na than other plots , while, the C + P plots recovered more total N, exchangeable Ca, and cation exchange capacity (CEC). Compared to the year the forest was first cleared, exchangeable Ca, Mg, K, and Na were able to recover to about their original values. Thus, other nutrients appear to require more than seven years to recover to their original values in an ultisol of Nsukka area

Keywords：*Soil Nutrient, cassava, pigeon pea, fallow*

P3-125

[DS5] Soil Health: Key to Food Security

Development the Quality of Organic Fertilizers from Chicken Manure by Using Biochar

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The objective of this research to improvement the organic fertilizers quality was made from chicken manure with peanut shell and biochar. There are 4 formulas of organic fertilizer which are different in ratio of biochar as follows: formula 1). ratio of chicken manure and peanut shell is 1: 1, formula 2). ratio of chicken manure peanut shell and biochar is 1:1:0.05, formula 3). ratio of chicken manure peanut shell and biochar is 1:1:0.1 and formula 4). ratio of chicken manure peanut shell and biochar 1:1:0.15. It was found that all formula the quality are on standard level, pH (5.5-8.5) EC (0-10 dS/m), and P_2O_5 more than 0.5%. The percentage of organic substance is more than 20 % of the weight. Moreover, the results showed that only for the formula 3 contains nitrogen less than 1 % of the weight and the formula 4 contains highest nitrogen (1.76 % of the weight). For the analysis of the ratio of carbon and nitrogen, only the formula 4 pass the standard ratio (17:1). Overall, this study suggests that biochar can improve quality of organic fertilizers made from chicken manure with peanut shell by the mix biochar into rate 1:1 0.15: by mass. This formula provides the best quality pass the standard fertilizer of the Department of Agriculture Thailand. Additionally, using biochar as a component in the organic fertilizer can improve the smell of the chicken manure.

Keywords：*organic fertilizer, chicken manure, biochar*

P3-126

[DS5] Soil Health: Key to Food Security

Potential Risk of Cadmium in Soil-Plant System as a Result of Long-Term (10 Yr) Pig Manure Application

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Livestock manures may be a primary source of cadmium (Cd) to Chinese agricultural soil because several out of the ordinary values were reported by some studies. In this study we have evaluated the extent of Cd contamination of soils subjected to long-term (10yr) different pig manure application rates (equivalently 0, 100, 250 and 500 kg total N ha-1yr-1 from 2002 to 2008 and 0, 10, 25 and 50 t fresh weight ha-1yr-1 from 2009 to 2011, respectively) and the Cd concentrations in tissues of two crops (maize and soybean) grown on the same soils. During 10 yr, annual input rate of Cd through pig manure ranged from 26.33 to 135.50 g ha-1 yr-1, while mean removal rate of Cd via crop was about 1.03 to 4.36 g ha-1 yr-1. The pig manure application significantly increased soil total and DTPA-extractable Cd concentrations, and the total Cd levels exceeded Chinese soil quality criteria (0.3 mg kg-1). The same trend was also observed for Cd in maize and soybean, and the Cd concentration in the grain of soybean was higher than threshold values for animal and human ingestion (0.2 mg kg-1). However, no yield depression was observed in this study. Based on the balance calculation, atmospheric deposition rate was also a main source of Cd in the experimental area (10.27 g ha-1 yr-1). Moreover, the application of pig manure enhanced the leaching loss rate of Cd but still fairly small (0.12-0.73 g ha-1 yr-1). This study assists in understanding the potential risk of Cd accumulating from pig manure application to agricultural soils.

Keywords：*Livestock manures, cadmium,DTPA,maize,soybean*

P3-127

[DS5] Soil Health: Key to Food Security

Efficiency of Combined Application of Rhizobia and Pgpr Containing Acc-Deaminase for Promoting Growth of Legumes on Marginal Lands of Pakistan

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Legumes belong to economically one of the most important and third largest plant family. In Pakistan these are grown on marginal lands and/or in rainfed areas which results in poor yield. Among several factors which contribute to low productivity of legumes, elevated level of ethylene in plant due to number of biotic and abiotic stresses could be a major growth limiting factor. Ethylene is well known for its negative role in the establishment of legume rhizobium symbioses which leads to poor nodulation. Some plant growth promoting rhizobacteria (PGPR) are gifted with an enzyme 1-aminocyclopropane-1-carboxylate (ACC) deaminase which facilitate plant by decreasing the stress hormone (ethylene) levels. In the present study number of rhizobial strains and PGPR having ACC-deaminase activity were isolated from nodules and rhizosphere of mung bean, chick pea and lentil, respectively. The rhizobial and rhizobacterial isolates of each legume (mung bean, chickpea, and lentil) were used alone as well as in their combinations under axenic conditions to screen effective combinations for the improvement of growth and nodulation of these legumes. Selected combinations of rhizobia and rhizobacteria containing ACC-deaminase enzyme were studied in pot and field trials under natural conditions for mung bean, chickpea, and lentil. Rhizobia and PGPR containing ACC-deaminase improved the growth, nodulation and yield of respective legume but their combined application was more effective. The credibility of these strains was also verified by conducting a classical triple response bioassay in etiolated seedlings of lentil, chickpea and mung bean which revealed that combined application of the selected rhizobacteria containing ACC-deaminase and rhizobia diluted the classical triple response. Thus, it can be concluded from our study that co-inoculation with rhizobia and rhizobacteria containing ACC-deaminase along with some other growth promoting characters could be the most effective and novel approach for promoting nodulation and yield of legumes (lentil, chickpea and mung bean) grown on marginal soils of Pakistan.

Keywords：*Rhizobium, PGPR, ACC-deaminase, Co-inoculation, Legumes*

P3-128

[DS5] Soil Health: Key to Food Security

Enhanced Soil Health for Sustaining Higher Productivity and Food Security in India

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Healthy soil is one which is capable of supporting adequate production of food, fuel, fibre and the continued delivery of other essential ecosystem services. Under intensive agriculture, evidences exist for widespread degradation of soil in the form of erosion, loss of organic matter, contamination, compaction, increased salinity/sodicity and acidity. In India about 121 million ha lands are at various stages of land degradation. Besides this, the arable soils suffer from nutrient mining due to exhaustive cropping and pollution due to addition of urban solid waste and industrial wastes etc. Deterioration in soil health is mainly responsible for deceleration in the total factor productivity in Indian agriculture. Soil fertility mapping studies showed that the available N, P and K are low to medium, respectively in about 90, 80 and 50 percent of the Indian soils. Fifty percent of the arable soils are deficient in available Zn. Continuous use of sulphur-free fertilizers has increased the wide spread S deficiency in 41.0 percent soils. Boron deficiency is also wide spread in acid and calcareous soils of India.

Strong market forces and new investments in agriculture have increased NPK fertilizer consumption to 25.4 million tonnes. However, there still exists a negative balance of around 10 million tonnes nutrients (NPK) between removal by crops and addition through fertilizers annually. As a consequence, the response to applied fertilizer nutrients is declining. Inappropriate agronomic management practices often result in loss of nutrients through leaching, volatilization and gaseous emissions. Current status of nutrient use efficiency (NUE) is quite low in case of P ((10-20%), N (30-50%), Zn (2-5%), Fe and Cu (1-2%). In an era of multiple nutrient deficiencies, single nutrient application approach can lower NUE. Experimental results on the benefits of balanced fertilizer use are numerous.

Legumes help in meeting part of the high nitrogen needs of intensive cereal-cereal cropping systems such as rice-rice, rice-wheat, maize-wheat etc. and at the same time also improves the soil organic carbon (SOC) in the long run in different cropping systems. In the event of imbalanced fertilizers applications in soybean-wheat system over 35 years, organic matter status of soil declined in long term fertilizer experiment in Alfisols of Ranchi, whereas, balanced fertilization with NPK and NPK + FYM improved the organic matter status in Vertisols at Jabalpur. These experiments focused on addressing issue of the soil organic carbon pools and their bearing on the nutrient dynamics bring out the state of soil health and productivity trends in relation to climate change and management practices.

Department of Agriculture and Cooperation, Government of India sponsored a geo-referenced soil fertility mapping project to map fertility status of 170 selected districts provides information on current status of soil health in the country in different production systems and also provides an opportunity to improve the soil health by adopting appropriate integrated nutrient management practices. Key to ensure higher NUE and manage multi-nutrient deficiencies, is to manage variability in nutrient availability spatially, using GIS as decision support tools. A Decision Support System for prescribing fertilizers to different crops using geo referenced fertility maps has also been developed.

Bulky organic manures may not be able to supply adequate amount of nutrients, nevertheless their role becomes important in meeting the above objectives. Government of India is promoting integrated nutrient management (INM), balanced and judicious use of chemical fertilizers, bio-fertilizers and locally available organic manures like farmyard manure, compost, vermin-compost and green manure based on soil testing to maintain soil health and productivity. A National Project on Management of Soil Health and Fertility (NPMSHF) has been set up for establishing new soil testing laboratories and strengthening of the existing laboratories with micronutrient testing facilities. In addition, assistance for soil testing laboratories is also being provided to States/ Union Territories under the Rashtriya Krishi Vikas Yojana (RKVY). There were 1,049 soil testing laboratories in the country with an annual sample analyzing capacity of 10.7 million as on 31.03.2011. Based on the soil analysis, State Governments have issued 41 million soil health cards to the farmers. These and other initiatives shall help to promote soil health and sustain higher crop productivity to ensure food security in the country.

P3-129

[DS5] Soil Health: Key to Food Security

Evaluation of Soil Health, Sustainability Index, Carbon Sequestration Potential and Productivity under Organic and Conventional Rice (oryza Sativa L.) Production Systems

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Remarkable progress has been made in the last 50 years in agricultural production at the cost of soil health. Indiscriminate use of chemical fertilisers and pesticides has resulted in soil, water and atmospheric pollution which ultimately reduced the soil productivity and there are increasing concerns for long term sustainability of high input rice based systems. Organic farming has been considered as one of the best options for protecting/sustaining soil health and is gaining lot of importance in present day agriculture. Soil suppressiveness to diseases is also a main component of soil health and suppressive soils have to be considered as healthy soils because disease outbreaks are limited here. Favourable improvement in soil physical, fertility and biological properties was reported in many organic farming experiments. Further, organic agriculture enables ecosystems to better adjust to the effects of climate change and also improves carbon sequestration potential of the soil. Although grain yield under organic farming is often lower than under conventional farming, increased yields and sustainability of rice based cropping systems with organic inputs were also reported by several researchers.

Keeping this in view, field experiments were conducted for 5 years covering 10 crop seasons (2004-05 to 2009-10) on a deep black clayey vertisol (Typic pellustert with pH 8.2; EC 0.7l d S/m; free Ca CO3 5.01%; CEC 44.1 C mol (p+)/kg soil; 0.69% soil organic carbon; 228 kg/ha available N; 105 kg P2O5 /ha; and 530 kg K2O /ha.) at the Directorate of Rice Research, Hyderabad, India to study the influence of organic and conventional systems on soil health, sustainability indices, carbon sequestration rate and productivity of fine quality rice varieties. Soil health in terms of physical, fertility, biological properties and soil suppressiveness to diseases and carbon stocks and sequestration rate were determined after 5 years of study and grain yield data was recorded in every season.

There was a significant improvement in soil physical (bulk density and penetration resistance), fertility (organic carbon and available N, P and K) and biological (soil respiration and enzyme activities viz., glucosidase, phosphatase and dehydrogenase) health indicators with organics compared to conventional system. The increase in SOC, available N, P and K with organics was by 50-58 %, 3-10%, 10- 30%, and 8-25%, respectively. The bio - control ability of soils against rice sheath blight pathogen showed significant reduction in sheath blight lesion area (43-91%) in organic farming compared to conventional farming indicating the disease suppressiveness of organic system.

Further, soil quality indices viz., nutrient index (NI), microbial index (MI) and crop index (CI) indicated maximum nutrient (1.10) and microbial (1.19) indices with organics compared to inorganics that recorded 0.97 & 0.95 NI & MI values, respectively. Whereas, the crop index was maximum with inorganics (1.12). The sustainability index (SI) of the soil system, measured from

above three indices using a triangular approach was maximum with organics (1.63) against 1.33, recorded by inorganics which was just above the minimum sustainability index of 1.30

The soil organic carbon stocks were higher with organics (19.5 and 17.5 t/ha) compared to conventional system (13.6 and 13.0 t/ha) during wet and dry seasons, respectively. The carbon sequestration rate was positive with organics (0.97 and 0.57 t/ha/yr) and negative with inorganics (-0.21 and -0.33 t/ha/yr during wet and dry seasons, respectively). Thus, it is evident that organic farming can lead to better C sequestration under different climatic conditions, especially in dry season, where such situation is expected due to climate change.

Productivity of rice in both systems was at par from third year during wet season and from fifth year during dry season. During wet season, grain yields under conventional chemical farming were superior to organics by 15-20% during the first two years which improved with organics in the later years to comparable levels with inorganics. However, during dry season, inorganics were superior to organics for four consecutive years and organics (4.0 t/ha) recorded yields on par with inorganics (4.2 t/ha) in the fifth year.

Thus, soil health, sustainability indices and crop productivity of intensive rice-rice system in vertisols under tropical climate improved under organic system over a period of time with further improvement in carbon sequestration rate showing its adaptation/mitigation potential against the adverse climate change effects.

Keywords：*soil health, sustainability of rice-rice system, carbon sequestration, climate change*

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[DS5] Soil Health: Key to Food Security

The Effect of Organic Biogas Slurry Nutrient Solution on the Contents of Soluble Sugar and Vitamin C in Vegetables

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Biogas slurry, one of residues after anaerobic fermentation of various organic compounds such as human and livestock manure and straw residues, is an excellent organic fertilizer. It is rich in nutrients such as nitrogen, phosphorus and potassium, and is in the form of available nutrients with high nutritional capacities and nutrient efficiency, so it is a multielemental quick-acting fertilizer. Biogas slurry contains a certain amount of humic acids which play a direct role in formation of soil aggregates; the organic ingredients in biogas slurry such as fiber provide essential material base to loose soil and increase soil organic matter content. Long-term use of biogas slurry can improve soil fertility and its physical and chemical properties, while reducing pollution and fertilizer costs. The Organic biogas slurry nutrient solution is a kind of compound of biogas slurry, PGPR bacteria and nutrient solution with the best ratio of the three matters. PGPR rhizosphere bacteria (Plant Growth-Promoting Rhizobacteria, PGPR for short) is isolated and filtered from rhizosphere and can improves crop growth inhibit soil-borne diseases. PGPR rhizosphere bacteria takes the principal thing in the organic biogas slurry nutrient solution recombining with microbes of genetically engineered bacteria, solubilizing phosphorus bacteria and slubilizing potassium bacteria. The organic biogas slurry nutrient solution is a reassemble of various bacteria which are beneficial to agriculture. PGPR active bacteria can provide different crops during their growth and development with NPK nutrients requirements, while also secrete various metabolites and regulate plant metabolism. It can stimulate crop growth, inhibit pathogen and degrade pesticides as well. So, the organic biogas slurry nutrient solution is one of the multifunctional biological fertilizers with functions of nutrition, growth promoting and biological hygiene. In this paper, the effect of organic nutrition biogas slurry on vegetable quality such as of pepper, tomato and cucumber was studied. There were four treatments, including T1 (Water 1.5 kg/m2), T2(Water 1.5 kg/m2 +PGPR15ml）、T3(Biogas slurry 0.75 kg/m2+Water 0.75 kg/m2 +PGPR 15ml) and T4(Biogas slurry 0.75 kg/m2+ Water0.75 kg/m2). The solubility sugar and vitamin C of the three vegetables has been measured. The results showed that pepper solubility sugar and vitamin C contents of T2, T3 and T4 treatments increased by 1% and 19.4%, 10.47% and 31.0%, 2.14% and 21.2%, respectively, compared with T1 control treatment. Those contents of three treatments for tomatoes increased by 45.0% and 32.6%, 46.2% and 46.6%, 38.9% and 55.13%.. And they increased by 39.9% and 17.5%, 84.2% and 56.8% , 53.2% and 21.6% in cucumbers, respectively for three treatments. These results indicated that T3 treatments with biogas slurry and PGPR is the best combination both for vegetable solubility sugar and vitamin C contents, which are important indicators for vegetable qualification and benefit to human health.

Keywords：*organic nutrition biogas slurry, vegetable, soluble sugar, vitamin C, quality.*

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[DS5] Soil Health: Key to Food Security

Microbial and Biochemical Properties of Soils from Several Production Areas of Platycodon Grandiflorum A. D.c. and Panax Ginseng C.a. Meyer in South Korea

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Platycodon grandiflorum A. D.C. (Campanulaceae) and Panax ginseng C.A. Meyer (Araliaceae), commonly known as doraji and ginseng respectively, are two of the most valuable medicinal crops that are widely cultivated in South Korea. The roots of both plants are traditionally used as medicinal herbs as they are known to have numerous health benefits. Several studies were already conducted to qualitatively and quantitatively assess the bioactive compounds in the roots of both plants; while some studies have already done classification and characterization of various ginseng cultivation areas only through physiological and chemical analysis. In this study, both chemical and microbial properties of soils collected from several Platycodon grandiflorum and Panax ginseng farms were characterized to assess the quality of soil in several production areas of P. grandiflorum and P. ginseng in South Korea. The need to analyze the soil quality in P. grandiflorum and P. ginseng farms is necessary in order to determine the factors that contribute to the optimum quality and yield of both crops, and also establishment of the relationship between soil chemical and biological properties is important to fully understand the factors affecting nutrient availability and soil health in P. grandiflorum and P. ginseng farms in South Korea. Soil samples were collected from different P. grandiflorum and P. ginseng farms within Gyeongsangbuk-Do. Soil samples from different doraji and ginseng farm areas were labeled D1, D2, D3, and G1, G2, G3, respectively. Among the soils collected from different doraji farms, D2 exhibited the highest pH, percent total carbon, percent total nitrogen, C/N ratio, and available phosphorus, while soils from D3 site had the highest exchangeable bases (Ca^{2+} and Mg^{2+}) and cation exchange capacity (CEC). However, soils from D1 had the highest microbial activity and diversity. The principal component analysis (PCA) of soils showed comparable carbon source utilization by the microbial community in D2 and D3, but not in D1. The pH, percent total carbon, and C/N ratio of soils from doraji farms had positive correlation with PC2 while exchangeable calcium had negative correlation with PC1. Exchangeable calcium and CEC also had negative correlation with richness of metabolized carbon. For ginseng, soils from G2 exhibited neutral soil solution pH with high C/N ratio, available phosphorus, exchangeable calcium, and cation exchange capacity (CEC), while soils from G1 and G3 exhibited slightly acidic soil pH. Soils from G3 had the highest microbial activity and diversity. Also, the PCA of soils from ginseng farms showed comparable carbon source utilization by the microbial community only in G1 and G2, but different in G3. In a previous study done by Choi et al. (2007), it was found that phosphorus play a critical factor in root growth of ginseng while calcium can be essential for the growth and survival of ginseng roots. In this study, available phosphorus and calcium were found to have positive correlation with PC2 along with pH, C/N ratio, and CEC. The substrates that were highly utilized which contributed to PC2 were pyruvic acid methyl ester, L-phenylalanine, L-asparagine, and N-acetyl-D-glucosamine; while for doraji soils, the substrates that were highly utilized which contributed to PC2 were L-phenylalanine, D-xylose, β-methyl-D-glucoside, and N-acetyl-D-glucosamine. These sets of substrates and their degree of utilization can serve as a unique fingerprint for a particular microbial community (Ultra et al., 2011) that is a possible contributing factor in the soil quality and in the quality of doraji and ginseng growth. Moreover, the correlation data show which soil chemical properties contribute to the uniqueness of the microbial community in ginseng and doraji cultivated soils and may explain the soil attributes that determine overall soil health.

Keywords：*Platycodon grandiflorum, Panax ginseng, cultivation area, soil quality, soil nutrient availability, soil chemical and microbial properties*

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[DS5] Soil Health: Key to Food Security

Nitrogen Simple Effect on Agronomic Charasteristics of Lettuce & Spinach

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Lettuce, romaine (Lactuca Sativa L.) and spinach (Spinacea Oleracea) are important vegetables crop that are effected for growth fertilization. Tehran province is a major supplier of spinach and lettuce for Iran. In this field study does for a survey of research, nitrogen effect on agronomics characteristics. This research seeks to find models that describes the data well and aids in defining reasonable fertilization recommendations that result in optimum crop yield, fertilizer use efficiency, water use efficiency, agronomic efficiency, nitrate and quality without risking over fertilization. Coefficients of the models were obtained as approximations from the regression models based on SAS, Excel and Mstatc soft wares. This paper is an attempt at modeling these observations.

Keywords：*Lettuce, Spinach, Nitrogen, Agronomic*

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[DS5] Soil Health: Key to Food Security

Assessing the Environmental Risk of Contaminants of Emerging Concern in Fields Receiving Reclaimed Wastewater

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While options for developing water supplies via traditional approaches are limited, municipal wastewater is readily available as it is produced at the proximity of the demands, is reliable, and may be treated to meet required standards. However, municipal wastewater undergoing conventional treatment will experience quality changes due to differences in source and treatment processes. Residues of over the counter and prescription drugs, as well as estrogenic and androgenic hormones have been frequently found in reclaimed wastewater water. Collectively, these contaminants are referred to as contaminants of emerging concern (CECs). The presence of CECs in reclaimed wastewater and their implied risks from the reuse, if not immediately addressed, will likely accentuate the negative public perceptions and hinder the adoption of water reuse practices. Through the support of the Regional Water Quality Coordination Program, we have conducted laboratory, lysimeter, and field research to investigate the fate and transport of CECs in soil and water and employed screening models to evaluate their potential impact on the environment. Results showed that (1) sorption of five selected PPCPs, including bisphenol A (BPA), carbamazepine (CBZ), gemfibrozil (GFB), octylphenol (OP), and triclosan (TCS) were well described by the Freundlich equation, but sorption to the soils varied among the different CECs, and their sorption affinity on soil followed the order of TCS > OP > BPA > GFB > CBZ. The degradation of the selected CECs in soil was influenced by the microbial activity and soil type. The poor sorption and relative persistence of CBZ suggest that it may pose a high leaching risk for groundwater contamination when reclaimed wastewater is used for irrigation; (2) The occurrence and seasonal variation of 14 CECs in influents, effluents and sludge from five wastewater treatment plants (WWTPs) in southern California were studied in winter and summer. Risk quotients (RQs), expressed as the ratios of environmental concentrations and the predicted no-effect concentrations (PNEC), were less than unity for all the compounds except for estrone in the effluents, indicating no immediate ecological risk is expected. However, RQs were higher than unity for 3 compounds (estrone, octylphenol, and carbamazepine) in sludge samples, indicating a significant ecotoxicological risk of sludge land application to human health; (3) No compound was detected in the leachate draining through the 89-cm profile of a loamy sand soil and a sandy loam soil in lysimeters during 4 months of irrigation according to typical golf course operations in southern California. But the pollution risk screenings identified clofibric acid and ibuprofen would be most prone to cause the pollution to groundwater; and (4) field experiment showed that some CECs were found in the top 40-cm soil layer, but no CECs were detected in groundwater samples taken from the monitoring wells located in a field that have received reclaimed wastewater irrigation for as long as 25 years.

Keywords：*Wastewater reuse, contaminants of emerging concern, risk assessment*

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[DS5] Soil Health: Key to Food Security

A Productive Maize-Soybean Relay Intercropping System for Food Production and Soil Fertility in Southwest China

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With the increasing of food demand and decreasing of agricultural land resources worldwide, a sustainable and productive planting system become more and more important for supporting the increasing population. Thus, sustainable field management based on ecological principles should be paid more attention. In China, more than 28 million hectares of annually sown area were under intercropping, and maize-soybean relay intercropping covered more than 6.7×10^5 hectares in 2011 in Southwest China. Many research results showed that cereals and legumes intercropped could improve crop yield, whereas the information about whether maize-soybean intercropping would be a sustainable cropping practice with more economic, ecological and environmental benefits was limited. A three years field experiment, which included maize-soybean relay intercropping, soybean monoculture and maize monoculture three planting models, was carried out to evaluate the possible advantages on food production, soil nutrients uptake and soil microbial diversity in maize-soybean relay intercropping system. For the maize-soybean relay intercropping, maize and soybean were planted as alternating strips, every soybean strip was relay intercropped between maize strips, thus each soybean and maize intercropped strip consisted of 2 rows soybean and 2 rows maize. The soil type was purple soil. The three years experimental data, which included crop grain yield and biomass, crop N, P, K uptake, soil N, P, K concentration and soil microbial biomass, along with the six years correlated statistical data from the nearby farmland in hilly area of Sichuan Basin were collected. The results demonstrated that maize-soybean relay intercropping increased grain yield and aboveground biomass with the Land equivalent ratio (LER) ranged from 1.74 to 1.87. The maize-soybean intercropping improved nitrogen use efficiency by 11% compared with monoculture. After three years cultivation, the 0-20cm soil organic matter, available N, P and K content under maize-soybean relay intercropping were higher 5.6%-6%, 11.3%-21.4%, 14.6%-36.1%, and 4.3%-5.9% , respectively, than monoculture maize and soybean. In addition, intercropping also makes contribution on protection of microbial diversity, with Shanon-wiener index improved by 6.5-10% compared with monoculture. In a conclusion, maize-soybean relay intercropping was a sustainable agricultural ecosystem, which could enhance the ecosystem services on food production, carbon sequestration, nitrogen use efficiency and biodiversity conservation compared to monoculture system.

Keywords：*Relay intercropping, Land equivalent ratio, Soil fertility, Soil microbial diversity, Sustainable agriculture*

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[DS5] Soil Health: Key to Food Security

Analysis of Maize Production Intensification Strategies for Heterogeneous Smallholder Farms in Kenya and Zimbabwe

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Poor soil health associated with crop production with little or no additions of organic or mineral nutrient resources is an underlying cause of low crop productivity and food insecurity in sub-Saharan Africa (SSA). There is need to support smallholder farmers to intensify crop production mainly by increasing the use of fertilizers and improved crop varieties, while managing organic resources to maintaining soil fertility. Efforts are also required to nutrient management recommendations to ensure that agronomic and economic efficiency is optimized for highly variable soil fertility conditions. We used the Nutrient Expert for Hybrid Maize (NE) decision support tool to explore the potential impact of various options for maize production intensification for various categories of farmers in Siaya, Western Kenya, and Wedza, Eastern Zimbabwe. Nutrient Expert (NE) applies the site-specific nutrient management concepts to develop strategies to manage fertilizer N, P, and K. Determination of N, P, and K nutrient requirements for a given field by NE is based on the relationship between the balanced uptake of nutrients at harvest and grain yield. The N, P, K fertilizer requirements are mainly based on the soil's nutrient supply potential, and attainable yields depending on other soil constraints and water-limited yield. Farm types generated from past studies were used as a basis for development of farm-specific maize production intensification nutrient management strategies. At the two study sites, soil fertility conditions and current maize productivity was strongly related to farm resources endowment, with high resource endowment (HRE) category farmers having more fertile soils and achieving >3 t/ha compared to about 2 t/ha and 1 t/ha for medium resource endowment (MRE) and low resource endowment farmers, respectively. Despite water limited yields of >6 t/ha, farm-specific attainable yields were highly variable, depending on soil constraints. In Wedza, NE analysis showed that MRE and HRE farms can at least double maize productivity and net profits by increasing fertilizer use by about 100 and 50% respectively. In Siaya, there was scope for MRE and HRE to increase maize yields and net profits with optimal N and P fertilizer rates, and including application of K. However, NE results suggest the need to increase fertilizer use under low and moderate soil fertility conditions, but reduced fertilizer application in the fertile soils on HRE farms in Siaya. At the two study sites, the poor soil fertility conditions on the LRE led to very low attainable yields of <2.5 t/ha. Due to small farms sizes and poor soil fertility conditions, the capacity for self-sufficiency in maize production was low for the LRE, even with optimal nutrient management. The need for managing drought risk in Wedza necessitates options for reducing target yields and reducing fertilizer application rates. Application of manure, or surface retention of maize residues in conservation agriculture systems, reduced fertilizer P and K requirements, but had no effects on N requirements. The analysis conducted using NE showed that socio-economic and soil fertility diversity between smallholder farms had profound effects on crop productivity and nutrient management recommendations to optimize yields and profits. Simple approaches that integrate scientific data for refinement of nutrient management practices to suit different types of farmers are essential for guiding assessment of practical options for sustainable maize production intensification in heterogeneous farming systems.

Keywords：*Farm types, soil fertility, maize, intensification, Africa*

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[DS5] Soil Health: Key to Food Security

Influence of Farmer Management Practices on Soil Fertility, Maize Production Intensificivity and the Role of Cattle Manure in Recovery of Degraded Soils Smallholder Farming Systems in Zimbabwe

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Manure is a key nutrient resource on smallholder farms in the tropics, especially on poorly buffered sandy soils, due to its multiple benefits for soil fertility. Farmers preferentially apply manure to fields closest to homesteads (homefields), which are more fertile than fields further away (outfields). A long-term experiment (9 years) was established in Murewa, Zimbabwe to assess the effects of mineral nitrogen (N) fertilizer application in combination with manure or mineral phosphorus (P) on maize yields and soil chemical and physical properties under variable soil fertility conditions. Sites included homefields and outfields on sandy and clayey soils. Significant maize responses to application of N and manure were observed on all fields except the degraded sandy outfield. Large amounts of manure (> 17 t/ha/year) were required to significantly increase soil organic carbon (SOC), pH, available P, and base saturation, and restore productivity of the degraded sandy outfield. Maize grain yields in sandy soils did not respond to the application of 100 kg N/ha and P fertilizer; manure application had immediate and incremental benefits on crop yields in the sandy soils. A combination of 25 t/ha manure and 100 kg N gave the largest treatment yield of 9.3 t/ha in the homefield clay soils, 6.1 t/ha in clay outfield, 7.6 t/ha in sandy homefield and 3.4 t/ha in the eighth season. Manure application improved rainfall infiltration in the clay soils from 21 to 31 mm/hr but in the sandy soils manure effect on infiltration was not significant. Despite the large manure applications, crop productivity and SOC build-up in the outfield sandy soils was small highlighting the difficulty to recover degraded soils. The major cause of poor crop productivity on the degraded sandy soils despite the large additions of manure could not be ascertained. The current practice of allocating manure and fertiliser to fields closest to homesteads exacerbates land degradation in the sandy outfields and increases soil fertility gradients but results in the most harvest for the farm. On clay soils, manure maybe targeted to outfields and mineral fertiliser to homefields to increase total crop productivity. Farmers who owned cattle in the study site can achieve high manure application rates on smaller plots, and manure application can be rotated according to crop sequences. Consistent application of manure in combination with mineral fertilisers can be an effective option to improve crop yield, SOC and moisture conservation under smallholder farming conditions. The dilemma for restoration of soil fertility and ensuring food security is that poor farms with the most depleted fields are also the farms without access to manure. There is, therefore, little possibility for the poor farms without cattle to raise sufficient amounts of manure or other organic resources to restore soil fertility in depleted fields.

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[DS5] Soil Health: Key to Food Security

Managing Rice Residues and Fertilization to Improve Nutrient Use and Productivity of Irrigated Lowland Rice

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Two field experiments were conducted in two sites with different soil properties to determine the appropriate management of rice residues coupled with cultural practices, such as land preparation and fertilization to improve the nitrogen use efficiency and productivity of irrigated lowland rice. The study showed that in general, mowing of rice stubbles and either plowing or rotavating the soil did not affect the plant nutrient uptake (PNU), grain and straw yields, and yield components. In 2010 dry season, the highest PNU, yield, and return on investment (ROI) were obtained from the Minus-one Element Technique (MOET)-based fertilization compared to Nutrient Manager (NM)-based. In contrast, NM-based treatments had higher agronomic (AEN) and physiological efficiency of fertilizer nitrogen (PEN) due to higher level of N applied using the MOET compared to NM-based fertilization. In 2010 wet season, the incorporation of rice straw alone increased the uptake of P and K, similar to the crop supplied with additional inorganic fertilizer. Inorganic fertilizer treatments with or without additional chicken manure (CM) had higher grain and straw yields, yield components specifically number of tillers and panicles compared to CM and control treatments. The AEN of NSIC Rc212 was highest in plots with recommended inorganic fertilizer (RIF), while CM produced the highest PEN due to higher percentage utilization or absorption of N in treatment with the least amount of N applied. Supplemental inorganic fertilizers in addition to rice residues and CM are indispensable to increase the rice yield. Incorporation of 4-5 t ha-1 rice straw for one cropping season of rice is not sufficient to significantly increase the N uptake and yield of the subsequent rice crop. The 2 month- fallow period after incorporation of straw and stubbles prior to transplanting did not affect rice yields suggesting that this length of time was sufficient to decompose the incorporated rice residues. The application of organic materials like rice straw and chicken manure was also instrumental in attaining adequate level of ROI. Therefore, continuous recycling and incorporation of rice straw in the soil during fallow period is not detrimental to the subsequent rice crop and contributes to the soil nutrient reserves which may lead to the improvement of yield and income in the long run.

Keywords：*Fallow period, mowing, nutrient uptake, nitrogen-use efficiency, rice straw management*

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[DS5] Soil Health: Key to Food Security

A Comparison of Crop Response and Biomass Yield of Four Different Crops Irrigated with Abattoir Wastewater

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Agriculture and allied activities are accounted for over half of total water consumption in Australia, with a major portion being used by meat industries, where food safety and hygiene are essential. The meat producing sector is one of the largest sectors within Australia's food processing industry. The ever increasing number of abattoirs and volume of effluents discharged leads to environmental issues. With 152 abattoirs, Australia is among the world's largest producers of red meat and second largest exporter of beef and sheep meat. Water is a considerable cost to the abattoirs where huge quantity of water is needed for cleaning and rinsing of abattoir floors and walls. All the water used by abattoirs is discharged as wastewater, inducing enormous pressure on fresh water resources, soil and vegetation, thereby contributing to climate change and global warming.

The objectives of the current work were to examine the physical and chemical characteristics of abattoir wastewater irrigated soils and assess the changes in soil fertility. The soils used in this study were collected from Primo Smallgoods Abattoir (Port Wakefield, South Australia, Australia) at different sites such as currently irrigated (CI), currently not irrigated (CNI) and soil outside the irrigation area as control (CTRL). The collected samples were air-dried, characterised for physico-chemical properties and used for greenhouse plant growth experiment. Soil collected from land treatment site was moderately alkaline; the pH of the CI soil was moderately acidic (6.3); with CNI and CTRL measuring 8 and 8.6, respectively. The electrical conductivity was very high ranging from 500 to 1109 µS/cm. The nutrient contents in CI were up to 2080 mg/kg of nitrogen (N) and 489 mg/kg of phosphorus (P); in the CNI soil it was 1634.6 mg/kg of N and 327 mg/kg of P; and in the control soil 669 mg/kg of N and 98.6 mg/kg of P were recorded. Phytoremediation of abattoir wastewater contaminated soil with high biomass producing plant species (Pennisetum purpureum, Arundo donax, and Helianthus annuus) can be a cost effective technique to reduce the risk of nutrients and bio-organic compounds reaching aquatic environment. Hence, the aim of this study was to examine the nutrients addition through abattoir wastewater irrigation and find out possible solution to reuse resources effectively.

A completely randomised block design was employed for the plant growth experiment, where four crops (Pennisetum purpureum, Medicago sativa, Sinapis alba and Helianthus annuus) were grown separately on three different soils (CI, CNI and CTRL) in plastic pots. The pots were irrigated with abattoir wastewater at two different loading rates (50 and 75% of field capacity) and the entire experiment was conducted in three replicates. Two types of water (tap and wastewater) and two loadings were applied throughout the planting period based on the field capacity. The plants were harvested 120 days after planting, oven-dried and used for analyses. The overall dry matter yield was compared between the soils and treatments. Under wastewater irrigation, among the four species grown in the CI soil, Pennisetum purpureum (125g) and Helianthus annuus (115g) showed high biomass yields, followed by Sinapis alba (70g) and Medicago sativa (25g). The plants grown under tap water showed about 30% lower yields compared to the abattoir wastewater irrigation. Similar trends in the biomass yields were observed for CNI and CTRL soils under the two water treatments, with the biomass yields in the following order CI>CNI>CTRL soils.

The results confirm the beneficial effects of abattoir wastewater irrigation at the greenhouse level. However, a proper cropping pattern and wastewater irrigation management plan is essential to utilise the nutrients available in the wastewater irrigated land treatment sites. The increase in fertility is evident from the effects of wastewater on biomass growth and also the abundance of nutrients accumulated in plants. A mass balance calculation on the applied, residual and the plant-accumulated nutrients over a few cropping periods will help us in understanding the nutrient cycling processes involved in the abattoir irrigated land treatment sites, which will serve as an effective tool for the environmental management.

Keywords：*wastewater, irrigation, soil analysis, nutrients, physical chemical, phytoremediation, and dry matte*

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[DS5] Soil Health: Key to Food Security

Effect of Integrated Nutrient Management on Yield of Brown Sarson (brassica Rapa L.) and Post Harvest Physico-Chemical Properties in Alfisols of Temperate Kashmir

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In the present study, the effects of integrated nutrient management on various soil physical and chemical properties was evaluated using Brown sarson (Brassica rapa L.) as a test crop under greenhouse conditions. The experiment was carried out under eight different treatment combinations of NPKS, vermicompost and Azotobacter viz., one treatment of balanced chemical fertilizers i.e., T2 (100% NPKS), four treatments of organic fertilizer sources i.e., T1 (control), T3 (Azotobacter), T4 (vermicompost) and T5 (vermicompost + Azotobacter) and three treatments of combined fertilizers i.e., T6 (75% NPKS + 50% vermicompost), T7 (75% NPKS + Azotobacter) and T8 (50% NPKS + 25% vermicompost + Azotobacter) in a Complete Randomised Design (CRD) with three replications. The results revealed that the yield parameters like seed, stover, biological yield and harvest index significantly increased with different treatment combinations of NPKS, vermicompost and Azotobacter. The treatment T6 (75% NPKS + 50% vermicompost) was found superior for the yield parameters over all other treatments. Application of balanced NPKS along with vermicompost and Azotobacter significantly improved the various soil physico-chemical properties like bulk density, pH, EC, CEC and organic carbon of the experimental soil. Application of inorganic fertilisers showed marked improvement in post harvest available nutrients (N, P, K and S). The combined effect of T6 (75% NPKS + 50% vermicompost) showed significantly much better results for available nutrients (N, P, K and S).

Keywords：Key words: Brown sarson, vermicompost, NPKS, Azotobacter, physico-chemical properties

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[DS5] Soil Health: Key to Food Security

The Impacts of Extreme Weather Events on Crop Productivity and Soil Fertility under Future Climate

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The projected changes in atmospheric concentration of carbon dioxide ([CO2]) and global mean temperature are some of the key issues concerning the sustainability of agricultural production. Superimposed on these are predicted changes in the frequency and severity of extreme weather events such as drought and flooding that may impact crop productivity directly or indirectly through changes in soil fertility and function. Yet, the impacts of these extreme weather events on crop productivity under future climate conditions are not currently well known. Therefore, we examined the impacts of extreme weather events (flooding and prolonged drought) on soil fertility and cotton productivity under current and future climatic conditions (elevated [CO2] and temperature) using a glasshouse experiment. Preliminary results show that plant growth responded strongly and positively to elevated temperature (independent of elevated [CO2]). Plant growth also responded to elevated [CO2]; however, this was only observed at ambient temperature. Flooding had a negative impact on plant growth and soil nitrogen availability but only at elevated temperature. The effect of drought was most pronounced in the elevated [CO2] treatment at ambient temperature. Together, these results suggest that there are interactions between water and climate treatments on plant growth and soil fertility. Therefore, this study highlights the importance of examining the impacts of these extreme weather events on crop productivity within the context of future climatic conditions if we were to ensure the sustainability and resilience of agricultural industry in the future.

Keywords：*climate change, flooding, drought, soil fertility, crop productivity*

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[DS5] Soil Health: Key to Food Security

Chemical and Physical Conditions of Silt in Caves and Pits of Dinaric Karst in Croatia

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Results of chemical and physical analyses of sediments within speleological objects in Croatia have been reported. Sampling and analyses were carried during 1981-2012. Average depth of sampling was 1–15 cm. Analyses of 81 samples from 44 speleological objects (caves and pits) are completed so far, and results are presented in this work. Investigations include standard chemical soil analyses and some heavy metals (Pb, Cu, and Zn) concentrations. Heavy metals were determined by atomic absorption spectrophotometer 'Perkin Elmer 300 S'. Samples were compiled in different parts of caves and pits from long distance of entrance and in upper parts of channels. The gained results are specific for underground samples of speleological objects and its dominant conditions. Silt in caves and pits is very poor provided with humus (0,16 - 0,96 %) and very poor provided with total content of nitrogen (0,02 - 0,09). The greatest differences in particular samples are those for phosphorus. Samples are very poor provided with phosphorus and potassium, but some samples are week and moderate provided with phosphorus. This anomaly showed further be investigated an it possible that samples are polluted with some organic sources. Acidity are in range 7,5 - 9,1 (pH in H2O), and are more or less carbonate (1,69 - 65,28 %). Mechanical soil composition is sandy clayed loam, clayed loam, easy and heavy loam. There's no doubt that samples found in Lukina jama-Trojama pit system on mount Velebit, (-1431 m deep) and samples in caves from very long distance by the entrance (minimum 1 km), have the lowest contain of heavy metals between 81 samples collected and analyzed from caves and pits through Croatia. The content of lead approximately are from 10-24 mg Pb/kg. Sampling in speleological objects shows that mostly of pits and caves are slightly contaminated by heavy metals (especially with lead). Around the towns and bigger places waste sewage waters and other pollutants (trash, organic compounds, refuse deposits are the dominant sources of pollution) pollution increase. Wet and dry deposition has influences in other speleological objects, but in very long distance from entrance we could find unpolluted sediment.

Keywords：*Caves and pits, sediment, heavy metals*

P3-142

[DS5] Soil Health: Key to Food Security

Leaching Behavior of Chlorpyrifos and its Main Metabolite Tcp through 5 Types of Soil Columns in Laboratory Conditions

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By applying the OECD soil column method, the leaching behavior of chlorpyrifos and it main metabolite, 3,5,6-trichloro- 2-pyridinol（TCP）, in five types of saturated soil was compared. The results show the following: (1) Chlorpyrifos can be retained in the five types of saturated soil, and the rate of chlorpyrifos residues in the five types of soil columns are 86.9% (Black soil), 80.3% (Red soil), 77.9% (Limestone soil), 74.7% (fluvo-aquic soil) and 68.9% (Purple soil) of the application amount; (2) No chlorpyrifos was found in the leachate; (3) TCP could fully migrate in the five types of 30-cm-long soil columns and the TCP residues in these columns are 34.4% (Black soil), 29.6% (Red soil), 24.8% (Limestone soil),14.1% (fluvo-aquic soil) and 10.3% (Purple soil) of the application amount; (4) The average concentrations of TCP in the 400 mL leaching solution were from 0.31 μg•mL-1 to 0.23 μg•mL-1; and (5) The Koc and GUS values of the TCP in the five types of soil showed that TCP has a great leaching risk compared with its parent compound of chlorpyrifos

Keywords：*Leaching, soil column, TCP, chlorpyrifos*

P3-143

[DS5] Soil Health: Key to Food Security

Source Apportionment of Lead and Cadmium in Cropland Near a Contaminated Site: A Combined Approach of Positive Matrix Factorization and Geostatisticalanalysis

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Chemical compositions of soil samples are multivariate in nature and provide datasets suitable for the application of multivariate factor analytical techniques. One of the analytical techniques, the positive matrix factorization (PMF), uses a weighted least square by fitting the data matrix to determine the weights of the sources based on the error estimates of each data point. In this research PMF was employed to apportion the sources of heavy metals in 104 soil samples taken within 1 km radius of a lead battery plant contaminated site in Changxing County, Zhejiang Province, China. The site is heavily contaminated by high concentrations of Pb and Cd. PMF successfully partitioned the variances into sources related to soil background, agronomic practices, and the lead battery plants combined with a geostatistical approach. It was estimated that the lead battery plants and the agronomic practicescontributed 55.37% and 29.28%, respectively, for soil Pb of the total source. Soil Cd mainly came from the lead battery plants(65.92%), followed by the agronomic practices(21.65%), soil parent materials(12.43%).This research indicates that PMF combining with geostatistics is a useful tool for source identification and apportionment.

Keywords：*Soil lead;Soil cadmium;Source apportionment;Positive matrix factorization;Geostatistics;*

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[DS5] Soil Health: Key to Food Security

Soil Spectroscopy: The Present of Soil Monitoring to Accomplish Food Security

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The Millennium Ecosystem Assessment states that soil provide a multitude of land based-ecosystems goods and services supporting and regulating the life on the planet. To be fully operational for assisting decisions at local, national and global levels, the soil science community has developed regional, continental and worldwide soil databases, which are now available for some uses such as land resource assessment and risk evaluation. However, they are based on conventional soil surveys which are scarce, sporadically available and are time intensive and expensive. Cost effective tools to monitor soil properties across continents (e.g. Europe) are required. Soil spectroscopy has shown to be an efficient tool for the rapid and cheap detection of soil fertility. During the past 20 years soil spectra have been acquired worldwide and subsequently analyzed in comparison to their wet chemistry results. Spectral models to evaluate many soil properties were published and locally used with remarkable success. European Commission's Joint Research Centre created to date the most complete and consistent soil spectral library at continental scale, and is trying to incentive the use of soil spectroscopy by laboratories serving farmers associations to daily monitor soil fertility and health. Our future goals are (i) to address the increasing demand for information on the state of the soil for every farming system, developing a unique method for the operational use of soil spectroscopy at multiples scales, and (ii) to raise awareness about the significant advantages of monitoring soil health with soil spectroscopy for the accomplishment of food security .

Keywords：*Soil, soil spectroscopy, soil monitoring, food security*

P3-145

[DS5] Soil Health: Key to Food Security

Growth, Yield and Physiology of Fluted Pumpkin (telfaria Occidentalis) Planted on Heavy Metal Contaminated Soil in Response to Different Organic Amendments

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Contamination of agricultural land by heavy metals limits agricultural productivity and it is the major route through which heavy metals enter into animals and human beings. Care must therefore be taken in using contaminated land for crop cultivation. Fluted pumpkin (Telfaria occidentalis) is one of the popular vegetables widely consumed for its medicinal and nutritive values (Protein 29%, fat 18%, vitamins and minerals 20%). It has high concentration of iron (Fe) which makes it a source of food supplement for people suffering from blood shortages. With the increasing awareness of its importance and the recent advocate on urban agriculture, its production in urban and peri-urban centres has also increased. However, most lands in urban and peri-urban centres are already contaminated by heavy metals mostly from anthropogenic sources thereby reducing the amount of cultivable land for crop production. Metal immobilization and transformation to more stable fractions through the use of organic amendments is now being promoted as soil remediation technique to enhance the growth and reduce metal uptake by plants grown on contaminated soil. These organic materials have the ability of increasing soil fertility and pH which in-turn reduce the bioavailability of heavy metals for plant uptake. Though the ameliorative effects of composts on crop grown on heavy metal contaminated soil have been demonstrated in several experiments but different organic materials behave differently depending on source, form, time and rates of application.

In this research work, effects of different forms and types of organic amendments (Mexican sunflower extract; SL, Mexican sunflower Compost; COM, Poultry manure; PM and Compost tea; COL) applied at different times and rates on the growth, chlorophyll contents, lead uptake, Protein and yield of Telfaria occidentalis (Fluted pumpkin) grown on lead polluted and unpolluted soils were assessed. Lead (Pb) contaminated soil was collected from abandoned lead-acid battery wastes dumpsite (containing about 12% Pb) at Kumapayi village in Egbeda Local Government Area, Oyo State, Nigeria while the uncontaminated control was collected from the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria. The amendments were applied using 3 application rates (R1, R2 and R3); COM (10, 20 and 30t/ha), COL (100, 200 and 400m3/ha), SL (100, 200m3/ha and 400m3/ha) and PM (10, 20 and 30t/ha). For the contaminated soil, the treatments also include different time of application of organic amendments (Before planting; BP and after planting; AP). The untreated Pb contaminated (CONTL) and uncontaminated (CONTN) soils served as control treatments. Each treatment was replicated four times using complete randomized design (CRD). Data on growth parameters (vine length, number of leaves and leaf area) and yield (fresh and dry matter yield) were collected at one and two months after planting.

Results obtained showed that, the fresh and dry shoot weights, leaf chlorophyll content, leaf area, number of leaf and ash content in fluted pumpkin grown on CONTL were reduced by 51%, 50%, 43%, 25% and 83% respectively compared to CONTN. Application of organic amendments however increased the growth, yield, chlorophyll and ash contents both on contaminated and uncontaminated soil compared to the Pb contaminated control (CONTL) with higher rate of COM applied BP being superior. It increased the number of leaves, leaf area, chlorophyll content and dry shoot weight by 60, 127, 115 and 233% respectively. Pb uptake was generally reduced in fluted pumpkin grown on amended soil. Similarly, on the fresh shoot weight which is the economic part of the fluted pumpkin (Telfaria occidentalis), COMR3BP also outperformed other treatments. Except for the SL, application before planting increased the yield more than those applied after planting. SL compared to other organic amendments had the lowest value for vine length both at 1and 2 month(s) after planting (MAP). High concentration of lead was also recorded in the leaves of fluted pumpkin treated with SL. The protein content recorded in the CONTL plant was however, not significantly different from other treatments. Though higher than the EU permissible level, organic amendment generally reduced Pb uptake by T. occidentalis with values that were significantly lower than that of CONTL treatment. It also enhanced the growth, yield, chlorophyll and protein contents of fluted pumpkin (Telfaria occidentalis) planted on Pb contaminated soil.

Keywords：*Heavy metals, Organic amendment, Telfaria occidentalis, Yield, Mexican sunflower, Compost, Leachate,*

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[DS5] Soil Health: Key to Food Security

Irrigated Lands and Food Security in Central Asia

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Irrigating land is the pivot of harvest in Central Asia (CA). In the whole irrigating lands are 9,3 mln hectares, water consumed for agriculture 7,4 mlm cubic km in CA. Water-filled cultures (rice and vegetable) land has rise up three times from 1990 year to 2012 (mostly in AmyDarja-SyrDarja basin).

Soil deterioration was processed steadfast during the latest 50 years (desertification adds about 12% each ten years, salinisation, toxicants accumulation, etc) of CA. The economic reasons are: 1) extensive non changing monoculture, over pesticides (till 20 kg per hectare); 2) over-irrigation water (35% -55% of volume); 3) weak statement of the most of soils, for example high soil filtration, the soils have changeable characteristics that isn't good for growing; 4) lack of contemporary soil assessment, include mapping. We have aggravated all the influences together (with additional social influence - high population growing) and what we got is the shortage of land per capita, so harvest per capita. It coinciding with "Limits of Growth" concept: in Kyrgyzstan land per capita in 1975 – 0,27, but in 2010 – 0,14; in Tajikistan in 1975 - 0,17, but in 2010 - 0,10. Market costs of rice high up 50%, wheat 75% for four latest years (in Kyrgyzstan and Tajikistan).

We have done several maps 1:200.000 of CA soil different kinds (deep 1 m), map of soil pollution - by six obsolete pesticides, mercury, uranium (10-15 uranium ppm in soil of vegetable-land near former USSR uranium main).

We have made mathematic-map scenarios for 30-50 years. There are four main ones: 1) Good (in case of high effective soil and water policy), irrigation-water volume do thrifty to 9300-9800 cubic m/hectare, and demographic grow would be moderated till 1,0% per year; 2) Middle, with 9800-1000 cub meters/hectare, demography 1,2-1,3%; 3) Bad situation with 1000-1200 cub m/hectare, 1,3-1,5%; 4) In case of no changing in situation it would be worse (about 12000 cub m/hectare, 1,5-1,9%). Two last scenarios should lead to steadfast shortage of harvest (especially in South and East Uzbekistan, and North Tajikistan – 60% of CA population), wide spread of poverty and malnutrition, hungry-riots, rise up illegal migration to Russia and Europe.

We have tried to implement several technology and scientific contemporary tools of land protection: 1) during 2004-2011: we implementing computer-accounted water-sharing system and "small farm artificial-rein system" – these tools on the one hand it had prevented over-irrigating and from the other it had saved the water volume 3-5 times (this matter was reported in the Brisbane River symposiums, 2006, 2007, Yerevan EU Water, 2007); 2) latest year: we have begun (after application of establishing 2012 Organic Agriculture Federation FOD of Kyrgyzstan) – tool of use new space map, tool of numbering-mapping (which include all previous field-data and paper-maps).

Keywords：*irrigation, soil pollution, lsoil deterioration*

P3-147

[DS5] Soil Health: Key to Food Security

French National Network Devoted to Ensure Durable Recycling of Organic Residues in Agriculture: Field Experiment Network, Professional Network and Shared Databases

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Agricultural recycling of organic residues is encouraged by French and European legislation and associated activities (Directive 2008/CE/EC on Waste, End of Waste project) for efficient organic waste management, reduction in soil organic matter losses and reduction in mineral fertilizer use in agriculture (CE 2002, CE 2013). Recycling of organic residues like manure, compost and digestate, could provide a good alternative to other organic waste management techniques (e.g., incineration, land disposal) (Houot 2008). The recycling of nutrients contained in organic residues (i.e. NPK, micronutrients) also contributes to global and sustainable management of agricultural soils as well as food safety, and brings an answer to the societal issue of waste disposal, especially when the environmental and economic costs of mineral fertilizer production are considered. Nevertheless, because of the origin of the raw materials used as inputs for organic residue production, it is necessary to evaluate precisely and to ensure the innocuousness of recycled organic matters and prevent soil storage of trace elements and other contaminants. Organic residues application needs to be quantified well in order to prevent putative soil over-fertilization and associated risks of water contaminations (for instance with nitrogen and phosphorus) as well as noxious gas losses after spreading. France displays various agronomic, pedologic and climatic conditions, a large diversity of raw materials and organic residues production techniques. Such a variety leads to heterogeneity and uncertainty over actual field effects after spreading, such as organic matter mineralization and nitrogen losses.

There is a need to share harmonized data acquired at the plot level and representative of the French context of organic residue recycling in terms of soils, crop, climates and organic residues diversity. In that respect, a national observatory network has been initiated in 2011 by a consortium of French professionals involved in organic residues recycling (i.e. French research institutes, agricultural science institutes, extension services, and agronomy universities). It aims at sharing methods devoted to the study of organic residue recycling and data acquired in field experiments carried out in France to evaluate actual benefits and risks associated to the organic residue recycling in agriculture (long-term as well as various short-term specific field experiments). The network is coordinated at the national level by INRA (National Institute of Agronomic Research) and ACTA (head of the network of the French agricultural science institutes). In addition, a national information system is developed in order to store and share long-term data at the national level. It is open to professionals and scientists belonging to the network and more generally working on organic residue recycling in agriculture, who provide it with precise data about recycled organic residues effects acquired in field experiments (i.e. nature of raw materials, composition, production processes and storage conditions) and analytical results regarding the actual agronomic values of organic residues recycled in France (i.e. in order to establish typologies of organic residues in respect to the expected field effects).

The aim of the presentation is thus to (i) present to the international soil science community the above-mentioned French network, (ii) share some results from the field-experiment network regarding the evolution of the soil physicochemical properties as related to repeated organic residue inputs, (iii) show current and future available data for the international community working in soil and agricultural sciences and interested in organic residue recycling effects (i.e. gas emission risks, soil organic matter storage, soil density alteration, soil chemical fertility, soil contamination risks…) and (iv) discuss with the international community the opportunity to share and transfer to developing countries the methodologies developed in the French network devoted to ensure an optimized recycling of organic residues in agriculture; this discussion could lead to harmonized methodologies to evaluate benefits and risks of recycling organic residues in agriculture at the plot level and under controlled conditions, as well as to shared guidelines, references and data gathered on a wide range of organic residues and agricultural, pedological and climatic contexts.

Keywords：*network, databases, soil, organic residue recycling, field experiments, shared methodologies*

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[DS5] Soil Health: Key to Food Security

Temporal Dynamics of Soil Physical Conditions for Crop Growth under a Range of Tillage Practices and the Impact on the Performance of Contrasting Modern Cereal Varieties

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When plant breeders develop modern cereal varieties for the sustainable intensification of agriculture, insufficient thought is given to the impact of tillage on soil physical conditions for crop production (Hallett & Bengough, 2013). In earlier work, we demonstrated that barley varieties that perform best in ploughed soil (the approach traditionally used for breeding trials) were not the same as those performing best under shallow non-inversion or zero-tillage (Newton et al., 2012). We also found that the Quantitative Trait Loci (QTL) associated with improved phosphorus uptake, and hence useful for marker assisted breeding, were not robust between different tillage regimes (George et al., 2011). The impact of the soil environment had greater impact than the genetics in GxE interactions. It is obvious that soil tillage should be considered when breeding the next generation of crops.

Tillage may also have important impacts on carbon storage, but we found that despite greater soil carbon at shallow depths under non-inversion tillage, the carbon stored throughout the soil profile was not affected by tillage (Sun et al., 2011). Studies on soil tillage impacts to crop productivity and soil quality have generally been performed in one season, on single sites that have had insufficient time to develop. Our current research explores multiple sites, on different soils, with temporal measurements of soil physical conditions under contrasting tillage regimes. We use the oldest established contemporary tillage experiments in the United Kingdom, with all sites sharing ploughed and shallow (7cm) non-inversion tillage treatments. In eastern Scotland (Mid Pilmore), the site also has zero tillage and deep ploughing (40 cm) treatments, and was established 11 years ago. In east England there are two sites, both also having a deep non-inversion tillage treatment, and they were established 6 (New Farm Systems) and 8 (STAR) years ago. We measure a range of crop and soil properties at sowing, one month after sowing and post-harvest, but here we focus on physical conditions (e.g. Least Limiting Water Range, aggregate stability). These data are also linked directly to a root elongation seedling assay (Valentine et al., 2012). Samples are taken over the rooting zone in the topsoil, plough pan and subsoil. Farm economics and yields are also measured, with the performance of a range of barley varieties measured at Mid Pilmore.

The first year's dataset from this comprehensive project will be presented. Early data identified plough pans under shallow non-inversion tillage that will limit root growth at all sites. Aggregate stabilities vary as expected, with plough soils at shallow depth being less stable than non-inversion tillage, but greater stability in plough soils at greater depth due to incorporated organic matter. Very rapidly following cultivation, the seedbeds coalesce, resulting in a more challenging physical environment for crop growth. We are exploring the mechanisms in soil structure temporal dynamics in greater detail, including the resilience of seedbeds to

structural degradation through natural weathering and the action of plants. Ultimately, we aim to identify crop varieties suited to local soil conditions and management, possibly with root traits boost yields and soil physical quality. We also want to identify soil physical indicators that will identify improved soil management practices for food and environmental security.

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Keywords：*food security, soil physical conditions, root traits, tillage, crop variety*

P3-149

[DS5] Soil Health: Key to Food Security

Phytomanagement of Biosolids-Amended Soil

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Phytomanagement describes the use of plants and soil conditioners to generate valuable products and improve environmental outcomes on poor quality soils. This paper describes how phytomanagement can be applied to low-fertility soils that have been rebuilt with biosolids. Disposal of biosolids is a global environmental issue with most biosolids currently being placed in landfills. However, due to their high concentrations of valuable nutrients, especially nitrogen (N) and phosphorous (P), biosolids can reduce the need for mineral fertilizers. Nevertheless, the use of biosolids as a mineral fertilizer replacement does pose problems as they may contain high concentrations of heavy metals, pesticides, and pathogenic organisms. Therefore, controls are needed to ensure that contaminants do not accumulate in the food chain.

To reduce the risk of contaminants entering the food chain, biosolids application could be used to rebuild degraded or marginal soils. However, the high rates of biosolid application required to significantly improve plant growth can lead to unacceptably high concentrations of N in drainage water, hence increasing eutrophication risks in surface waters. Blending biosolids with sawdust may mitigate this nitrate leaching through biological immobilization of nitrate. It could also be feasible to use certain plant species that secrete compounds known as Biological Nitrification Inhibitors (BNIs) to mitigate nitrate leaching from biosolids-amended soils. Selecting BNI species that produce valuable biomass could be used to provide an economic return from degraded soils, while reducing the negative environmental effects associated with high rates of biosolids application. A critical success factor in such an operation is to select plant species that are either non-food crops or crops that do not accumulate contaminants in their edible portions.

With these factors in mind, we aimed to add value to marginal land by using biosolids combined with economically important NZ native and exotic plant species. We grew manuka (Leptospermum scoparium), kanuka (Kunzea ericoides), pine (Pinus radiata), oilseed rape (Brassica napus), sweet sorghum (Sorghum bicolor) and ryegrass (Lolium perenne) in 10 L lysimeters in a greenhouse experiment at the Plant Growth Unit at Lincoln University. These species were chosen because they add value to the land through the production of timber (P. radiata), essential oils (L. scoparium, K. ericoides, B. napus), honey (L. scoparium) or bioenergy (S. bicolor, B. napus) and even fodder (L. perenne, B. napus, S. bicolor). Here, it is critical that any fodder crops do not accumulate unacceptable concentrations of contaminants. All plants were grown in a low-fertility loam either unamended (control), or

amended with biosolids (1300 kg N ha-1 eqiv.) biosolid/sawdust mixture (1300 kg N ha-1 eqiv., ratio 1:0.5) or urea (200 kg N ha-1). The experiment was maintained at field capacity. Drainage water was collected weekly and analysed for N.

Soil amendments were shown to positively affect plant growth in all species. The woody species (P. radiata, K. ericoides, and L. scoparium) leached significantly less N than the herbaceous species (S. bicolor, B. napus and L. perenne). ICP-OES measurements showed biosolids applications influenced the accumulation of contaminants in plant parts which hence affected sugars, amino acids and essential oils in plant tissues, analysed via HPLC. A shift was observed in total rhizosphere microbial biomass (chloroform fumigation extraction) and microbial community structure, assessed using automated ribosomal intergenic spacer analysis (ARISA). This technique allows an understanding on how the plants used in the phytomanagement system affect microbially-mediated chemical processes in the rhizosphere that ultimately affect the fluxes of contaminants and nutrients. Results indicate that appropriate planting strategies in combination with biosolids / sawdust amendments can result in high yields of valuable plant material while simultaneously reducing N loss and avoiding unacceptable concentrations of contaminants in valuable plant portions.

Keywords：*biowaste, biosolids, soil remediation, phytomanagement, nitrate leaching, nitrification inhibition, soil contamination*

P3-150

[DS5] Soil Health: Key to Food Security

Developing a National Framework to Evaluate Indicators for Soil Health Monitoring

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The soil health is the capacity of soil to functions as a vital living system able to fulfil all its functions including sustaining biological productivity, promoting environmental quality and maintaining plant, animal and human health. The complex interactions of soil chemistry, physics and biology determine the soil health on which sustainable production depends. Soil biology is a key component of soil health as it regulates many soil physical and chemical properties including nutrient cycling. However, soil biodiversity is immense and highly complex. As a result, employing soil biology as indicators of soil health was considered beyond immediate scope. Recent advancements in (1) technologies to define and identify soil biology and (2) the theoretical framework to link biodiversity with important soil functions have provided the necessary evidence to potentially use biological indicators for national-scale monitoring.

In this presentation, development of national scale soil quality indicators will be discussed. I will highlight a need for a strong framework to select robust, repeatable and auditable soil indicators. Further consideration such as identification of priority indicators and logistic associated with deployment at national scale will be highlighted. The presentation will then discuss how such an approach is applicable to farming communities and how this can be adopted for farming regions for routine monitoring activities in order to ensure enhanced and sustainable farm productivity.

Keywords：*soil health, food security, farm productivity, soil functions*

P3-151

[DS5] Soil Health: Key to Food Security

Identifying Microbial Drivers and Key Modulators of Soil Health in Grain Cropping Systems

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Healthy soils sustain primary productivity, maintain environmental quality, and enhance plant and animal health. Soil organic matter (SOM) which consists of plant and animal residues in various stages of decomposition is crucial to soil health; providing ground cover, increasing soil stability, cycling nutrients, habitat and erosion control. The level of SOM in soil is an important determinant of soil health and productivity and the cycling of carbon on a global scale. Soil microbes carry out a wide range of processes that are important for soil health and fertility including SOM turnover. However, microbial control over processes rate related to SOM turnover is not well understood. It is validly postulated that changes in soil structural properties induced by agricultural management practices impact soil aggregation which govern soil chemical and physical heterogeneity and consequently the distribution of microbial communities and their activities among aggregates of different size. Current knowledge of microbial communities and their activities within different microenvironments (i.e. aggregate size) is poor but is essential for understanding the regulation of soil process rates and therefore SOM turnover at the farm system scale. To gain meaningful insights into the dynamic contribution of soil microbial community to broader ecosystem function(s), information from the "omics" should be coupled with the actual processes rates, land management practices, and soil quality parameters. We have taken a gene→genome→ecosystem based approach to address questions related to the regulatory and metabolic networks of microbes involved in SOM turnover and to identify the microbial drivers and key modulators of soil health in different soil types and under different management practices in grain producing agro-ecosystems. Dissecting the genome(s) of various bacteria has provided information about important traits related to differences in survival strategies and ability to influence SOM pool. Our results provides strong evidence that microbial community composition responds significantly to land use and management practices and are correlated with soil parameters including SOM. In addition we have also observed the association of specific bacterial assemblages with particular soil chemistries within different soil aggregates. Our study provides detailed understanding on the mechanisms of microbial regulation of SOM dynamics which is the key challenge for predicting soil health and fertility under various management practices. Quantifying the relative importance of different microbial groups in microaggregate formation will significantly advance this area of science by providing the empirical data required for developing models that will enable us to better predict SOM processes in agricultural systems at much larger scales. Through this research, we will outline how microbes in soils regulate the cycling of SOM within grain cropping systems with the particular aim of implementing practices that enable soil microbes to influence increased grain crop productivity and sustainability.

Keywords：*Soil organic matter (SOM); Micro-aggregate; Soil health; Metagenomics; Management practices; , Soil microbes*

P3-152

[DS5] Soil Health: Key to Food Security

Amounts of Heavy Metals in Paddy Soils of the Khorat Basin, Northeast Thailand

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Rice is the most important food crop in Thailand and it is dominantly grown on lowland soils. Paddy soil used for intensive cultivation of rice in Thailand vary considerably in pedology, mineralogy and geochemistry. This study determined the distribution of heavy metals in paddy soils on diverse soil parent materials and in various environments in the Khorat basin, Northeast Thailand. The study was carried out on 20 soil series. One hundred sites under paddy cultivation were sampled at three depths (Ap, Ap-60 and 60–100 cm). Heavy metal contents were determined by extraction with aqua regia followed by ICP-OES analysis. Factor analysis was used to identify groups of attributes of similar behavior and soil samples of similar composition. The first group of attributes consists of sand, Si and Zr and relates to the sand content of the soils. The second group is diffuse and consists of clay, silt, CEC,OC, Total N, pH H2O, pH KCl, Al, As, Ba, Be, Bi, Ca, Ce, Co, Cr, Cu, Fe, Gd, K, La, Mg, Mn, Mo, Na, Nd, Ni, P, Pb, Rb, S, Sc, Sr, Th, Ti, V, Y and Zn. For soils on recent alluvium, alluvium over residuum and wash over residuum there is a close association among As, Ba, Cu, La, Mg, Mo, Pb, Rb, S, Sc, Th, V and Zn. In soils on residuum derived from basalt there is a close association among Be, Bi, Ce, Co, Cr, Fe, Gd, Mn, Ni, P, Sr and Ti. Heavy metal concentrations in all paddy soils increase with depth and with the increase in clay content. The median concentrations of Al, Be, Ce, Fe, K, Mg, Na, Nd, P, S, Si and Ti in all paddy soils were comparable to those for worldwide normal soils whereas the median concentrations of As, Ba, Cu, Gd, La, Mo, Pb, Rb, Sc, Sr, Th, Y and Zn were lower than typical values for normal soils. Only Watthana (Wa) soil series on residuum derived from basalt have median concentrations of Bi, Co, Cr, Mn and V higher than values for worldwide normal soils and approaching critical concentration for environmental standard. The large variation in chemical composition within and between paddy soils in Khorat basin mostly reflects differences of parent material composition. Variations in chemical composition due to the contamination by fertilizer application and other agrochemical input are minimal or absent.

Keywords：*Heavy metals, paddy soils, Northeast Thailand*

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Concentrations of Metals and Metalloids in Different Size Fractions of Contaminated Podzols and Their Relationship with Contents in Foodstuffs

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Environmental researchers and soil scientists often analyze the fraction < 2 mm of soils whilst exploration geochemists prefer a finer fraction (<0.180 mm or <0.063 mm), which have been used to create several geochemical soil databases or maps. The main purpose of the present study was 1) to compare metal(loids) concentrations in three size fractions in the top-layer of agricultural Podzols and 2) to assess the relationship between the levels in any of the three fractions and concentrations in 3 foodstuffs (cabbage, tomato, maize).

This study was carried out in the surroundings of the Estarreja Chemical Complex (ECC), one of the most important poles of the Portuguese chemical industry, installed in the middle of the last century. The most important input into the environment is chiefly related to past industrial activities, namely with the production of sulphuric acid from arsenopyrite roasting and with the activity of a chloralkali plant. Some rehabilitation works have been implemented since 2003 but for many years the liquid industrial effluents were discharged in the sewage outlet coming from the factories and the solid wastes were deposited on the soil without any treatment.

Podzols, mostly permeable sandy soils with low humus content, are the most extensive soils in the study area and many are used for agriculture. Pollution of agricultural soils is a concern as it can affect foodstuffs quality and safety and even human/animal health.

Soils samples were collected in 26 locations around the ECC; they were dried and sieved to < 2 mm, <0.180 mm and <0.063 mm. Available grown foodstuffs were also sampled (edible parts of 26 cabbages, 25 tomato and 12 maize ears) and dried at 40º C. A set of 11 elements (As, Bi, Cd, Cu, Fe, Hg, Mo, Pb, Sb, Se and Zn) were analyzed by ICP/ES-MS, in both soils and foodstuffs, after extraction with aqua regia. These elements are select for the present study because they are cited in the literature as present in the Portuguese pyrites processed in the ECC.

Concentrations of metal(loids), for the three size fractions of the soils, were found to be in the order Fe > Zn >Pb> Cu> As > Ni; for the remaining five elements the median value does not exceeded 1 mg/kg. For the studied metal(loids) the concentration in the coarser fraction is at least thrice lower than in the finer fractions; this can be related with the sandy soil texture, dominated by quartz. The contents in the fraction <0.063 mm are slightly higher than the contents in <0.180 mm but there are no significant differences between the contents in these two fractions, for all the elements studied.

For environmental approaches As is the element of major concern in the study area. 46% of the soil samples present total As concentrations in the coarse fraction that exceed protective Health Canadian Soil Quality Guidelines (SQG) for agricultural purposes. However if the levels in the finer fractions are taken into account all soil samples are above this limit. For Cu, Pb and Zn, more than half the soil samples show, in the fine fractions, concentrations higher than the SQG.

The spatial distribution of the elements in these agricultural soils shows similar anthropogenic patterns in the three size fractions. The highest concentrations are found near the factories and sewage outlets.

The contents in three fractions are well correlated (Spearman correlation coefficients, all significant at $p< 0.01$). However it was found higher relations between the <2 mm and < 0.180 mm fractions: above 0.80 for As Bi, Cu, Hg, Sb e Zn and lower for Fe and Cd (0.72 for both).

In the foodstuffs and for elements of higher environmental concern the maximum levels are for cabbage: 3.5 mg/kg, 1.13 mg/kg, 0.08 mg/kg and 0.46 mg/kg for As, Cd, Hg and Pb respectively. The contents in tomato fruit and maize ears are much lower.

No significant correlations (Spearmm $p< 0.01$) between contents in foodstuffs and any soil fractions were found, except for Hg in the two finest fractions and the contents in tomato and cabbage ($0,50< r < 0,54$, $p<0.01$).

Further study should include more foodstuffs, more samples and take into account the available fraction of the elements in soils.

Keywords：*Contaminated podzols, Grain size fractions, Foodstuffs security*

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Effects on AG, BE, CO, HG, SB, TH, Tl, U and V in Sugarcane from Application of Sewage Sludge in a Tropical Soil

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Sewage sludge application to agricultural soils improves soil physical and chemical properties. The use of sludge in agriculture represents one of the most viable alternatives for its final disposal. However, the presence of metals may limit its application because of the risk of soil contamination and metal transfer via the food chain potentially causing metabolic disorders and chronic diseases in humans. Thus the risk of soil and food contamination by metals must be considered. However, field studies under tropical conditions to evaluate the effect of sludge on the concentrations of Ag, Be, Co, Hg, Sb, Th, Tl, U and V in soil and plants are scarce. The objective of this research was to evaluate the effect of application rates of sludge on Ag, Be, Co, Hg, Sb, Th, Tl, U and V concentrations in a tropical soil and its potential availability to sugarcane plants in a field experiment. The experiment was carried out on an Typic Hapludult in a commercial cane field (SP, Brazil). The sludge, generated in an aerated biological system ponds, was obtained from the Jundiaí Wastewater Treatment Plant (SP, Brazil). The sludge was applied in the furrows, just before cane planting (cv RB 85-5536), at the rates of 0, 3.6, 7.2, and 10.8 t ha-1 (dry basis). Nitrogen was applied at the rates of 0, 30, 60, and 90 kg ha-1 of N. Phosphorous was applied at the rates of 0, 45, 90, and 180 kg ha 1 of P2O5. Since sludge is poor in potassium, KCl was supplied at 160 kg ha-1 of K2O on all plots. To evaluate the residual effect of the sludge on the first cane ratoon growth, mineral NK fertilizers were applied at the rates of 120 kg ha-1 N and 140 kg ha-1 of K2O, on all treatments. The experiment design was in randomized block, in a 4 x 4 x 4 factorial scheme (Sludge, N and P, respectively), with two replications. The application of sludge has increased up to five times the initial Ag levels in soil and leaf, but the results did not fit to a linear or quadratic model. The Ag added into the soil via sludge was in an available form to the plants, which may be due to the small element affinity for organic matter. In spite of the highest levels of Hg in soil with sludge application (approximately 13% higher than control), foliar Hg levels in sugar cane plant decreased linearly with sludge application rate. In other parts of the sugarcane, in both cane plant and cane ratoon, the Hg concentration was not affected by application rate of sludge, which allows to infer that the Hg remained low in available forms to plants, possibly due to complexation by organic matter. The concentration of Be in soil decreased with the sludge doses. Considering the strong complexation of Be with organic matter, we can assume that organic matter applied via sludge has promoted a binding of Be to non-extractable forms, thus resulting in the decrease in the availability of Be with the doses of sludge. There was no effect of sludge doses on the Be concentration in the different parts of the sugarcane plant. For leaf and stalk, conversely, with the highest sludge dose, there was a decrease in the V concentration. This indicates that the lower concentration in soil occurred because of a greater extraction of this element by sugarcane plant. Probably, the V in soil was linked with organic matter, being held in the cationic species (VO2+), which is more easily uptaken and extracted by the plant. The concentrations of Co, Sb, Th, Tl and U in soil and sugarcane (cane plant and cane ratoon) were not changed by the application of sludge, which values were within the normal range for soil and plant. Even the highest element concentrations were far below the quality and prevention values established by the legislation for agricultural soils. The results from this study indicate that agronomic utilization of sewage sludge, based on the nitrogen criterion, on a tropical soil do not cause Ag, Be, Co, Hg, Sb, Th, Tl, U and V contamination in soil and sugarcane within a short term.

Keywords：*Biosolid, Saccharum spp., Soil contamination, Trace elements*

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Effects of Chromium Nitrate on Phytohormone Content and Mitotic Activity in Maize (zea Mays L.) Seedlings

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Heavy metal pollution is one of the most important environmental problem. Heavy metals pose serious problems for all organisms including plants to human and requires urgent precautions because they are the pollutants that cannot be degraded to nontoxic forms. In this study, toxic effects of chromium on maize (Zea mays L.) seedling have been assessed by mitotic index assay. In addition to determine pytohormones changes such as Cytokinin (ZA), Gibberellin (GA), Indole Acetic Acid (IAA) and Abscisic Acid (ABA) High-Pressure Liquid Chromatography (HPLC) was utilized. Chromium nitrate (CrN3O9) applied to Zea mays seeds at four concentrations (5, 10, 20, 40 mM). The results showed that, the increasing dose of chrome applied to Zea mays L. seeds suppressed the mitotic activity, caused chromosomal abnormalities and decreased mitotic index value in a dose dependent manner. The level of pytohormones was also significantly affected at the above Cr concentration. It was revealed that ABA hormone to increase and the other hormones to be decrease. Especially the increasing of ABA levels under Cr stress indicated that the inhibition of mitotic activity was related with abscisic acid accumulation in the seeds. Consequently, it may be a part of the defense system against the stress.

Keywords：*Phytohormone, chromium nitrat, mitotic index, stress.*

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[DS5] Soil Health: Key to Food Security

Assessing Environmental Risks of China's Intensive Agricultural Land-Use Systems: A Case Study in Dongting Lake Basin

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Chinese intensive agriculture with large inputs of chemical fertilizers and other resources has led to a reduction of rural environmental quality. Many studies showed that intensive agricultural land-use systems produced or suffered severe environmental risks which degraded soils and environmental quality. This study tried to use Hierarchical Holographic Modeling (HHM) method for environment risk identification and assessment in Taojiang County in Dongting Lake basin. HHM is a method within the theory of Scenario Structuring, aiming to identify, prioritize, assess, and manage a set of risk scenarios of a large-scale system. This holographic approach is able to yield a risk identification framework in a systematic way. The HHM framework considered the causes and consequences of risks, in which 7 risk sources were characterized. They are wastewater irrigation, excessive fertilization, livestock manure application, pesticide application, utilization of mulching plastic film, mining, straw burning. Each risk source could result in one or more environmental risks. Therefore, risk identification screened, filtered and graded each risk sources using risk matrices defining 4 levels of risk as the product of the risk probability and severity. Risk identification results showed that agricultural land-use systems in Taojiang suffered two major environmental risks: heavy metal pollution, nitrogen (N) and phosphorus (P) loss. Research showed that heavy metal pollution in paddy filed was mainly from wastewater irrigation. The irrigation effluents were from two sources — polluted rivers by effluent discharge and mining. Thus, soil polluted by heavy metal was significantly correlated with the spatial distribution of polluted rivers and mining, suggesting that factory discharge and mining were major risk sources. The area of cultivated arable irrigated by wastewater in Taojiang is 39600 ha, accounting for 5.57 percent of arable land. The risk of N and P loss is another major environmental risk in the study area. The annual losses of total N and ammonium N are respectively 21.82 and 2.54 kg per ha, and that of total P and dissolved P per year are respectively 2.26 and 2.70 kg per ha. Risk assessment also showed that South towns suffered higher risk levels than North towns in Taojiang. The outcomes of this study were essential for policy-makers to take actions for mitigating the environmental risks in intensive areas.

Keywords：*Intensive agricultural areas, risk assessment, environmental risks, agricultural land-use systems*

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Soil Chemical Health Assessment of Taro Soils of Samoa

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Composite topsoil samples (0-10 cm deep) were collected from forty taro farms in the two main islands of Upolu and Savaii in Samoa in order to measure the farms' soil chemical health status and evaluate any soil nutritional problems that may affect taro productivity. Topsoils were analysed for chemical indicators that include pH (1:5 soil:water ratio), organic C, total N, Olsen P, exchangeable K, Ca, and Mg, and the micronutrients Cu, Fe, Mn and Zn. The topsoils are moderately acidic (pH 5.53). The levels of organic C and total N (11.3% and 1.02%, respectively) are high since long-term cultivation by machinery has not occurred in Samoa. However, Olsen P levels tend to be low (10.1 mg/kg) and can potentially be a limiting nutrient for taro in the long term. Exchangeable Ca and Mg are both high. However, the topsoils have only medium levels of exchangeable K and given the high uptake of taro for this nutrient, this could be another nutrient element that may limit production. Micronutrient levels (Cu, Fe, Mn and Zn) of the soils are generally very high so deficiencies are unlikely.

Keywords：*soil chemical properties; taro soils; Samoa*

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[DS5] Soil Health: Key to Food Security

Assessing Economic Benefits of Arbuscular Mycorrhizal Fungi as a Universal Indicator of Soil Health

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A measure of the presence, function and economic value of arbuscular mycorrhizas is proposed as a universal indicator of soil health. Arbuscular mycorrhizas are known to have both direct and indirect effects on plant growth and soil structure can be influenced by mycorrhizal hyphae associated with fine roots. The roles of hyphae in soil include enhancing water access in water-limiting conditions and the protection of soil organic matter. As such, mycorrhizas could influence economic benefits through their direct effect on soil quality, and through their impacts on plant growth that are independent of soil quality. The presence of mycorrhizas is pivotal to soil physical, chemical and biological processes but their potential contributions can be overridden by soil management decisions that do not take them into account.

Although some of the contributions of mycorrhizas are well documented, it is difficult to quantify their economic benefits in agricultural ecosystems. This is because there has been little work done, either to identify systematically all such benefits, or to identify how variables that influence mycorrhizal function might interact with each other to influence overall benefits. To complicate matters further, it is possible that the nature and magnitude of such benefits might be site specific, so that all possible mycorrhizal impacts for specific rotations in specific paddocks during a particular season may need to be considered.

Factors known to affect the magnitude of mycorrhizal influence (both positive or negative) on agricultural plants include the level of soil phosphorus, the number and abundance of different types of mycorrhizal fungi present, the plant host species, the size of the plant and its stage of development, and the levels of soil carbon and nitrogen. Other issues that are likely to influence mycorrhizal colonisation include plant stressors such as disease, heat and water limitation, and the presence of other soil organisms which interact directly with mycorrhizal hyphae. In addition, the various factors that influence mycorrhizas may interact with each other, and these could have a negative, synergistic or additive effect.

In order to estimate economic values of mycorrhizas at paddock or farm level, various factors affecting mycorrhizal influences on plants and soil need to be quantified. However, there are risks to making such estimates if they are based on: (i) inaccurate measurement of mycorrhizal hyphae in soil and in roots associated with variation in root density and/or root architecture, (ii) inaccurate measurement of mycorrhizal function, including varying contributions of different fungi throughout the stages of the plant growth cycle, (iii) misunderstanding of the behaviour and measurement of colonisation of roots by species, stains or morphotypes of mycorrhizal fungi, (iv) inaccurate assessment of benefits and disbenefits due to failure to account for mycorrhizal variation according to crop rotation, (v) not recognising the discreet effects of C and N cycles on mycorrhizas and their interactions with P, (vi) lack of recognition of effects of other soil organisms which may be under or overstated, (vii) lack of recognition of effects of plant disease and other stressors leading to distorted quantification of mycorrhizal contributions, and (viii) inaccurate assessment associated with independent and inter-related climate attributes.

Risk minimisation strategies can be taken into account to deal with some or all of the factors that impede realistic economic valuation of mycorrhizas. Some of the risks apply widely, but others are more farm- or even paddock-specific. Without even rudimentary local knowledge of arbuscular mycorrhizal fungi in agricultural ecosystems, there is potential that management practices will be used that fail to fully consider, and consequently fail to capture, benefits from these widespread and potentially beneficial soil organisms. Within the rhizoshere, mycorrhizal fungi occur at the interface of soil bio-physical and bio-chemical processes and this central position warrants clarification of their role as an indicator of soil health.

Keywords：*arbuscular mycorrhizas, indicator, soil health, agriculture*

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[DS5] Soil Health: Key to Food Security

Assessing the Qualities of Soils in Different Soil Series Using Scoring Functions and Geostatistical Methods in the Harran Plain, Southeastern Turkey

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This study presents the primary findings of soil quality initiative research conducted in the Harran Plain, Southeastern Turkey where extensive agricultural practices have been performed since irrigation started. This research, being supported by The Scientic and Technological Research Council of Turkey (TUBITAK), was initiated to monitor soil quality for better decision making in soil management. For this purpose, from the most commonly existing 5 different soil series which are under different crop rotation (continuous cotton, wheat-corn rotation) and management (manure application and without manure application) and have different textural classes, over 400 soil samples were collected and around 30 soil parameters including various soil physical (wet agregate stability, bulk density, saturated hydraulic conductivity, penetration resistance in field, available water content), chemical (CEC, soluble and exchangeable cations; Ca, Mg, Na,K, ESP, EC, available P, K, total N and plant available micronutrients; Fe, Zn, Cu, Mn) and biological characteristics (Soil organic matter, microbial biomass, soil respiration, soil enzyme activities and the amount of soil microorganisms) were determined. In order to decide the least minimum data set which at the same time best reflects the level of degradation and productivity of the soils investigated, Principal Component Analysis was used and soil quality indexes were obtained from selected variables using both linear and nonlinear scoring functions. In order to better understand and reveal soil quality problems and limitations existing across the study area, soil quality indexes obtained were combined with various kriging techniques (orginary, cokriging and regression kriging) where slope, soil series and other topographycal variables were tested as secondary parameters.

Keywords：*Soil quality, Scoring function, Kriging, Harran Plain, Turkey*

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[DS5] Soil Health: Key to Food Security

Soil Contamination with Heavy Metals and its Impact on Food Security in China

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With the rapid economic expansion, environmental degradation has become increasingly sever during the past three decades in China. For example, soil pollutions associated with toxic organic compounds (e.g., residual pesticides and persistent organic pollutants) and heavy metals have been identified among China's most urgent environmental threats to be dealt with immediately. In particular, the accumulation of heavy metals in soils and its impact on food safety is of increasing concern in China. It has been reported that more than 20 million ha of agricultural land have been contaminated with heavy metals that can result in the potential health risks to human beings and soil ecosystems. This can potentially jeopardize the food security in China.

Accumulation of heavy metals in agricultural soils are closely related to many anthropogenic activities, such as application of fertilizers and pesticides, irrigation of wastewater, discharge of mining, improper disposal of metal containing wastes, land application of animal manures, sewage sludge and coal combustion residues. Arable crops and vegetables can take up heavy metals from contaminated soils, which is one of the main pathways of introducing heavy metals to human food chain. Events related to soil and vegetable contamination, food safety and human health risks, e.g., rice and vegetables with elevated concentrations of cadmium, are often reported in the media in recent years. The Chinese government has recently developed a number of new policies for prevention of soils from further soil contamination, and remediation of contaminated soils. This presentation will provide a comprehensive review on heavy metal pollution in soils, its impacts on food security, recent development in relevant government policies, and new technologies for remediation of soils contaminated with heavy metals in China.

Keywords：*Soil contamination;heavy metals;food security;China*

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[DS5] Soil Health: Key to Food Security

Mechanisms of Non-Wetting Soils under Laboratory Conditions

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Up to 5 million hectares of agricultural land in Western Australia are affected by soil water repellence which results in decreased crop yield due to inhibiting initial germination. It is believed that coatings of hydrophobic material on soil particles or aggregates and hydrophobic organic matter of decomposing plant material is responsible for non-wetting soil conditions influencing soil health. There are still major research gaps in understanding the formation and spatial distribution of non-wetting soils including the mechanisms of preferential flow and water transport. This research aims to investigate water repellent soils in the laboratory during an experimental setting with controlled factors. Using a small scale artificial water catchment (60 x 60 cm) filled with soils of varying levels of water repellence and a controlled rainfall simulation allows us to study effects like surface runoff or preferential and selective water infiltration. Various surfactants which reduce water repellency are tested. Innovative methods such as non-invasive electrical resistivity tomography (ERT) allow a time lapse study of electric resistivity change due to water infiltration in a 2D manner across the artificial water catchment. This setting allows an effective way of testing the efficiency of wetting agents for non-wetting soils and further help to improve the understanding of processes involved in the formation of water repellent soils.

Keywords：*soil health, non-wetting, water repellent, electric resistivity tomography,*

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[DS5] Soil Health: Key to Food Security

Vermiculture Technology: An Eco-Tool in Sustainable Agroindustrial Waste Management and Remediation of Contaminated Soil in Thailand

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This paper aims to reviews the role of vermiculture technology as a tool for sustainable agro industrial waste management and land remediation in Thailand. Earthworms are important in many applications such as in soil ecosystems, waste management, bioremediation and biomonitoring of contaminated land, safe food and plant production. Waste disposal has been one of the big issues in Thailand, due to the expansion of industrial and agricultural sector and increase human population. That dispersed those waste to the environment, into food chain and effected human health. Moreover, the solid waste management in Thailand is not appropriated. In Thailand, agro industrial is generated in large quantities, is hazardous and creates problem for safe disposal due to the presence of certain soil contaminants, such as organic compounds, heavy metals, and human pathogens. In Northeast Thailand, soil deterioration has become a real problem for growers of the region. The several cases of research studies were conducted to prove the potential of earthworm in sustainable agro industrial waste and land resources management in Northeast Thailand. Therefore, this study aimed to assess the feasibility of utilization of vermicomposting technology by using the earthworm for sustainable agroindustrial waste management and remediation of contaminated soil. Agro industrial wastes were managed by utilizing vermicompost technolog. This study also examined the effect of different agro industrial wastes on changing nutrient (total nitrogen, available phosphorus exchangeable potassium, cation exchange capacity, organic carbon and carbon-nitrogen ratio) and the growth and reproduction of the earthworm. The degradation of toxic substances in waste, heavy metal and pesticide residues was monitored. The results found that the application of agroindustrial wastes by using earthworm and vermicompost technology could increase the nutrient content and to reduce soil toxicity and thus provide a sustainable way to manage waste and land resource rehabilitation. Moreover, the results and knowledge from our studies have been transferred to the public, farmers, local authorities, school teachers and students, temple practices and people who are interested in this technology for sustainable community development.

Keywords：*Contaminated soil, Earthworm, Agro industrial waste*

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Influences of Different Fertilization on the Accumulation of Nitrate Nitrogen in Swamp Cabbage and Soil Enzyme Activity

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The high content of nitrate nitrogen in vegetables poses a health risk to human health. In order to study the influences of different fertilizing patterns on the accumulation of nitrate N in swamp cabbage, a field experiment was carried out in the suburb of Shanghai. The experiment includes six treatments, CK, CF1, CF2, CF3, CM1 and CM2, which are no using fertilizer, 0; chemical fertilizer, 800 kg hm-2; chemical fertilizer, 1600 kg hm-2; chemical fertilizer, 2400 kg hm-2; rapeseed cake manure, 2250 kg hm-2; rapeseed cake manure, 4500 kg hm-2, respectively. Each treatment is in triplicate and each plot is 10 m2 in area. The content of nitrate N in the vegetable and the activity of soil enzymes were analyzed throughout the growth period. The results were as follows: (1) The more amount of fertilizer is applied, the higher content of nitrate N is accumulated in the vegetable. The content of nitrate N in the vegetable is positively significantly correlated with the amounts of fertilizer application（r=0.672）. Compared with CK, the content of nitrate N in the vegetable treated with CF1, CF2 and CF3 increases by 81.92%, 164.04% and 231.56%, respectively; that with CM1 and CM2 by 12.48% and 217.32%, respectively. The content of nitrate N in the vegetable treated with CM1 and CM2 reaches peaks after 30-35 days of application; that with CF1, CF2 and CF3 reaches peaks after 20-23 days. This suggests that the content of nitrate N in the vegetable grows relatively slowly when applied with cake manure. (2) During the entire period of growth, the content of nitrate N in the vegetable increases quickly at first and reaches a peak, and then declines and maintains a stable level after 18 - 25 days of application. (3) Compared with CK, the application of different fertilizers could all raise the activities of soil enzymes, including dehydrogenase, catalase, urease and phosphatase. In comparison, the application of cake manure could more significantly increase the enzyme activities.

Acknowledgements: This work was supported by the National Natural Science Foundation of China (No. 41130526).

Keywords：*Nitrate N; Vegetable; Fertilization; Cake manure; Soil enzyme activity*

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[DS5] Soil Health: Key to Food Security

Search for a Universal Soil Quality Index

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Sustainability of an agricultural production system is dependent on how soil health is maintained. The quantification of soil health is done on the basis of soil quality index which is composed of soil physical, chemical and biological attributes. To integrate them into a single index requires measurement of a large number of variables which is a mixture of both dynamic and static properties. Evaluation of some properties is time consuming, laborious and requires skilled man power as well as modern equipments. In this paper, an attempt has been made to develop a soil quality index (SQI) based on a minimum data set through a series of experiments carried out under various agro ecosystems.

Soil physical quality is one of the three important components of soil quality, besides biological and chemical quality. Decline in soil physical quality can have serious consequences on not only biological and chemical properties but also the productivity of crops. It is, therefore, important and relevant to study soil physical quality for maintaining soil health in the long run. In one investigation (Nishant et al, 2013a), Dexter S theory was applied to evaluate the soil physical quality in maize–wheat cropping system under two tillage/land configurations, namely, raised bed planting and conventional tillage and nine nutrient treatments consisting of no fertilizer, inorganic fertilizers, partial substitution of inorganic by organic sources and organic sources only. The results obtained have clearly indicated that tillage and nutrient management significantly affected soil physical parameters like bulk density, mean weight diameter. It also highlighted the need to determine properties like saturated hydraulic conductivity using undisturbed cores or under in situ conditions. From the results of experiments conducted, it was clear that there was a significant correlation between S index and soil physical parameters as well as crop yield which showed that S index can be usedeffectively for quantifying soil physical quality under diverse environments vis-à-vis crop yield. This study also highlighted the importance of soil physical properties as a constituent of SQI.

Since SQI integrates the effects of soil physical, chemical and biological attributes some of which are dynamic in nature and behave differentially in various agro-ecosystems (AES), an attempt was made to develop an SQI based on a minimum data set (MDS). Another set up studies were conducted to evaluate the sustainability of the crop production in three varying AESs in India, namely sub-humid, semi-arid and arid (Nishant et al., 2013b). Thirteen indicators were utilized to develop the SQI from the properties measured from the surface soil layer (0–15 cm). Each indicator of the MDS was transformed into a dimensionless score based on scoring functions (linear and non-linear) and integrated into four SQIs. The weighted non-linear index (WNLI) was identified as the most sensitive for all the AESs and was recommended as an index for future assessments. Based on this index, the quantificationof soil quality under several cropping systems was carried out for sub-humid, semi-arid and arid AESs andthe most suitable cropping system was identified. WLNI was positively and significantly correlated ($R2 = 0.79$, $p < 0.01$) with wheat equivalent yield for all the cropping systems. In another study, the various parameters measured were screened through Principal Component Analysis (PCA). Weighted additive and multiplicative methods were used to compute linear additive SQI, non-linear additive SQI, linear multiplicative SQI and non-linear multiplicative SQI. The non-linear multiplicative SQI was identified as the most sensitive SQI which was strongly correlated with the crop yield. This clearly indicated that the indices developed may be used satisfactorily for quantifying soil quality.

There is scope of further refinement in proposed indices after investigating the effect of individual soil quality parameter on the productivity of crops under a more diverse set of agro-climatic situations. Use of pedotransfer functions in estimating soil quality index is one aspect which needs evaluation. A much larger database of the parameters used for developing scoring functions, listed in the minimum data sets would decrease the uncertainty associated with its applicability.

Keywords：*Soil Quality Index, Agro-ecosystems, Scoring Functions*

P3-165

[DS5] Soil Health: Key to Food Security

Long-Term Monitoring of Pesticide Residues in Paddy, Upland and Orchard Soils in Korea

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A series of monitoring studies were carried out to evaluate the residue level of pesticides in different native soils from 1999 to 2006. The nation-wide collection of soil samples from paddy, upland and orchard, were analyzed by GLC (ECD or NPD) and GC/MS. The results obtained are summarized as follows;

out of 14 pesticides detected from paddy soils in 1999, the highest residue level was 0.25 mg/ kg, and the frequency was 21.7% as butachlor, 20.0% as isoprothiolane, and 16.7% as iprobenfos. In 2003, 7 pesticides were detected and their frequencies were 0-36.0%; the frequency was 36.0% as isoprothiolane and 33.3% as oxadiazon.

In 2001, a total of 25 pesticides were detected through monitoring in 170 upland soils and the highest residue level was 2.24 mg/kg. The detection frequencies showed the range of 0-53.5%. Especially, endosulfan showed the highest frequency of 53.5%. Residue levels and frequencies of pesticide in the year 2005 were almost the same compared with that of the year 2001.

As a result of monitoring in 150 orchard soils in 2002, 26 pesticides were detected and the highest residue level was 1.43 mg/kg. Of them, the frequency of endosulfan showed the highest as 45.3%. In 2006, 20 pesticides were detected in orchard soils. The frequency of total endosulfan was the highest as 5.3% but was lower than that of the year 2002.

Keywords：*Pesticide residue, monitoring, arable soils*

P3-166

[DS5] Soil Health: Key to Food Security

Status of Zinc and Iron Content in Different Rice Genotypes (grain And Straw) and Rice Growing Soils Across Different Agro Climatic Zones of Karnataka, India

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Micronutrient malnutrition have affected lives of billions as evident by 5 billion suffering from Fe deficiency and 2.7 billion suffering from Zn deficiency all over the world. Rice is the important staple food for more than half of the world population and provides 60 to 70 per cent body calorie intake to the consumers besides being an important source of Zn and Fe.

A survey work was conducted to determine the status of zinc and iron content in different rice genotypes (grain and straw) and rice growing soils under various rice growing agro climatic zones (ACZ) of Karnataka, South India. A representative soil sample, rice grain and straw samples were collected at the time of harvest from different farmers' fields representing eight ACZ of Karnataka. From each zone, more than two prominent genotypes were collected depending on the availability. The collected plant (grain and straw) and soil samples were subjected for analysis of DTPA extractable zinc and iron content by AAS.

Among the eight ACZ of Karnataka, the highest DTPA Zn and Fe were observed in Hilly Zone (HZ) [1.4 mg kg-1 Zn and 186.0 mg kg-1 Fe] and the lowest in North Eastern Dry Zone (NEDZ) [0.6 mg kg-1 Zn and 31.2 mg kg-1 Fe]. Similarly, the highest grain Zn content was observed in Coastal Zone (CZ) [27.9 mg kg-1] and the lowest in Southern Dry Zone (SDZ) [14.2 mg kg-1]. The highest straw Zn content was observed in the HZ (62.1 mg kg-1) and the lowest in NEDZ (34.4 mg kg-1). Furthermore, the highest grain Fe content was observed in CZ (48.2 mg kg-1) and the lowest in Northern Dry Zone (20.5 mg kg-1). The highest straw Fe content was observed in the HZ (219.6 mg kg-1) and the lowest in NEDZ (103.7 mg kg-1).

A total of 244 rice samples (grain and straw) were collected comprising 64 different rice genotypes from eight agro-climatic zones of Karnataka, South India. The results revealed that there was wide variation in Zn and Fe content of rice grain and straw of the same genotype. In general, the grain and straw Zn content across 64 rice varieties ranged from 7.8 to 51.3 mg kg-1 and 16.6 to 284.0 mg kg-1 with a mean of 19.8 mg kg-1 and 50.8 mg kg-1, respectively. Whereas, the grain and straw Fe content ranged from 9.6 to 88.8 mg kg-1 and 39.7 to 437.5 mg kg-1 with a mean of 32.9 and 160.3 mg kg-1, respectively.

The results of the present investigation revealed that 34 per cent out of 244 soil samples representing different ACZ, were found to be below the critical limit of 0.6 mg kg-1 Zn in soil. Similarly, all the soil samples (244) collected were found to be above the critical limit of 4.5 mg kg-1 of Fe. Among 64 rice variety collected from eight agro-climatic zones of Karnataka, the highest grain and straw Zn content was observed in Putta Batta (45.4 mg kg-1) and Aryza-6444 (102.3 mg kg-1), respectively. But, the lowest grain and straw Zn content was observed in Raksha (7.8 mg kg-1) and KMP-149 (16.2 mg kg-1) respectively. Whereas, the highest grain and straw Fe content was observed in Putta Batta (74.4 mg kg-1) and Kesari Batta (437.5 mg kg-1), respectively. The lowest grain and straw Fe content was observed in Nagamani (14.8 mg kg-1) and NLR (57.3 mg kg-1), respectively. The variation in Zn and Fe content of grain and straw of different rice genotypes may be attributed to soil pH, DTPA extractable Zn and Fe apart from genotypic variation in grain and straw Zn and Fe accumulation among the rice genotypes.

Wide variation in grain and straw Zn and Fe content was noticed between the genotypes and also among the genotypes as influenced by soil pH, DTPA extractable Zn and Fe content of soil.

Keywords：*Zinc, Iron, Grain, Straw, Genotypes*

P3-167

[DS5] Soil Health: Key to Food Security

Qualitative Attributes of Soil and Cocoa Forastero in Bahia, Brazil

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The Southern of Bahia, Brazil is suitable for the cocoa tree and, for 250 years of cultivation, base on such edaphic and climatic conditions of the Atlantic Forest biome, no other farming has presented agricultural and environmental positive characteristics than the cocoa. There are new demands for knowledge about the quality of the cocoa beans related to its chemical composition, which applies to many sectors of industry and cocoa market. Because of the lack of information relating the soil environment, as a whole, with the chemical composition of almond cocoa, in this study, following standard methods, had been analyzed two soils (LVAd arg - Hapludox and Nxe - Hapludalf) and beans of cocoa common (forastero), for evaluation of their quality attributes, statistical analysis using Pearson's correlation coefficient, and interpretation of results. The study of correlations between soil and cocoa beans clearly illustrate that the soil environment and their mineralogical composition qualitatively have influence in the cocoa chemical composition. In the LVAd arg - Hapludox, direct correlations were observed between Ca and Mg with P, catechin and epicatechin in cocoa beans; the CEC with K and total lipids of cocoa beans; and inverse correlation of mycorrhizae with acetic acid and Ca of cocoa beans. In the Nxe - Hapludalf, direct correlations were observed by the CEC to Si and Ba, and with the saccharose of the cocoa beans; and by the mycorrhizae with the glucose and free amino acids of the cocoa. The elements Cu, Si, Cd, Ba and Pb in LVAd arg had a direct correlation with total acidity and Mg of cocoa beans; in the Nxe the same elements showed inverse correlations with acetic acid and Cd, and direct with the total polyphenols and theobromine of cocoa beans. In both soils the water hold capacity had a direct correlation with the Si of cocoa bean. The LVAd arg has a greater number of correlations that are directly related to the quality of cocoa beans. The potential of agro-environment of the cocoa farming associated with the quality of cocoa beans may to do able a future designation of origin by the market.

Keywords：*Theobroma cacao L., Cocoa forastero, Farmlands, Geographical Indication*

P3-168

[DS5] Soil Health: Key to Food Security

Investigation of Heavy Metal Concentrations in Upland Soils of Gangwon Province in Korea

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The management of heavy metals in soil is important for environmental-friendly agriculture and keeping an ecosystem healthy. This study was investigated heavy metals (Cd,Cu,Pb,As,Zn,Cr,Ni) concentrations in 170 upland soil samples taken 0~15cm soil depth in Gangwon Province. The median value concentrations of the heavy metals were 0.14 mg/kg (ranged 0~4.58) for Cd, 16.8 mg/kg (ranged 3~161) for Cu, 9.3 mg/kg (ranged 0~198.5) for Pb, 5.2 mg/kg (ranged 0.7~23.2) for As, 74.4 mg/kg (ranged 35.7~192.5) for Zn, 20.5 mg/kg (ranged 2.9~90.7) for Cr, and 9.6 mg/kg (ranged 0.4~50) for Ni, respectively. Out of 170 points, one place has exceeded(Cd 4.6 mg/kg) the warning limit(4 mg/kg). However, this area where the mine is expected to be soil dressing. In addition, the average concentration of Cd was highest in alluvial fan, Pb was highest in valley, and Cr, Cu, Ni, Zn, and As were highest in hill. Heavy metal contents sorted by soil texture were higher in the loam soil in every elements. The average contents of heavy metals in upland soils of Gangwon Province in Korea were much lower than environmental standards.

Keywords：*Heavy metals, Upland Soils, Gangwon Province, Environmental Standards*

P3-169

[DS5] Soil Health: Key to Food Security

Response of Lettuce to Cadmium Exposure at Different Growth Stage

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A lot of phytotoxicity studies have been used to determine the toxic effects of chemicals. In spite of many studies about the phytotoxicity, there have been no related studies which evaluated the responses of plant at different growth stage. The physiological processes and metabolisms of the plants were altered during growth stage. It might cause different responses to metal. To evaluate the toxic effects induced Cd at different growth stage, lettuce (Latuca sativa L.) were exposed for 3 days to Cd by hydroponic solution. Then the plant were harvested for following analyses; root elongation, biomass production, Cd, Ca, Mg, K concentration, water content, and lipid peroxidation. Cadmium-exposed plants displayed nutrient imbalances in leaves. Root elongation, biomass production, water content, and chlorophyll a content were decreased and lipid peroxidation was enhanced. Root elongation showed greater sensitivity and correlation to Cd concentration in exposure solution with lower EC50 values and higher correlation coefficient values. It was showed significant alterations between 14-day old and 21-day old lettuce. These results suggest that the phytotoxicity test should be conducted with consideration about plant growth stage.

Keywords：*Cadmium, lettuce, phytotoxicity, growth stage*

P3-170

[DS5] Soil Health: Key to Food Security

Impact of Copper and Rotenone on Seedling Growth of Chinese Cabbage and the Soil Activity

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The Codex Committee on Food Labelling (CCFL) is debating whether or not to allow for use of substances such as copper octanoate, rotenone, spinosad, potassium bicarbonate in organic agriculture. Many countries of this Committee suggest that the above materials have a negative impact on crop growth and soil organisms. In Korea, copper compounds and rotenone are currently the most common biocide in organic crop cultivation to control plant disease of vegetables and fruit trees. The aim of this research was to evaluate the impact of copper and rotenone treatments on seedling growth of chinese cabbage and soil biological activity.

The trails were carried under growth chamber and laboratory condition. The concentrations treated with copper in arable soil were 100ppm, 150ppm, 300ppm, 450ppm, 900ppm, and rotenone concentration treatments were 2.5ppm, 5ppm, 10ppm, 20ppm. We were carried out the assessments to evaluate the impacts of treatments on crop growth and soil biological activity. The obtained data was evaluated by the Duncan test.

In this study, the risk associated with copper and rotenone use has been investigated. The obtained results showed a statistically significant decrease of soil biological activity and seedling growth of chinese cabbage in high copper treated plots. We also concluded that all treatments of rotenone concentration do not show a significant negative impact on soil biological activity. However, seed germination and seedling growth of chinese cabbage were significantly decreased by rotenone treatments.

The results of this study are cause for concern for decrease of soil biological activity and crop growth over 450ppm copper concentration. Rotenone has caused a very severe impact on crop growth inhibition, but Rotenone trails were increased soil activity by high concentrations. We suggest that copper and rotenone in the field does not use high concentration for controlling crop disease.

Keywords：*Organic agriculture, copper, rotenone, soil biological activity, chinese cabbage*

P3-171

[DS5] Soil Health: Key to Food Security

Proper Ranges of Soil Ph and Pe for Crop Growth

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Crop growth is governed by limiting factors such as the minimum nutrient and soil properties. Knowing that limiting factors related to crop growth enables us to recover an abnormal symptom of crop. This study was conducted to establish the proper ranges of pH and pe for crop growth using the data of on-site analysis. Ammonium ion dissociated from fertilizer or decomposed from organic matter was volatilized as ammonia gas in the soil over pH 7.5. Also, phosphate in the soil over pH 7.5 was poorly dissolved. Ammonia gas directly affected the yellowish symptom and necrosis of leaf, because the recovering from yellowish symptom of egg plant was achieved by removal of (NH4)H2PO4 in the solution in which comprised KNO3. Below pH 5.5 in the soil, nitrate and phosphate in soil solution were negligible and NO2(g) was also emitted and many an abnormal symptom was appeared. Because the representative symptoms were poor growth and club and stooped fruit and yellowing/whitening of leaf and they were disappeared by correcting soil pH, soil pH should be related to energy loss of crop. On the other hand, pe below 15 - pH affected crop wilt and root browning due to O2 shortage. As crop root competed against soil microbes in O2 consumption, the tomato wilt could be induced by over-supplied microbes. Because the tomato wilt was recovered by supplying the tea of compost which was made from sawdust of pine tree containing ingredients of repressing microbial activity, it could be induced by O2 shortage. These results suggest that soil pH should be sustained from 6.0 to 7.0 and soil pe over 15 - pH to keep soil productivity.

Keywords：*proper ranges, soil pH, soil pe, crop growth*

P3-172

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Land Resources Assessment for Agricultural Use in Some Areas West of Nile Delta, Egypt

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Due to constant decrease in agricultural lands, it is important to identify the best lands useful for sustainable agriculture development and protects the environment and that is socially equitable. The main objective of this study was to discuss the efficiency of agricultural land evaluation for assessing land use types in rural areas. In this research, the area west of Nile Delta that extends from Biba to Bani Mazar districts was selected as a case study site, which considers one of the high priority regions for future development in Egypt. As input, a total of fourteen representative soil profiles and number of observations points were used for collecting soil samples. Based on the ground truth data, laboratory analysis and imagery interpretation in cooperation with geographic information system (GIS) utilities, the physiographic map was generated. Three main physiographic units were identified as follow i.e. flood plain, desert plain and interference zone. The soils were classified mainly as Typic Torrifluvents, Vertic Torrifluvents, Typic Torriorthents, Typic Torripsamments and Typic Haplosalids.

Land suitability assessment was done to define the suitable areas for agricultural production using ALESarid-GIS system and MicroLEIS microcomputer program as well. According to the crop suitability results, the most suitable crops to grow in the study area were Wheat, Barley, Sunflower, Rice, Peanut, Cotton, Sugarcane as high suitable crops in the flood plain mapping unit. In the interference zone and desert plain units the most recommended crops are sugar beet, tomato, date palm, cabbage, wheat, sunflower, fig, olive potato and pea. Generally, the data on land suitability resulting from the evaluation models indicated that 25.3 % of the study area is considered as suitable for most evaluated crops, 13.7 % is moderately suitable, 38.1 % is marginally suitable and 22.9 % is not suitable. The main limitation factors for land suitability are the excess of salts, shallow soil depth, inadequate drainage conditions, sodium saturation and poor soil fertility.

Keywords：*Agricultural land suitability, Optimal land use, ALESarid-GIS, MicroLEIS, Western desert.*

P3-173

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Uncertainty Assessment for Mapping Changes in Soil Organic Matter Using Sparse Legacy Soil Data and Dense New-Measured Data in a Typical Black Soil Region of China

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The fertile black soil region in Northeastern China is the most important agricultural area for grain production of China. However, the soil organic matter (SOM) content in the area decreased dramatically in recent years due to decades of overexploitation, unsustainable agricultural management practices, and the soil erosion. Since the identification of changes in SOM in the area has gained great concerns for maintaining and improving the soil fertility and addressing the issues of climate change, relatively denser observations of SOM originated from varied studies conducted within the area in recent years becomes available. However, uncertainties associated with the predicting method for mapping changes in SOM remain unclear, because the quantity and distribution of the available legacy soil survey data in the area are still limited and sparse. In order to evaluate the accuracy of different mapping methods for detecting changes in SOM in black soil area using limited legacy soil data and relatively denser new-measured data and assess the uncertainties associated with the mapping methods, a total of 89 legacy SOM data (0-20cm) sourced from the soil survey in 1980 in central and southern parts of Hailun County in Northeastern China and 268 SOM data (0-20cm) measured in the area in 2008 were collected in this study. The most straightforward mapping method such as ordinary kriging (OK), inverse-distance weighting interpolation (IDW), and the soil type based method (ST) were used to derive the spatial patterns of changes in SOM, and the uncertainties associated with the mapping methods were quantitatively assessed through the uncertainty intervals of SOM realizations that generated by sequential Gaussian simulation (SGS) and/or Monte Carlo (MC) simulation. Results showed that the overall trend of changes in SOM over the last 28 years in the area is decreased. The spatial patterns of changes in SOM derived by OK-OK (Abbreviations before and after the dash represent the mapping method for SOM data in 2008 and 1980, respectively) and IDW-OK, OK-IDW and IDW-IDW, OK-ST and IDW-ST are similar, respectively. Change map obtained by the ST-ST method is also similar to those derived by OK-ST and IDW-ST method, but local details of changes in SOM presented by the ST-ST method are less than those obtained by the OK-ST and IDW-ST methods. The OK-ST method, with an uncertainty tradeoff compared to the OK-OK and ST-ST method, can be considered as the most suitable method for mapping changes in SOM in the area due to the limited legacy soil survey data and inaccurate sample location information records in the area. Moreover, when the availability and spatial configuration of the legacy SOM data is considered, the traditional ST method is still promising in the application of SOM change modeling when facing limited legacy soil survey data and inaccurate sample location information, because the method is simple, straightforward, and has the ability of mapping SOM spatial distribution effectively using limited legacy soil sample points.

Keywords：*Soil organic matter (SOM), Spatio-temporal change, Uncertainty assessment, Sequential Gaussian simulation, Monte Carlo simulation*

P3-174

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Origin and Distribution of the Gypsiferous Soil in Iraq

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Gypsum is known as one of minerals that contains in the soils under semi- arid or arid condition. Increasing this mineral in soil with fluctuation of groundwater table such as in Iraq may cause many problems for agriculture and infrastructure.

2220 soil samples have taken from different sites across Iraq, and which selected at two different depths (25 and 150) cm in these sites. The percentage of gypsum had measured and classified for these soils base on Iraqi procedures (Barzanji, 1973; Soil Investigations, 2002). Hence, two different maps for the two depths have produced which showed the distribution of gypsiferous soils in Iraq. Map of depth 25 cm reflects high percentages (~47%) of gypsum in soils, allocation in AL-jazeera site in northwest of Iraq and area surround Euphrates River in centre of the country. While, map of depth 150 cm reveals increasing in gypsum content (60-75%) with depths for all sites, except the Quaternary deposits in the south part and the western desert in Iraq which their percentages between 0 and 10%. In general, these maps demonstrate that at 25 cm depth about 27 to 35% of Iraqi soils are gypsiferous soils, and the percentage reached 43 for depth 150 cm.
Furthermore, this study illustrates that origin of gypsum in soils is on-site came from outcrops of formations contain gypsum which deposit in soils as secondary gypsum. In addition, the origin of groundwater in the area that has high percentage of gypsum is sulfate, and it appears to have a signification influence in distribution of gypsum in soils. The high percentage of Iraqi gypsiferous soils can be found in area involve groundwater deeper than 5 metre. However, distribution of gypsum in soils from flood plain (Quaternary deposits) formed by irrigation and evaporation.

Barzanji, A.F., 1973; gypsiferous soil of Iraq. Ph. D. Thesis, University of Ghent, Belgium.
Soil investigations, 2002: Prepare a map of the distribution of gypsum ratios in soils Iraq / the first stage, the General Company for Research on soil and water resources, the Ministry of Irrigation, Iraq, unpublished report.

Keywords：*gypsum, soil, Iraq*

P3-175

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Assessment of Land Suitability and Availability for Food Crop Development Using a Fuzzy Set Approach in Gis

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Recently, spatial information on land suitability and land availability for specific purposes has become a prerequisite in regional development. Although spatial data on land resources and their uses have become more available and detailed, in some circumstances, their geographical representations for spatial decision making are considerably intricate. Accordingly, it requires advanced methods that could deal with those complex and detailed data in an effective manner. The principal aim of this study is to fully utilize fuzzy set and geostatistical methods in Geographic Information System (GIS) to assess land suitability and land availability for food crop development in a relatively dynamic region. The area selected for this study is a part of the Mamminasata Region, South Sulawesi; one of the strategic regions in Indonesia. Due to its status as a strategic region as stated in the Indonesian Government Act No. 55 Year 2011, this area has recently experienced rapid land use changes. This has given rise to a problem of preserving the best land for food crop development. The Mamminasata region (as an acronym for Makassar, Maros, Sungguminasa, and Takalar) covers four districts, including the whole area of Capital City Makassar, and some parts of Maros, Gowa, and Takalar regencies with a total area of approximately 240.000 ha. Some parts of the Maros area was used to test a fuzzy set method in searching of land suitability and availability, before it can be applied to the whole Mamminasata Region.

The methods and procedures used follow the following steps. First, assessing land suitability for main food crop commodity (i.e., maize) using a fuzzy set method with the Semantic Import Model (SIM) in a GIS. With a fuzzy set approach, land attribute values were converted into continuous values (ranging from 0 to 1.0), according to the class limit determined based on field experiences, results of experiments, or fixed conventional standards. The evaluation criteria were based on land attributes which are divided into three main components: soil profile, topography, and climate. Each of field attributes within each component was valued from 0 (minimum) to 1.0 (maximum) according to the suitability of maize. Those values were represented as the membership values (MF), also ranging from 0 to 1.0. The results were expressed as a land suitability index (LSI). Second, classifying land use employing satellite images (Landsat and SPOT) using supervised method. It was followed by collecting ground truth samples for map accuracy assessment. The main aim of land use mapping in this study is to provide thematic information on different land use categories, for use as the basis for assessing land availability. Third, examining land availability from spatial matching processes within GIS. Available land for food crop development was revealed from a higher LSI and appropriate types of existing land use for agricultural development.

The result from land suitability analysis in Maros Regency for food cropping indicates that around 25% of land areas have an LSI (land suitability index) value of above 0.70 (suitable and very suitable), about 11% fall between 0.50 and 0.70 (moderately suitable), and 63% were under 0.5 (not suitable). The main limiting factor for maize cultivation in this region is topography, especially slope gradient (s). Further, in the study area, land use types are mostly dominated by scrubs and dryland agriculture followed by paddy field, forest, fish pond, residential, plantation, industrial area, international airport, grass land, quarries, river, and unidentified ones with relatively small area. A preliminary results indicate that with the assumption that the regional government will give the highest priority for area with land suitability index (LSI) of more than 0.75, then after overlying with the land use types, there will be a total of 24,716 ha (or 35.6% from total suitable area an index more than 0.50) of land is available for cropping. Other area will be better to be preserved for conservation and development of urban residential area. In terms of land use decision making perspective, such information may be used to direct land use change to a more beneficial and sustainable situation.

Keywords：*land suitability, land availability, Mamminasata, fuzzy set, GIS*

P3-176

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

The Value of Soil Information for the Development of a National Forest Site Classification System

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The intensive nature of management practices in the exotic monoculture plantations of South Africa requires reliable decision support systems. The various challenges the industry is confronted with in terms of socio-economic developments as well as increasing awareness of broader ecosystem values and environmental risks, highlight the importance of a unified approach to forest site classification and evaluation. Despite many successes in research and development, managers, planners and researchers do not have a National Forest Site Classification System for decision making in this increasingly complex environment. The purpose of this paper is to propose a limited set of easily manageable soil factors for use in such a system, with maximum application value in a forestry environment. The variables proposed are parent material, soil classification, effective soil depth, depth limiting material, and topsoil organic matter and texture. This set of variables can be related to soil moisture and nutrient supply, and is based on site ecological principles in support of sustainable forest productivity. This database, if used in combination with appropriate climatic indices, can support many operational and strategic applications in the plantation forestry industry, such as site-species matching, site quality prediction and growth and yield modelling, site-specific nutrient management, assessments of risk and site sustainability, as well as general silvicultural aspects.

The presentation will highlight strategic issues the forest industry in South Africa is confronted with, together with the value a site classification system can add in this context. The selection of the relevant soil variables is discussed from a scientific perspective, together with the research requirements that require attention in order to better understand the relevance of specific soil variables. The use of high resolution rasterized soil data will be demonstrated for a range of applications in the plantation forest environment.

Keywords：*Forest site classification and evaluation, site factors, parent material, soil classification, , soil organic material, soil depth, soil texture*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Spatial Distribution and Influencing Factor of Soil Moisture in Typical Depression Area of Karst Region

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In this study, the geo-statistics and GIS method was combined used to characterize the spatial variation and distribution of soil moisture content at depth of 0-16 cm and to investigate the influencing factors in a karst depression area of southwest China, based on the grid sampling at 20 m intervals by TDR method in the 200m×600m depression area during the dry and rainy seasons in 2005. The results indicated that the surface soil moisture content was influenced by the antecedent rainfall (the rainfall accumulation 10 days before the sampling time) and the soil moisture was more sensitive to the antecedent rainfall in dry season than that in rainy season. The mean soil moisture content varied from 21.67% to 28.79% in the four sampling during the dry and rainy seasons. The variability of soil moisture content showed by CV values decreased with the increasing mean soil moisture content either in dry or rainy season. The semi-variogram theoretical models of the soil moisture content during the dry and rainy seasons were all exponential models. And the parameters of these models including nugget, sill and range indicated that the spatial variability and its dominant influencing factors of soil moisture content both changed with the dry and rainy season. Similar results were also obtained from the patterns of soil moisture content of the four sampling generated by the ordinary kriging interpolation. The soil moisture content, distribution and spatial variability were different at different sampling reason and sampling region of the depression. The distribution of soil moisture content was mosaic pattern in dry season, compared with the strip or band pattern in rainy season. And the distributions of soil moisture content in arid and humid conditions were not identical especially in the same dry and rainy season. The environmental factors and human activities both affected the spatial distribution of soil moisture content in the depression area. The variability of soil moisture content decreased with the increasing mean soil moisture content due to the antecedent rainfall either in dry or rainy season. And the soil moisture content was always different in different land use types. The abandoned field and orchard field always had the relatively higher moisture content either in dry or rainy season, followed by the rehabilitated field and gazing field, and the cultivated field including corn and soybean field had the relatively lower soil moisture content. Furthermore, a significant positive correlation was found between the soil moisture content and the soil organic matter. And altitude and bare-rock ratio were also important factors influencing the soil moisture content in the depression area. Therefore, corresponding strategies of rational usage and management of soil water resource should be made according to the different spatial distributions and influencing factors of soil moisture content in dry and rainy season in depression area of karst region.

Keywords：*karst depression area; soil moisture; spatial distribution; influencing factor; dry and rainy season*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

The "Land Unit and Soil Capability Map of Sardinia (Italy)" at a 1:50,000 Scale: The Pilot Area of Pula-Capoterra

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The land use planning activity of the Regional Administration of Sardinia (RAS) has undergone a substantial change after the approval, in 2006, of the Regional Landscape Plan (RLP) that establishes the directions for any land use planning in Sardinia and requires that pre-existing sectoral, province and city plans, as well as plans for protected areas, have to be changed to comply with these directives. In the RLP, the soil is specifically considered one of the main landscape components and in the RLP guidelines a soil survey of the whole communal territory is required (at the suggested reference scale of 1:10,000). Moreover, Land Unit and Land Capability maps are explicitly required, and the adoption of a single regional reference legend for these maps is strongly recommended. The Planning Department of the RAS has recently realized the need for specific knowledge and tools to support land use planning according to the RLP rules. Consequently, a new project for the creation of a "Land Unit and Soil Capability Map of Sardinia", at a scale of 1:50,000, was recently initiated in four pilot areas. Two regional Agencies (AGRIS and LAORE) and two Universities (Cagliari and Sassari) are involved in the project, each of them being responsible for one pilot area. In this work we present the results of the pilot area Pula-Capoterra (46,040 ha).

A GIS approach was used. We used the soil-landscape paradigm for the prediction of soil classes and their spatial distribution or the prediction of soil properties based on landscape features. The work was divided into two main phases. In the first phase, the available digital data on land cover, geology and topography were processed and classified according to their influence on weathering processes and soil properties. The methods used in the interpretation are based on consolidated and generalized knowledge about the influence of geology, topography and land cover on soil properties. Digital thematic maps of soil-forming factors (parent material, landform, land cover) were produced to build the first draft of the Land Unit Map to be used as a basis for the production of the final "Land Unit and Soil capability Map of Sardinia" at a scale of 1:50,000. The dataset was developed in a GIS environment, exploiting its potential to produce derived maps by intersections, reclassifications and summarizing themes using GIS functions. The existing soil data (areal and point data) were collected, reviewed, validated and standardized according to international and national guidelines. The data of 155 soil observations considered to be usable, 69 of which correspond to soil profiles with routine analytical data set, were input into a specific database created for the project. During the second phase, the first draft of the Land Unit Map was implemented with the existing soil data and verified in the field. During the field work, 601 new soil observations were carried out, 61 of which correspond to soil profiles with routine analyses. Considering that in the area 8,755 ha do not have soil cover (urban areas, industrial areas, and rock outcrops), the final survey density is equal to 1 soil observation per 50 ha. Finally, the Land Unit and Soil Capability Map was produced by classifying the land units using a reference matching table of land capability classes created for this project.

The legend of this map is divided into three main sections, called Land Unit, Soil and Soil Capability, respectively. Each section is divided into several parts as follows: (i) Land Unit: identification code, description of parent material, description of landforms, and description of land cover; (ii) Soil: description of main morphological and physicochemical properties, taxonomic classification according to U.S. Soil Taxonomy, taxonomic classification according to WRB, and typology and value according to the RLP Guidelines; (iii) Soil Capability: subclass of soil capability, main limitations, and suggested practices of soil conservation.

Acknowledgments

This work has been supported by the RAS under the decree DGR n. 56/36 dated 29.12.2009.

Keywords: *Soil map, Soil survey, Land use planning*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Information Technology-Based Nutrient Management for Higher Crop Production in India

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Four decades after the Green Revolution the sustainability of Indian agriculture is facing serious challenge to the country's food security all over again. Indiscriminate intensive cropping systems and unbalanced fertilizer application robbed the soil of its nutrients and polluted the ground water and contaminated the crops enlarging the gap between riches and poor. The critics termed it as "Red Revolution not Green Revolution". Experts feel that there is an enormous potential for propagating sustainable agriculture in India. But there is a need of paradigm shift from commodity-centered to ecologically-sustainable farming systems. This paper gives a critical analysis of the overview of the potentials of recent advances and scope for future developments on the information technology-based tools to improve nutrient management and emphasize for their adoption. It has been demonstrated the superiority of user friendly simulation modeling over conventional approaches for fertilizer recommendation and enhancing fertilizer use efficiency significantly (10-30%). Widespread use of IT based tools can reduce soil and water pollution, particularly nitrogen, emanating from modern agriculture and enhance the rural income of small farmers (80% in India).

Keywords：*Information technology, fertilizer management, simulation modelling, nitrogen use efficiency*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Petrological and Analytical Characterization of the Benue Watershed Topomorphic Vertisols of North Cameroon: Spatial Analysis and Agricultural Potential Evaluation

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Vertisols are well represented in the tropical zone and well known for their extremely high chemically fertility. Nevertheless, due to their high compacity and seasonal cracks which limit plant growth, they remain relatively less agriculturally exploited. The present work aims, firstly, to perform a detail characterization of vertisols, and secondly, to do statistical and geostatistical analysis of vertisols to facilitate maximum agricultural exploitability. The study concerns the topomorphic vertisols of the Benue watershed (North Cameroon), developed under a classical sudanian climate, savannah vegetation and on recent alluvial material.

The work was done in the field and in the laboratory. After detailed landscape analysis in the field, soil survey was done using Auger boreholes and pits. Georeferenced samples were collected both in vertical profiles and in two plots (cropland in Garoua, savannah in Badoudi). Laboratory work included petrographic, mineralogical, geochemical, mechanical and physico-chemical analyses. Part of the data was then treated statistically and geostatistically based on kriging.

The main results revealed that the vertisols, with a profile depth of 2-2.5 m above the water table, show a dark grey colour, a heavy clayey texture, a high bulk density (1.8-2.2 g/cm3), a very low porosity (15.4-30.76 %) and numerous stress cutans that follow voids. The mineralogy was dominated by smectite, small quantities of kaolinite, quartz, feldspars and traces of goethite. Silicon and aluminium were the dominant components. The alkaline and alkali-earths were also high. Physico-chemically, the soils showed high CEC, high exchangeable bases, high base saturation (BS), low organic carbon (OC), high available phosphorus (AP), low total nitrogen (TN) and high C:N ratio (10-26.5). Mechanically, they showed very high liquid limits, low plastic limits, high plasticity indices and low shrinkage limits (8-13 %).

Statistically, most of the vertisol properties varied significantly among the two plots (ANOVA, $P<0.1$, 0.05 and 0.01) due to intrinsic soil variability at the scale of the soil series. The principal component analysis (PCA) led to a reduction of 17 original variables of each plot into five principal components explaining 79.40 % (Savannah) and 76.83 % (sorghum farm) of total variance. They include S/Ca/CEC/pH, OC/TN/AP, N:P/C:P, Mg:K and Ca:Mg/clay under savannah, and clay/pH/S/CEC, OC/TN/AP, Ca:Mg/K, BS and N:P under cropland. Geostatistically, most vertisol characteristics in the cropland were fitted by a pure nugget effect model, while those under savannah were fitted by a linear model.

Agriculturally, under savannah, clay, characterised by a good spatial distribution and a pure nugget effect variogram constituted the basic fertility parameter. Its value (>35 % in the whole plot) remained above the threshold value necessary for optimum nutrients assimilation by plants. The other favourable agricultural parameters were pH.H2O, OC, TN, AP, exchangeable Ca (ECa), exchangeable Mg (EMg) and exchangeable K (EK). Only TN was below critical level for plant growth. The OC, pH.H2O and AP were either partially a function of position in the plot. The most interesting combinations, above critical limits in the whole plot, were ECa, EMg and EK. However, these elements were not in the cationic balance ratio of 76%Ca:18%Mg:6%K necessary for optimum plant assimilation. The pure nugget effect with regular periodicity of organic matter was attributed to the presence of cracks and/or successive protective vegetation tuffs separating intertuff spaces which are vulnerable to erosion. This observation could be applied to clay in the present study, notably concerning the presence of successive protective vegetation tuffs which might represent points of maximum fertility. Once the plot is subjected to cultivation, most of the fertility parameters (notably OC, TN, AP, ECa, ENa, Ca:Mg and Mg:K ratios) become fitted by a pure nugget effect model. This could be due to regular homogenization of the plot by farming activities. When the values of those parameters were compared with predefined literature values, one notes that nitrogen remained below critical levels, while OC, AP, ECa, Ca:Mg and Mg:K ratios were below or above based on their position in the field. Other interesting parameters in the cropland were clay, pH.H2O, EK CEC and EMg.

Overall, although under cultivation, the vertisols remain fertile with a better distribution of fertility parameters compared to those under savannah; though, their general fertility level appears lower.

Keywords：*Smectite, statistical analyses, kriging, vertisol, Benue watershed, North Cameroon, Central Africa.*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Soils Monitoring as an Extension Tool

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The Northern Rivers Catchment Management Authority extends for over 50,000km2 from the Hastings catchment to the Tweed catchment some 500km along the NSW north coast and tablelands to the Queensland border. The area supports a population of over 500,000 including 7500 farmers with the largest enterprises being beef cattle followed by horticulture/intensive farming (macadamias, blueberries & vegetables), sheep producers, sugarcane and dairy farmers

In 2007 the NRCMA as part of implementation of the regions Catchment Action Plan identified a project the Soils Baseline Project to benchmark the regions soils. This was carried out on a catchment or soil landscape basis with stratification of sites best replicating the area or soil landscape, landuse and farm enterprises.

Over the five years of the project 223 farms were sampled and 460 samples collected at 0-10 and 10-20cm using protocols consistent with agreed statewide soil sampling protocols. All sites were GPS recorded with each sampled measured against a control which may have included a remnant vegetation or non farmed site though over 90% of the survey sites were on farms. The remainder were natural bushland. A key aim of the program is to engage farmers, increase knowledge, skills and capacity of farmers to interpret soil sample results and manage their soil sustainably.

Soil characteristics measured included soil physical properties (Bulk Density, Emerson Aggregate test, soil moisture content), chemical (pH, Ec, C, N, P, CEC, Ca, Mg, K, Na & Al) and biological (ground cover, earthworms, root density) attributes. The proforma from the Northern Rivers Soil Health Card developed by SoilCare, a soils based Landcare group was used to record the biological attributes including ground cover percentage, ease of soil penetration, diversity of soil macrolife, root density and plant vigour.

Landholder selection covered a range of landuses and management styles. Landholders choose the sites and were encouraged to select a ‘typical’ site and one which was not doing so well or which they wanted to ‘improve’. Where possible landholders were present and participated in the sampling and soil health interpretation. Following laboratory analysis, landholders received a report comparing their results with other sites. The data was in a format that ensured confidentiality.

Eight seminars were conducted in the major centrally located towns at the conclusion of the annual sampling program. Over 150 landholders (67%) participated in these workshops which gave an an overview of the projects findings together with an opportunity for the landholder to discuss his or her specific farm sample results. Feedback from landholders was very positive. They were initially cautious of the NRCMA and how the site data would be used. Though over 5 years considerable trust has developed among project operators, the NRCMA and landholders.

The NRCMA has sampled four of the seven NRCMA catchments representing some 3% of the Northern Rivers CMA farmers. The raw data has been stored as part of the NSW Soils and Land information system (SALIS) and the data written up as a summarised report is available online which is accessable to all interested stakeholders. It is anticipated that the effective close working relationship developed over the life of the project with the participating farmers will hold us in good stead when sometime in the future we go back to the re-sample the sites. The aim is then to quantify the change in soil health as result of land management practices implemented for the specific farm though offering wider applications to farmers with similar soil and landuse.

Keywords：*Soils Monitoring, Soils sampling, Landholder Engagement,Sustainability*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Modernizing Soil Interpretations for Changing Needs

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The use of soils information to make informed management decisions has been one of the primary justifications for the Soil Survey in the United States since its very beginnings in the early 20th century. In the US, all these assessments of the potential uses, suitabilities and limitations of soils, from agricultural production to engineering properties, have become consolidated under the overarching category of Soil Interpretations.

From the early years of the soil survey through the development of computer databases in the 1970s, soil interpretations were based on written guides that were used by the soil surveyors to develop the interpretation tables contained in soil survey manuscripts published by the National Cooperative Soil Survey (NCSS). Tables contained use and management interpretations by map unit or component. Interpretive results for a tract of land could be determined by cross referencing the hard copy soil map and the interpretive table(s). Examples of common interpretations provided in soils surveys include crop, forage and range suitability groups and use limitations for recreation, building site development, and engineering uses.

Starting in the 1970s, tabular data were transferred from paper forms into a national database. This soils database, now called the National Soil Information System (NASIS), contains measured and estimated soil properties for soils as collected and compiled by the NCSS. Since 2003, the Soil Survey Geographic (SSURGO) database which contains both spatial and associated tabular data has been the source of official soil survey information for the US.

The development of NASIS and SSURGO provided new opportunities for the soil interpretations. The national databases allowed for the development and application of standard interpretive criteria on state, regional and national scales replacing local written guidelines. More sophisticated computer algorithms have further improved the accuracy of interpretations though the use of nested rule sets and the use of diffuse criteria instead of fixed thresholds. There are now approximately 90 national interpretations and several hundred regional and local interpretations.

Technology for distributing soil interpretive information has also changed over time. The current internet-based distribution system called the Web Soil Survey allows the public to identify an area of interest and to view soil maps and interpretive information. Information is available for most areas in the United States and the territories, commonwealths, and island nations served by the USDA-NRCS. Additional internet-based services, including the Soil Data Access website, allow skilled users to obtain certified spatial and tabular soils data, including interpretations, directly from the national repository. The newest method of delivering digital soil and interpretive information is the raster-based gridded Soil Survey Geographic Database (gSSURGO). Its 10m raster

data of soil properties contains the full database available with regular SSURGO data and a selected set of commonly used interpretations aggregated to the mapuint level.

The NCSS continues to identify ways to improve existing products and develop new products. Ongoing activities include improving the consistency of the soils data that underpins interpretations across political boundaries, developing a "minimum data set" of commonly used interpretations to include in SSRUGO and gSSURGO, and working with local cooperators to assess and improve existing interpretations. The NCSS also continues to seek new ways interpret soils and to make that information more easily accessible. As an example, practice specific soil interpretations are being explored to support NRCS conservation planning and practice implementation. Another future focus area is the development of real-time interpretation systems that allow incorporation of site-specific information. We are also exploring potential interpretation systems that will allow users to incorporate other spatially-referenced data sets including climate and landuse, to develop accurate and site-specific interpretive information products. On the distribution side, efforts are underway to look at how interpretive information can be effectively delivered through other avenues including via smart phones and tablets.

By building on its long history and record of success in interpreting soils information to meet user needs and incorporating new ideas and technology, the Soil Science Division, the NRCS and the wide National Cooperative Soil Survey are well position to continue to deliver interpretive information that meets customer needs now and on into the future.

Keywords：*Soil interpretations, United States, National Cooperative Soil Survey*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Circus Method for Modelling Soil Distribution on Hydrothermic Gradients

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New approach named circus method is developed and offered for modelling soil distribution on hydrothermic gradients.

Keywords：*circus method soil distribution modelling hydrothermic gradient*

P3-184

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Soil Classification Using Near Infrared Spectroscopy and Ga-Plsda Procedure

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The soil types were traditionally determined by soil physical and chemical properties, diagnostic horizons and pedogenetic processes. It is laborious and time consuming to classify soils accurately. In recent years, near infrared (NIR) spectroscopy comprehensively characterizes soil physical and chemical properties, which can be used for soil classification alternatively. We present a discriminant analysis and variable selection method that enables the accurate soil classification in northeast China. We sampled 315 farmland soils at 0-10 cm depth in northeast China in fall 2011. There are five counties including Yushu, Dunhua, Gongzhuling, Changtu and Fuxin. Dominant soil types of this area are: Black soil, Albic soil, Chernozem, Brown soil and Cinnamon soil (Chinese Soil Classification System), corresponding to Phaeozems, Albic Luvisols, Chernozems, Haplic Luvisols and Eutric Cambisols according to FAO soil classification system (IUSS Working Group WRB. 2007).

Near infrared diffuse reflectance spectra were obtained from all soil samples (three separate spectra for each sample) in the range of 7500 to 4000 cm 1 with 64 scans and 4 cm 1 resolution. The multivariate statistical method, partial least squares-discriminant analysis (PLSDA, a supervised method), was used in the present study to classify the soils based on the NIR spectra of soil samples. The results showed that the PLSDA yields respectable rates of classification accuracy, especially combined with the genetic algorithm (GA), which was used to identify the spectrum variables that had high contribution to the PLSDA model. The comparison of classification accuracy between the PLSDA model and the GA-PLSDA model showed that GA-PLSDA is far superior to PLSDA. With PLSDA model, the correct rates are 92%, 87%, 89%, 62% and 87% for Albic soil, Brown soil, Chernozem, Cinnamon and Mollisol respectively, while the correct rates for GA-PLSDA model are 92%, 100%, 90%, 80% and 100% for the corresponding soil types. These results implied that the GA variable selection technique can significantly improve the accuracy rate of soil classification using NIR spectroscopy. In addition, the GA-PLSDA method can also be used to interpret the spectral features which are attributed to soil classification. The results suggest that the proposed methodology is a promising alternative for classify soil types. It has the potential to significantly improve soil classification and the understanding of soil forming processes and mechanisms.

Keywords：*soil classification, near infrared spectroscopy, genetic algorithm, partial least squares-discrimina*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Priority Selection Rating of Sampling Density and Interpolation Method for Detecting The Spatial Variability of Soil Organic Carbon

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Soil sampling density and spatial interpolation method have important effects on interpreting the spatial variability of regional soil organic carbon (SOC). However, there are few comparisons of the two factors. This study was conducted in Yujiang County, Jiangxi Province, China, based on254 soil samples collected from the center points of a 2km×2km (D2×2) grid across the whole county, an area (AⅠ) of 927 km2. For comparison129 samples were acquired from the center points of a 1km×1km (D1×1) grids in the central area (AⅡ) spanning 130 km2 within AⅠ, and 139 samples from center points of a 0.5km×0.5km (D0.5×0.5) grid in the central area (AⅢ) spanning 40 km2 within AⅡ. The spatial distributions of SOC within areas AⅠ, AⅡ, and AⅢ areas at their corresponding sampling density were all predicted via the two interpolation methods ordinary kriging (OK) and kriging combined with land use information (LUK). Prediction accuracies from OK and LUK at 3 sampling densities were assessed based on 65 validation samples in the area of AⅢ. The results demonstrate that the correlation coefficients (r) between the measured and predicted values of validation locations obtained from OK (r=0.231, 0.472 and 0.523) and LUK (r=0.632, 0.788 and 0.879) increased with decreased grid size, and the root mean square errors (RMSE) from OK (RMSE=6.77, 5.37, and 5.21 g kg-1) and LUK (RMSE=4.85, 3.42, and 3.01 g kg-1) all decreased with the sampling density increasing from D2×2 to D1×1 and D0.5×0.5. The coefficients (r) were higher and the RMSEs were lower from LUK than those from OK at all sampling densities, respectively. The result that RMSE of LUK at D2×2 was lower than that from OK at D1×1 and even at D0.5×0.5 indicates the LUK method can use fewer soil samples than OK to predict SOC spatial variability at same accuracy. The conclusion that can be inferred from the present study is that when estimating SOC spatial variability in the hilly red soil region of China, an efficient interpolation method should be understood before the study is conducted, and then determines the proper sampling density according to required prediction accuracy and cost.

Keywords：*Soil organic carbon (SOC); spatial interpolation method; sampling density; SOC spatial variability;*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Improving Identification and Description of Horizon Boundaries to Enhance Soil Data Quality

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Soil profile descriptions as recorded in our databases are the raw data for various soil data evaluations. The more explicit rules for the description are, the better the data can be evaluated. While attribute parameters and a set of permissible values are often well defined, one of the central objects of the profile description, the soil horizon, does not receive a straightforward, applicable and clear procedure for identifying its boundaries. Some soil survey field handbooks note as a basic criterion that horizon identification is based on differences of the values of one or several of the attribute parameters defined in their horizon description section. Most description systems not only address simple, clear horizon boundaries, but also transitions and interfingering of various shape. When however to delimit a (further) transitional horizon and when just to describe a diffuse transition, is generally not considered properly.

Hence, in the case of smooth transitions or 'irregular' (not plane-like) boundaries between layers with distinctly deviating properties, the subjective element in soil description increases, because transitions between horizons, how distinct or diffuse they might be, can be described in two ways. First, the (usually) lower horizon boundary can be characterized regarding its shape, distinctness and possibly rough orientation (horizontal or oblique). The less distinct the transition is, or the more two horizon types occur in distinct, well-separated domains in the same depth range, the better a second possibility can be used in the form of combination horizons, often designated using two master horizon symbols. To mark that within the combination horizon two distinct domains with differing properties exist, the master horizon symbols are separated by a special symbol, e.g. by a virgule (e.g. FAO guidelines) or plus character (e.g. German Kartieranleitung). The information recorded for each of the two possibilities is quite different, and for later evaluation often inadequate, including classification purposes. Even if the classification of a phenomenon is done in the field, e.g. albeluvic tonguing is noted for a soil profile, it is only clear that the criteria of the respective diagnostic of WRB were met. It should be a principle in soil data generation that description of phenomena is done (and recorded) before any classification procedure starts.

The problems with current horizon description are:

1. Description of a horizon transition as lower horizon boundary. Shape, distinctness and orientation of the boundary have a clear meaning. Missing is a quantification, e.g. of the area (volume) of tongues penetrating into the horizon below, and, if not noted with the depth information or even confused with the distinctness, the vertical extension of the transition.
2. The combination horizon alternative. Even more inconsistencies occur: neither the horizon-internal boundaries are described regarding distinctness, nor the shape or area share of domains (sometimes, a minimum value of the latter is defined, e.g. 10 %). In contrast, the width of the transition zone as a whole is clearly recorded in the upper and lower boundary depth of the combination horizon. Notwithstanding, the description of horizon boundaries (of the horizon above the combination horizon and of the combination horizon itself) is done, but its meaning becomes fuzzy, as the combination horizon itself represents the transition. The consequence is that even a more detailed horizonation might result in no better and sometimes even less evaluable profile descriptions.

Another source of variability in the profile description is missing rules on minimum thickness of a horizon or maximum thickness of a transition zone between horizons described as (diffuse) horizon boundary. As there are phenomena rated such important that even 1 cm thickness is enough to qualify for a diagnostic horizon (e.g. albic horizon of WRB 2006), it seems unsatisfactory to define a lower boundary for horizon minimum thickness. For the description of a diffuse horizon boundary, no upper limit is given, which is possibly a better handle to improve soil data evaluation.

To overcome the problems mentioned, rules are proposed when which of the two possibilities of horizon boundary description should be used, and which parameters had to be described in any of the two cases. In addition, a way how to record the horizon data in databases in a better evaluable way is outlined.

Keywords：*Soil Description, Soil Data Evaluation, Soil Horizon, Data Quality*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Spatial Behavior of Soil Properties on Different Tillage Management (Case Study; A Semiarid Region, Iran)

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The heterogeneity and variation of soil properties should be monitored for a better understanding of the influencing factors such as management. The aim of the current study was to investigate the spatial variability of some soil properties in adjacent lands with different tillage type. Soil sampling was performed linearly along contour line from the middle position of slope with 5 m intervals. In overall, 45 soil samples were collected from a field with conventional up-down tillage and 40 samples from an adjacent filed with contour tillage. Soil samples were analyzed for pH, electrical conductivity, organic matter and calcium carbonate equivalent. The data obtained were analyzed using t test by SPSS. The soil acidity, organic matter and calcium carbonate equivalent of both fields were significantly different, while in term of electrical conductivity they were similar. Spatial analysis of the data was performed by GS+ software for all data set and the data of each field separately. The studied soil properties of the two fields showed different spatial pattern and their semivariograms were modeled differently. These results confirm that random components of spatial variation of soil properties would be detectable in smaller ranges in compare to wide ranges. Accordingly, tillage type is an effective factor influencing random variability and needed to be consider in spatial analysis of soil properties in area consisting of fields with different tillage systems. This kind of spatial analysis could assist the farmers for better soil management.

Keywords：*semi variogram, random component, tillage management, spatial variability*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Sustainable Forestry: The Imperative of Soil Mapping in Forest Resource Inventory, Modelling and Management in Scotland, UK

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Site specific knowledge of soil resources is essential to understanding their potential contribution to silvicultural management. This is particularly important in Scotland, UK, where there is great diversity of climate, geology, landscapes and consequent soil forming-processes within a relatively small area. Here we will present an overview of the soil classification system used and current approaches to gaining more detailed soils information, and how this is incorporated into decision support in silvicultural management. This will be illustrated by a number of case studies.

Scotland forms the northerly part of the landmass of Great Britain, lying at latitude of approximately 55-60 degrees North, with a largely temperate climate influenced by its proximity to the Atlantic Ocean. Scotland's landscape has been radically changed after a long period of human settlement, deforestation and agricultural improvement, which led to a gradual reduction in forest cover to 4% by the end of the 19th Century. Re-establishing woodland cover was identified as a national priority and during the 20th Century, extensive planting took place to create a largely state-owned forest estate, with extensive plantings on upland areas of grassland, dwarf-shrub heath and peatlands, previously managed as extensive grazing for domestic livestock and game species.

A prerequisite in the decision-making process whether to grow trees and if so, what species, are detailed soil surveys. These surveys map the distribution of different soil types, enabling identification of combined site and soil characteristics and their suitability for the desired management objectives. A Forestry Commission soil classification was devised for mapping at 1:10,000 scale, covering 15 main soil groups and soil phases including, Brown earths, Podzols, Ironpan soils, Calcareous soils, Gleys, Peatland soil types (where the organic layer exceeds 45cm), Rankers and Skeletal soils. Soil attributes recorded include soil type, lithology, depth of organic horizons, subsoil texture, stoniness, 'Soil Moisture Regime', 'Soil Nutrient Regime', impedance to tree rooting and the presence/absence of 100 site-diagnostic plant species.

At present, detailed soil mapping is being carried out on areas where the established tree crop is nearing harvest, and also new land acquisitions are mapped before planting. Information is gathered using free survey methods, where the frequency of inspection pits is determined by the variability and predictability of soil patterns. Boundary lines showing the extent of different soil types are mapped onto aerial images. These are digitised directly after geo-rectifying. Soil complex map units of up to three component soil types are used where different soils occur in intimate association and/or in repeating patterns, often related to topographic patterns such as glacially-deposited moundy moraine, or rock-controlled topography.

There is greater awareness by forest managers of the need for detailed soil and site type information to be incorporated into silvicultural management decision support systems (DSS), such as the Forest Research (FR) web based 'Ecological Site Classification' (ESC) v3. Soil data, notably on rootable depth, subsoil texture and soil wetness, are key to the assessment of windthrow or tree snap. By using the FR DSS 'ForestGALES', incorporating these data, the potential tree crop rotation length, can be determined. With potential for greater perturbations in climate, the implications for forest management are of concern. Appropriate resource assessments are essential for objective forest/land management for the future and this will be illustrated by case studies.

The Forestry Commission, UK, uses a specifically designed GIS system 'Forester', which contain many datasets, along with the rules and standards by which they are managed. It is used for evidence-based policy making and to manage the forest estate. ESC, using the soil and site data is a vital and integral part of this GIS system. Soil survey skills in the UK were in danger of being lost, but emphasis on upgrading the resolution of soils data used in forest management has raised awareness, facilitating training and mentoring and overcoming this potential knowledge gap.

Forestry in the UK is focussed on woodlands delivering multiple benefits, notably, increased biodiversity, amenity use, water protection and enhanced landscape quality, as well as timber production. Soil is a key determinant of how these aspirations might be best achieved from our woodlands and the detailed mapping and interpretation of soil resources is an imperative in the management of the nation's forests.

Keywords：*Soil mapping, forest resource inventory, decision-support tools, forest management*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Soil Climate Parameters of Russia: A Cartographic Analysis

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Parameters of soil climate are the particular characteristics of soil water and temperature regimes. They are of crucial importance for sustainable management of soils and for predicting potential soil changes under the impact of global climate change and numerous local factors. For Russia with extensive permafrost zone (about 60% of the country), the importance of changes in parameters of soil climate and, hence, changes in freeze/thaw processes, depth of permafrost, and intensity of cryogenic processes can hardly be overestimated. Though the trends of soil climate generally follow the trends of atmospheric climate, the relationships between them are influenced by many other factors and have yet to be examined more carefully. In this context, the theoretical and practical significance of data on soil climatic parameters is evident.

In Russia, measurements of soil temperature at weather stations have been performed since the end of the 19th century at standard depths of 20, 40, 80, 120, 160, 240, and 320 cm. Sufficiently long records making it possible to calculate the climatic norm (1961-1990) and its recent changes are available for 667 stations. On the initiative of David Gilichinsky, these data, together with other climatic parameters, have been collected and organized into the Soil Temperature Database of Russia. In addition, there are not that numerous and regular, but extremely important data on soil temperature and moisture conditions obtained in the field under natural vegetation conditions, as well as on disturbed sites, croplands, etc.

An attempt of cartographic analysis of these data was made by the authors. A series of small-scale maps of the particular parameters of soil water and temperature regimes were developed and included in the National Soil Atlas of the Russian Federation (2011). Two different approaches were applied. First, we used data from weather stations averaged for 1961–1990 to produce the maps by the simple interpolation method (the inverse distance weighting method was applied). Thus, the maps of the mean annual soil temperature (20 cm), the sum of daily temperatures >10ºC (degree-days), the sum of daily temperatures <0ºC (degree-days), the duration of the periods with temperatures >10 and < 0ºC, and the depth of penetration of temperatures >10 and <0ºC into the soil were developed. Second, we produced analogous and some other maps (mean monthly soil temperatures for the warmest month, mean annual amplitude of soil temperatures, and the maps of parameters of soil water regime (sources of soil moisture, hydrological regime of soils, soil moisture status, character of soil water discharge, and character of soil water migration)) on the basis of available information on soil temperature and water regimes measured directly in the field with due account for the local soil, vegetation, relief, and other factors that affect soil temperature and moisture. In this case, the parameters of soil climate measured at weather stations were corrected for the set of local (regional) environmental conditions. Special attention was paid to the soil texture, the presence and thickness of the litter horizon, the soil moisture status, canopy density and characteristics (deciduous and evergreen species), snow accumulation, insolation, etc.

In the report, both sets of the maps are presented, and their comparative analysis is given. It is interesting that general patterns of soil temperature parameters on both sets of the maps are in good agreements. However, the particular delineations are different, which reflects the uneven distribution of the stations, on the one hand, and the effect of various local factors that are 'smoothened' during measurements at weather stations, on the other hand. Additional maps illustrating recent changes in the soil temperature parameters in the recent years are also presented.

Keywords：*soil climate, soil climate database, GIS*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Hydrophysical Database for Brazilian Soils: Challenges and Perspectives

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Access to soil hydrological data is vital for hydrologic projects and for supporting decision-making in issues related to the availability of food and water, as well as natural disasters.

Brazil, a country of continental dimensions, has accumulated a significant body of soil information, and holds a prominent position in the studies of tropical soils. In this study, hydrophysical database derived from Brazilian scientific publications is discussed. We developed a metadata describing the methods of determining some soil hydrophysical attributes and also presenting the characteristics of the site where these soil properties were estimated. Statistical analyses were performed to characterize the dataset based on the metadata-based data structure.

Total of 8,725 samples (without considering replicates) had soil moisture retention information associated with physical or chemical properties, such as organic matter content, granulometric fractions, bulk density, particle density and penetration resistance. Total of 63% of the publications present data of moisture retention related to determinations of organic matter (or organic carbon), granulometry and bulk density. The distribution of the samples with water retention information across the Brazilian territory showed that some regions were better represented than others, especially the Southeast and Midwest, where 2,245 and 2,321 samples were obtained, respectively. The North region lacks adequate representation, considering its social and environmental importance to the country. All Brazilian soils classes were represented. Two dominant soil types were Latossolos (FAO Ferrasols) and Argissolos (Acrisols, Lixisols or Alisols, according to FAO). This amount of soil water retention measurements also represented both topsoil and subsoil very well. All texture classes, except those with high silt content, were well characterized.

Total of 1,253 samples with saturated hydraulic conductivity measurements associated with water retention measurements were also found. The study showed that these data could not represent all Brazilian soil classes satisfactorily, neither the Brazilian states, in particular the ones in North and Northeast regions. Surprisingly, little appears to be known about the unsaturated hydraulic conductivity, as only 30 samples were analyzed.

The results analysis suggest that it is possible to develop a hydrophysical database on Brazilian soils that is all-encompassing, representative, with substantial volume of available data, homogeneous with respect to the methods of measuring soil properties and relatively diverse with respect to the physico-chemical properties. Some information on data quality needs to be collected.

The challenge in the development of the Brazilian soil hydrophysical database is to refine a data model that can encompass the wide range of available information and that meets the different kinds of queries of interest to different users in soil sciences. A preliminary structure of the database is in development. Considering the size of the Brazilian territory it would be of interest that the database development should become a joint effort of government agencies, universities and commercial enterprises.

Keywords：*water retention, hydraulic conductivity, tropical soil*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Baselines for Near-Total and Bioavailable Macro and Micronutrients in Topsoils of Continental Portugal

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The concept of low-density/low-cost sampling for geochemical mapping has gained renewed interest over the past two/three decadas. Initially, these programmes were focussed on the obtention of regional baseline information for mineral exploration but the resulting databases soon proved to be multi-purpose basic tools with application to environmental studies, agriculture, geomedicine and many other investigations.
This paper reports results of a low-density geochemical survey (652 sampling sites , 1 sample/135 km2) covering the entire surface of Continental Portugal taking A horizons (topsoils) as sampling media.
The main purpose of the present study was to assess the levels of some macronutrients (Ca, K, Mg and P) and micronutrients (Co, Cu, Fe, Mn, Ni and Zn) in total and available fractions of the Portuguese topsoils, their spatial variability and to evaluate the relationships between total and available fractions.
Standard procedures, as recommended by the International Project 259 'International Geochemical Mapping', for sampling, sample preparation, and analysis were used in order to achieve high quality and consistent data.
The sampling sites were selected to represent “natural” soils, therefore locations obviously affected by pollution (near factories, heavy traffic roads, mines) and arable soils were avoided. Duplicates were taken every 10 sites.
The samples were dried at 35-40ºC. Subsamples were passed through a 180 μm plastic sieve, homogeneized and quartered. Each soil was analyzed for 32 chemical elements for “near total” concentrations (hereafter indicated as total, extraction with an acid mixture 3-2-1 HCl - HNO3 - H2O and analysis by ICP / MS), pH, electrical conductivity and organic matter content. In addition to the total concentrations, in selected samples (about 20 %, representing the major soil types) the available concentrations also were determined. The assay was performed as follows: 1 g of sample was treated with 10 ml of 1M NH3CH3COO and the extract analyzed by ICP / MS.
Basic statistical parameters for the 10 nutrients were calculated and the spatial distribution of these elements was displayed in maps.
Portugal lacks its own regulation to assess soil quality, and at present follows the “Canadian Soil Quality Guidelines for Contaminated Sites” as recommended by the governmental authorities. If these guidelines were applied many areas of Portugal show, for several elements, natural concentrations above the limit values. For example, Ni is above the Canadian guideline (50 mg/kg) in 28 % of soils whilst for Co and Zn only 2% of soils show levels above the guidelines. The bioavailable concentrations are much lower, and were evaluated taking into account the Germany legislation (Protection Law for the pollutant transition soil-plant on agricultural areas with regard to growth impairments of cultivated plants), which uses bioavailable contents. It was found that for Cu and Zn 13% of the soil samples present concentrations above the propose guidelines.
The contents extracted with ammonium acetate in soil samples of mainland Portugal are very variable. The highest percentages of extraction were obtained for Ca (maximum of 88%, median 56%), Mn (maximum of 189%, median 10%) and Mg (maximum of 42%, median 4%) and the lowest were found for K (maximum of 0.2%, median 0.03%) and Fe (maximum of 0.6%, median 0.06%). The highest correlations (Spearman Rank Order Correlations coefficients, $p < 0.01$) between the total and available fractions are obtained for Ca (r=0.91), Mn (r=0.74) and Cu (r=0.68) and there are no correlations between total and available concentrations for Fe and K. The spatial distribution maps of the concentrations of these nutrients (total and available contents) confirm this evidence showing different patterns of distribution.
In conclusion, it was found that while the soils generally contain adequate amounts of nutrients, some areas with excess or deficiency are clearly seen in the maps and can be related to lithology and anthropic practices. Further work should include more elements and the determination of the available fraction for all samples in order to produce a Soil Nutrient Map of Portugal.

Keywords：*Nutrients, Soil database, Geochemical mapping , Portugal*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Environmental Indicators as a Tool for Improving Soil And Crop Management in Cereal Cropping Systems

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Human use and management of soil and water resources have shaped the development, persistence, decline, and regeneration of human civilizations that are sustained by agriculture. Nowadays, an increasing world population requires more efficient food production systems, and at the same time impacts on the environment have to be reduced. Agricultural sustainable intensification, that is, producing more outputs with more efficient use of all inputs on a durable basis, while reducing environmental damage and building resilience, natural capital and the flow of environmental services, is becoming a specific aim to accomplish demands put on agricultural systems. Technology has to play an important role in achieving this goal. Geographic Information Systems can be a very important tool to provide geo-referenced information to the farmers, for example, soil and cropping characteristics, as well as, climate and weather data. Taking advantage of these possibilities, we are developing in Spain the project sigAGROasesor, supported by the European LIFE+11 program, which aims to develop and refine a series of decision-support tools (DST) for extensive agriculture. These tools will make it possible to create a web platform offering on-line services to farmers, directed at allowing them to work more efficiently, effectively and competitively, yet always in line with environmental and social sustainability. The sigAGROasesor on-line services platform comprises three pillars on which this expert system and decision-support tool are based: 1) the application of the latest GIS technologies in the management of geo-referenced information, to make use of soil variability, climate, crop condition, plant health alerts, and biotic and abiotic risks in the decision-making process, b) the use of web-based DST to systematize the decision-making processes, and 3) the use of Geo-referenced traceability, as a tool to manage the records of the Crop Management Units (CMU). The DST will provide recommendations for extensive crops on the following issues: crop varieties, fertilization, irrigation, and risk of plant disease appearance at the CMU level. The GIS structure will permit a dynamic definition of the CMU, adapting these units to meet the needs of each specific user whilst offering the possibility of incorporating intra-parcel precision farming techniques. The DST will be tested on about 600 demonstration plots in ten different regions in Spain from 2013-2015 in order to validate and calibrate the tools. To achieve this goal, the data for the different variables (location, climate, leaching, etc) will be integrated in layers of information included in a GIS. These maps may either be obtained from existing data or derived from remotely-sensed data. One key aspect of the DST will be the calculation of parcel-related sustainability indicators, which also will be provided to farmers, enabling them to evaluate the environmental, economic and social impacts of the farming practices proposed by the tool. The following environmental indicators have been selected to cover a broad range of agricultural inputs and types of environmental impacts: a) Carbon footprint, b) Water footprint, c) Nitrogen, phosphorous and potassium balances, d) Energy balances, e) Phytosanitary application intensity and ecotoxicity. In this way we cover the main impacts associated to agricultural systems at the same time that we aim to increase crop productivity. Therefore, project indicators have been selected in order to test the successful implementation of the system: water consumption by irrigation (-5%), fertilizer and phytosanitary use (-5%), energy use and GHG emissions (-5%), crop productivity (5%). A general soil quality index has been chosen, soil organic matter content, with the goal of increasing its value at least by 5% through the project lifetime, so we make sure that soil quality is increased by farmers using the sigAGROasesor web platform. In summary, the final expected result is an accessible geoportal for extending traceability and precision agriculture at the level of the crop management unit, with a better use of resources, especially fertilizers, water, phytosanitary products and fossil fuels.

Keywords：*Soil maps, Decision Support Systems, Spatial Information Systems, Agrifood indicators*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Evaluating the Effects of Interpolation Method and Sample Size on Accuracy of Spatial Variability of Soil Variables And Reducing Sampling Cost

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The mapping of the geographic distribution of soil variables is very necessary for precision agriculture. In addition, choosing an optimal interpolation method and suitable sampling density for having accurate evaluation of variables and reducing the errors and the cost of sampling are very important factors in site specific management. In this study we compare the effects of number of soil samples and the interpolation methods for determining the best sample size and interpolation method for estimating of soil variables in unsampled area. So, 9 groups of soil sample size from 10 to 250 were selected from paddy fields of the Somesara which is located in the Guilan province in the north part of Iran. Soil variables (such as soil particles (clay, silt, sand), organic carbon (OC) and soil macronutrients (potassium, phosphorus and nitrogen) were analyzed for each sample. Kriging and Inverse distance weighting (IDW) with powers 1, 2, 3 and 4 were used. Cross validation was used to compare the prediction performance of the two interpolation method. Mean error (ME) and normalized root mean square estimation error (NRMSE) were used to determine the best interpolation method in each group. Comparison of the sample size and the amount of ME and NRMSE for each variable showed that IDW method with power one was the best interpolation method for sample group until 100 and after that Kriging was dominate. Results showed that except of Soil P and N, the amount of NRMSE across sample size decreased from 10 to 100 and after that the trend was constant. For these two variables the trend increased after 100. So, 100 samples would be a threshold. So, there aren't any changes in the accuracy of interpolation by the increasing of the soil samples, but the cost of sampling would be increased.

Keywords：*Spatial Variability-Kriging-Inverce Distance Weighting- ArcGIS-Soil Nutrients-*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Using Gis in Soil Science: A Framework for Use of Digital Spatial Data in Agronomic Studies

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Digital spatial data is an untapped source of environmental data, with much available freely online from various government and scientific organisations. The use of these data sets is being increasingly incorporated into soil science research. There is great potential to advance the depth and completeness of agronomic studies with incorporation of spatial data sets with field based experiments. This paper presents a methodology and framework for the use of spatial data in traditional field experiments through the use of geographical information systems (GIS).

Traditional soil studies focus on a linear experiment design to investigate various research questions. This linear design follows the following process; 1) establish a research design, 2) selection of a study site, 3) selection and sampling of field sites, 4) undertaking laboratory analysis, 5) undertaking statistical analysis, and, 6) evaluation of the results to answer the research questions (this usually includes assessment of the impact of other environmental factors on soils). This linear design is encompassed in the conceptual understanding that soils can be assessed as an independent entity once removed from the environment and that factors that influence the properties of soils are static. This methodology of soil and environmental factor isolation from each other has led to generic repetitive studies observing soil properties as static temporal and spatial points. The potential for a new paradigm in soil research is possible with the shift in use of spatial data in field research.

Spatial data and digital experiments with GIS will never replace field samples and traditional soil knowledge, but the need to establish a new paradigm in soil science is apparent. Soils are known as a factor of their environments in both formation and change. However the notion that soils can be isolated and then explained singularly as products of the environment was previously the only way to research soils. With the availability of software and data more information is available and the true complex nature of soils can be understood in terms of a systematic methodology of soils, where soils are results of environmental factors combined and reacting to each other within and external to the soil matrix.

This new methodology leads to a cyclic experimental design. Following process of; 1) establish research design, 2) investigation into possible study site locations through GIS, 3) establishing possible sample locations with comparison of GIS and on ground information, 4) sample soils, 5) laboratory and statistical analysis, 6) comparison of GIS information with spatial data (and potentially temporal data), 7) evaluation of the GIS information in terms of research questions, 8) evaluation of soil data in terms of research question, and 9) evaluation of GIS and soil data comparison in terms of research question. This framework for cyclic GIS and agronomic soil design also has the potential of eliminating error created with field sampling by eliminating areas of different environmental factor (i.e. geology) that can generate different results.

This new methodology and framework can be used for more traditional soil mapping/field experiments and for more complex analysis of soil properties where different environmental factors are desired. This framework and methodology could be done in the past with detailed knowledge of a study area, however now this detailed information is available on larger scales digitally. This makes access and use of the environmental information easier and possible internationally. The use of GIS data either with the use of the presented methodology and framework or in linear experiment, has the potential to revolutionise soil science and re-establish its importance and dynamic nature in the 21st century.

Keywords：*GIS, framework for agronomic study, digital spatial data*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

The Soils of the Upper Reach of the Heihe River Basin in Relation to Aeolian Dust

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Loess or loess-like mantles are usually formed as a result of aeolian dust deposition on the soil surface. This dust can form a large part of the source material for soil formation, and can even be the dominant parent material controlling pedogenetic processes. The upper reach of the Heihe River Basin is located in the middle section of the Qilian mountain range, which is strongly affected by dust transport from central Asia. To understand the mechanisms of soil formation affected by dust input, we investigated the soils in different landscapes across the whole mountain range, covering alpine cold desert, alpine meadow and grassland, alpine forest and desert grassland on the piedmont. The thickness of dust accumulation was recorded in the field. Particle size distribution, pH value, soil organic carbon content, equivalent amount of calcium carbonate and base saturation of the soils were determined in the laboratory. Silt is the main component of most topsoils in the study area; almost all soils have a peak value around 37 μm in their particle size distribution diagram, confirming its origin as aeolian dust. The deposition depth of fine-grained sediments varies among different soil landscapes. It can reach as much as 200 cm in desert grassland, decreasing with increasing altitude. In alpine forest and grassland 60-100 cm are the observed depths, while for alpine meadow landscape the depths are 15-40 cm. This maybe partly because of the weakened wind strength and partly because of the different abilities of vegetation types in catching the aeolian dust. The carbonate contents in soils are strongly influenced by the dust input. Desert grasslands are carbonate-rich; the carbonate is partially leached and accumulates in the subsurface and the soil types are Haplocalcids and Haplocambids according to Soil Taxonomy. In alpine areas, topsoil carbonate content is low due to stronger leaching, caused by acidic materials produced by plant activity, which increase the dissolution of calcium carbonate. Calcium carbonate films and powder clinging to rock fragments were observed in these soils, which mainly are Haplocryolls and Humicryepts. In alpine cold desert, vegetation coverage is less than 5% and only a small amount of aeolian dust deposition accumulates in the crevices of rock fragments, and the main soils are Lithic Cryorthents and Glacic Haplorthels.

In general, aeolian dust is of great importance in the development of soils in the upper reach of the Heihe River Basin and should be adequately appreciated in understanding these soils. Acknowledgements: This work was supported by the key project of the National Natural Science Foundation (No. 41130530, 913253002). We thank Dr. David G. Rossiter for his comments and help for English check.

Keywords：*aeolian dust; Heihe River Basin; soil types*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Available Micronutrients (ZN, CU, FE, MN and B) Status and their Relationship with Soil Properties in Soils of Krishnarajpet Taluk Mandya District Karnataka, India

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A study of the available micronutrients status in soils of Krishnarajpet taluk Mandya district was carried out at 35 different locations. Study was conducted at Agricultural College, Shimoga, University of Agricultural Sciences, Bangalore. Five surface soil samples were collected from each location and analyzed for phsico-chemical properties and micronutrients status. Mandya district is coming under Southern dry zone (Zone 6) of Karnataka and it is 695m from above mean sea level. This receives an average annual rain fall of 700mm and has an average annual temperature of 32oC.

Results indicated that the clay content in these soils varied from 3.80 to 28.70 per cent and 62 percent of the soils had a sandy loam texture. The soils were acidic to alkaline in nature (4.01-8.47), Electrical conductivity was in the normal range of 0.01 to 0.32 dSm-1 at 25 oC. Organic carbon status ranged from low to medium (0.11 to 0.82 per cent) and CEC of these soils was found to be low and it was in the range of 3.12 to 14.80 cmol(p+) kg-1. The CaCO3 equivalent of the soils was low and it varied from 0.14 to 1.49 per cent.

Available copper ranged from 0.082 to 4.634 mg kg-1. It was observed that available copper showed a positive and significant correlation with organic carbon (r = 0.409**), clay (r= 0.226**) and CaCO3 equivalent (r= 0.196*) of soil. The DPTA extractable Zn ranged from 0.066 to 0.85 mg kg-1 soil. About 85 per cent of the samples were deficient and remaining were sufficient in available zinc and also it had a positive and significant correlation with clay (r= 0.409**), soil organic carbon status (r= 0.678**), pH (r= 0.288**), CEC (r= 0.389**) and CaCO3 equivalent (r= 0.293**) of soil. But, it showed a negative and non significant correlation with electrical conductivity of soils. Available Fe and Mn status were in the range of 1.40 to 87.51 mg kg-1 and 0.124 to 28.44 mg kg-1, respectively. Only about 5 and 8 per cent of the soils were deficient in iron and manganese respectively. Manganese showed a non significant negative correlation with clay, pH, organic carbon and CaCO3 equivalent of soils. Iron exhibited a significant negative correlation with pH (r= -0.379**), clay (r= -0.227**), CEC (r= -0.226**) and CaCO3 equivalent (r= -0.299**) of soils. Further, In respect of available boron status, all soils recorded the values in deficient range (0.007- 0.166 mgkg-1). Boron had a non significant negative correlation with clay and a significant correlation with pH (r= -0.180*) and CaCO3 equivalent of soils (r= -0.190*).

Keywords：*micronutrientss*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Spatial Variability of Electrical Conductivity of Salt-Affected Soils in Northeast Thailand

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The problem of soil salinity represents a major challenge to agriculture and environment in Northeast Thailand. Careful assessment of the status and spatial variation of salt-affected soils is required to implement appropriate control measures and to secure sustainable land uses. Currently, mapping classes of these soils is based on the percentage of salt crusts formed on the soil surface. Scant information is available on the spatial correlation and, in turn, the spatial variability of the electrical conductivity (EC). The objective of this study was to describe the spatial variability of soil electrical conductivity of the saturation extract (EC_e) in areas of different degrees (classes) of salt-affected soils using geostatistics which is an essential tool for this purpose. Attention was on areas of very severely salt-affected soils (class 1), severely salt-affected soils (class 2), and moderately salt-affected soils (class 3). For each class, two study sites were chosen, totally six sites were taken into consideration. Soil samples were collected according to the stratified systematic unaligned sampling method in the dry season of 2012. In each site, a representative area of 50x50 m^2 was selected. This area was divided into 100 equivalent grids of 5x5 m^2. Within each grid, one sample were randomly collected at 0-30 cm depth. Thus, a total of 600 soil samples (100 samples x 6 sites) were analyzed for the EC_e. For the dataset obtained from each study site, geostatistics was applied to elucidate the spatial correlation of EC_e. The semivariogram was created for this purpose. The Ordinary Least Square (OLS) method was applied to fit the semivariogram model. The best-fit model (i.e., spherical or exponential) was determined based on the coefficient of determination (R^2). Corresponding parameters including nugget, range, and sill values obtained from this model were used to describe the spatial correlation. To generate the relevant spatial variability map, these three parameters were employed in the kriging interpolation.The results showed that the salinity levels as indicated by the EC_e values were very strongly saline (EC_e 56.70- 433 dS m^{-1}), normal to very strongly saline (EC_e 0.16- 49.00 dS m^{-1}), and normal to slightly saline (EC_e 0.11- 5.26 dS m^{-1}) for areas of very severely salt-affected soils (class 1), severely salt-affected soils (class 2), and moderately salt-affected soils (class 3), respectively. For every study site, the semivariogram model fitted well with the semivariogram samples (R^2 0.73-0.98). When using the semivariograms to describe the spatial correlation of the EC_e, it was found that the variation was generally high. It varied between classes and within the same class. The range values were 190 and 8 m, 34 and 61, and 170 and 16 m. for both study sites of classes 1, 2, and 3, respectively. The shorter the range, the higher the variation. The nugget effect varied between study sites indicating the uncertainty of the occurrence of the spatial sources of variation. Based on the salinity maps generated using the kriging interpolation, the areas of class 1 were entirely very strongly saline soils (EC > 16 $dS.m^{-1}$). For the areas of class 2, very high variation in salinity levels was found ranging from normal (EC < 2 $dS.m^{-1}$) to very strongly saline soils. In the areas of class 3, the soils varied slightly from normal to very slightly saline (EC > 2-4 $dS.m^{-1}$). The information on spatial variation of EC_e is very important for soil management especially in the areas of class 2, because these areas includes a large variety of salinity levels, ranging from normal to very strongly saline. In areas of classes 1 and 3, this information is less important because in the class 1 areas the soils, even though highly varied, were entirely very strongly saline. No arable crops can be grown on these areas. On the other hand, in the areas of class 3, the soils were generally normal to very slightly saline. There is very slightly effect on crop growth especially in the growing (rainy) season.

Keywords：*geostatistics, electrical conductivity, salt-affected soils, semivariogram, spatial variability*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

The Spatial Variability of Soil Heavy Metals in Xinji County, North China Plain

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Assessment of farmland quality requires a knowledge of the spatial patterns of some soil heavy metals. The soil heavy metal concentrations is a typical regionalized variable. A case study in North China Plain on spatial variability of soil heavy metals (Cu, Zn, Cr, Ni, Pb, Cd, Hg and As) was conducted using geostatistics in order to find out a local scale variability.100 soil samples were collected from the Xinji County in the region. The semi-variogram that is a basic tool in geostatistics can be employed to measure the spatial variability of the variable, and provides the input parameters for the spatial interpolation of kriging. The results showed that The semi-variograms of soil heavy metal concentrations were fitted to the spherical model respectively, and their correlation distance with different spatial dependence ranged from 5.616 km to 15.944 km. The As, Pb, Zn had the larger range near15 km, which indicated they were correlated and depended on the soil parent material. The Cu, Hg, Cd had a smaller range near 5 km, which implies that the length of the spatial autocorrelation is much longer than the sampling interval of 1.5 km. The C0/(C+C0) ratio can be regarded as a criterion to classify the spatial dependence of soil attribute. Usually, strong spatial dependence of the attribute can result in the intrinsic factors (soil formation), and weak spatial dependence in the extrinsic factors (soil management practices) (Cambardella et al., 1994; Shi et al., 2006). The C0/(C+C0) ratio of seven heavy metals between 25% and 75%, have moderate spatial dependence. The ratio of Cr is near 88%, which indicated a strong random variance at short distance.

Keywords：*soil; heavy metal; spatial variability; geostatistics, North China Plain*

P3-199

[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Web Tools for Soil Data Interpretation for Urban Planning and Management

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Soil is a non-renewable natural resource which performs essential environmental functions in rural and urban terrestrial ecosystems. For the effective management of urban ecosystem services, rational urban planning and sustainable urban development good soil information is essential. In practice, we are generally facing a lack of quality soil information especially in urban and suburban areas. When available however, these are very difficult to adequately interpret especially as they are used by non-soil experts - city administrations and planners. Focused and interpreted soil information such as soil quality, contamination, soil suitability should be available within effective and end-user oriented web-based systems, which would also provide user friendly evaluation and risk assessment tools.

EU INTERREG Central Urban Soil Management Systems project (Urban SMS), joined the municipalities from eight Central European cities and several research institutions. Main project goals were to set strategies for soil protection and to develop and test a web based computer system for an effective urban soil/environmental management within which, spatial soil information would be adequately structured and interpreted and used by non-experts as predefined soil evaluation tools. Each partner city has its unique quality and quantity of the soil resource, size, structure, data availability and quality as well as national/local legislation. In order to allow full adaptability according to city's uniqueness, the maximum possible flexibility of the system was essential.

This contribution gives an overview of the Urban SMS web system and the main project's outcome - a Web GIS based Urban SMS portal. Portal serves for planers and administrators to consult the spatial information (maps) and run pre-defined algorithms (tools). The web system is composed of Admin and User GIS pages. The Admin page is used by system administrators and soil experts to predefine input data sets, design / adapt soil evaluation algorithms, enter national / regional threshold values and edit the report outline with planning and management instructions or suggestions. Measured soil data and maps are interpreted by soil experts to relative input datasets. On the User GIS web page end user can view soil and any other preload municipality spatial information, query datasets on soil quality and land suitability and, the most important, to perform predefined analyses on selected polygons (i.e. planning areas). Analyses are performed by running individual tools. The result of the evaluation is a report which is summarising the important information which can be used for more effective planning and soil management decisions such as soil quality, suitability, size and area.

Eight soil related tools are available to the user: Loss of Soil Resource to assist the planning decisions and to protect best quality soils; Ecosystem Soil Quality to assess the environmental importance/value of soils; Sealing Rate to evaluate the importance/value of green areas in urban environment; Water Drainage to estimate the soil infiltration rate and potential water logging; Agricultural Soil Quality to address preservation of best quality agricultural soils; Connectivity to evaluate the relationship between objects and their distance to green areas and finally the Proximity tool to assist the assessment of spatial and economic impacts of urban green areas on surrounding parcels.

The system incorporates the urban planning strategy also set within the project and supports contemporary good practice guidelines for sustainable use of soil resources.

Keywords：*urban soil, soil protection, planning, web tools, soil information system*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

A Web-Based Spatial Decision Supporting System (s-Dss) for Landscape Sustainable Management: The Life+ Soilconsweb Project

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The multiple functions of soils are under increasing threat from a wide range of human activities. These threats are often complex and typically inter linked. The EU Soil Thematic Strategy considers as threats of major concern: erosion, decline in organic matter, soil sealing, soil compaction, decline in soil biodiversity and landslides. The complexity of these threats require a new way of thinking and acting on the territoryfor the managements of agricultural and environmental resources.
In this context our contribution aims to refer on some findings of the SOILCONSWEB (EU LIFE+) project which deals with a web based spatial decision support system embedding spatial and soil-plant-atmosphere modeling procedures, digital soil mapping engines and spatial data management processes;The primary aim of the project is to develop, to test and to apply a Web Based-Spatial Decision Supporting System (WB-SDSS) to support (stakeholders) decisions on landscape issues aiming at both the best soil conservation/land management and an easy landscape implementation of some important environmental EU directives and regulations. Decision makers (individuals, groups of interests and public bodies) through the system can have real-time (or near real-time) access to critical, accurate, complete and up-to-date spatial data held in multiple data stores. The SOILCONSWEB system is data-driven: the entire process feeds off the collection and availability of data to analyze. The system is a server-side Web: it requires only a browser installed on the client machine to carry out the system tasks.The SDSS has been developed, tested and applied in an area of about 20,000 hectares in South Italy (Valle Telesina, Campania region) but its development will enable future applications in other areas;
In order to deal the issue ofphysical processes involved in the dynamics of soil/landscape ecosystem, we present here a SOILCONSWEB tool specially designed for the estimate of the loss of soil ecosystem services related to new urbanization. The tool is GIS and dynamic-modeling based. It implements boththecalibrated Swapmodel(van Dam et al., 1997) for the simulation ofsoilwater flows, and GISfunctionalitiesto estimateon the flysome distributed landscape variables at different spatial scales. When activated in a user-specified areathis tool runs the Swap model using as input data high quality (measured)soil physical parameterand spatialized climate data. Are also available simulation of future climate data to estimate the impacts in a future climate change scenario. Simultaneously the tool applies some GIS functionalities within the area of interest, in order to query the DSS spatial database and to produce statistics of some soil-landscape parameters. The tool called "Simulates the effects of a new urbanization", returns as output the effects on soil services of a potential new urbanization from detailed to large scale. These effects are accounted by the loss of i) soil hydrological functions (water table recharge capacity and soil water content capacity); ii) potential wheat production; iii) potential food supply; iv) soil organic matter; v) landscape biodiversity;

Keywords：*Spatial Decision Support System, Hydrological Modeling, Soil Functions, Ecosystem Services;*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Spatiotemporal Changes in Farmland Flooding and Soil Series Distribution Characteristics in Korea

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Recently, meteorological disaster due to heavy-rainfall, -snow, and drought has been increasing caused by climate change. This study was research about spatiotemporal change of farmland inundation in order to provide farmland inundation mitigation and agricultural production infra improvement. Farmland inundation area data provided by National Emergency Management Agency were classified with time series and administrative district from 1986 to 2010. A trace map of inundation provided by Korea Cadastral Survey Corporation were included inundation-duration, -depth and -area, and compare attribute data of trace map of inundation with soil series and soil water retention capacity. ArcGIS has been used for all data processing. Average farmland area classified by administrative district has decreased about 20%(decreased by 13,067ha(1986) to 10,523ha(2010)) and although annual deviation of average farmland inundation area has been greater than average farmland area, it has continuously decreased by 752ha(1986) to 387ha(2010). Also, south and west coast area was the largest area in farmland inundation area, such as Gyeongsangnam-do(Gimhae, Miryang, Sacheon, Uiryeong, Jinju, Changnyeong, Haman), Jeollanam-do(Goheung, Naju, Yeonggwang, Yeongam, Hampyeong, Haenam), Jeollabuk-do(Gochang, Gimje, Buan, Iksan, Jeongeup) and Gyeonggi-do(Gimpo, Yeoju, Paju, Pyeongtaek, Hwaseong) the last 10 years and 25 years. Area of first quartile group(the top 25% of inundated farmland area) has accounted for 66~75% of the total area. The top 20% of total soil series has accounted for more than 80% of the total area of farmland inundation. Soil series of typical fluvio-marine deposit such as MANGYEONG, JEONBUG and GIMJE were distributed. Although the whole farmland inundation area had been decreased by water-based flood control project in the past, vulnerable farmland to flood has been occurring continuously from the past. Soil type of vulnerable farmland to flooding showed the characteristics of the typical fluvio-marine deposit. As results, farmland inundation has been required to analysis by inundation cause and vulnerability.

Keywords：*Spatiotemporal change, farmland flooding, GIS*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Historical Development and Utilization of Forest Soil Information in Korea

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Korea's forests cover nearly 64 percent of its land area today, but 40 to 50 years ago there was very little forested area. The conservation and recovery of deteriorated forest soils have been contributed to the rapid and successful forest rehabilitation. Thus, we summarized the modern-historical process of the production of forest soil information and its utilization in Korea. Korean forest soil survey has officially started since 1962. At that time, in order to create forests for erosion control and woody fuel production, simplified forest soil maps were produced by investigating the site and soil information to national forests from 1974 to 1976, which was the first soil map. It provided useful information about the potential productivity of forest soil by classifying its into 5 grades. Since then, the national forest soil investigation continued and the national digitalized forest soil maps of the scale of 1:25,000 was completed by 2003. Forest soil map was produced according to the classification system of Korean forest soil (8 forest soil groups, 11 forest soil sub-groups, 28 forest soil types) by using geomorphic element analysis method. Although the forest soil map was represented as forest soil types, various soil-related information such as slope, climate zone, erosion degree, soil depth and soil texture from field survey became a database. These kinds of Korean forest soil information have been utilizing not only in the filed of soil classification, but also in a lot of forest fields such as forecasting landslide occurrence, forest land use classification, building economic forest complex and selection of suitable tree species for afforestation. Furthermore, they are also used as items for the assessment of environmental effects which judge whether forest development is possible or not in the process of establishing the urban master plan. Especially, it has been recently utilized to make a digital map and quantify the carbon stocks in forest soils relating to national forest carbon inventory for POST 2015 in Korea. Furthermore, the integrated forest soil information has been carrying out public service which be provided with other information such as tree species, land use and so forth, just by clicking once through web system.

Keywords：*Forest soil, Soil survery, Mapping, Web service*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Soil Data, Information System and its Interpretation in Korea

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Soil survey and information is of great importance for the use and conservation of soil resources that are essential for human welfare and ecosystem sustainability. This paper introduces soil survey and soil inventory of Korea focusing on national soil database, soil and environment information system, and the use of soil database for natural resources management focusing on agricultural fields. Various scales of soil maps and soil testing data were established through a series of intensive National Soil Survey Projects and Soil Testing Projects conducted by Rural Development Administration (RDA) since early 1960s. An internet-based information system for soil and environment (http://soil.rda.go.kr) was developed on the basis of 'National Soil Survey Projects' and 'Agro-environmental Change Monitoring Project', which monitors spatial and temporal changes of agricultural environment. The system provides soil properties about crop suitability, soil characteristics, and fertilizer recommend. Soil attributes showed graphically in the digital maps are 111 properties which are crop suitability, soil texture (family), gravel content, drainage class, available soil depth, slope, topography, parent material, land use at the time of soil survey, soil suitability group for paddy, upland, and orchard, as well as soil classification regimes, etc. Each soil property can be provided in a form of map, showing its spatial distribution with statistics such as sum and average of the attributes. Soil and environment information system of Korea also provides web-based fertilizer prescription program for extension people to recommend the amount, type, and the timing of fertilizer application for optimum plant growth by diagnosis of soil nutrition in the crop land. Soil information is applied to map soil functional properties, soil carbon storage and available water capacity which are important for land management, plant production and ecosystem management. Mean value of carbon density of Korea is approximately 5 kg/m2 and available water capacity is approximately 154 mm. Total soil carbon storage of agricultural land in Korea is approximately 174 Gg. Soil carbon storage and available water capacity can also be mapped as a function of depth using the equal-are spline depth function.

Keywords：*Soil database, information system, digital soil mapping, GIS, Korea*

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[C1.2-2] Soil Data, Spatial information Systems and Interpretation Procedures

Using Remote Sensing and Spatial Modeling Approaches for Land Evaluation in Dry Wadis, Eastern Desert, Egypt

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Wadi Al Assiuti is one of the most promising areas, developmental areas in Egypt, which is located at the east of Nile river - south Part of Asyut Governorates. It is bounded by longitudes 31° 13′ 42' - 31° 40′ 12' E and latitudes 27° 01′ 35' - 27° 26′ 45' N. The application of a Spatial Multi-Criteria Evaluation (SMCE) approach to identify the most suitable areas for the production of maize, cotton, alfalfa, wheat, potato, tomato, Guava and mango crops. Climate, relief, soil databases as well as specific criteria of the selected crops was integrated using GIS raster coverage's.. This information was used to obtain the criteria maps, which in turn were used as input into the MCE algorithm. Several decision support procedures in the ILWIS software were applied to obtain the suitability maps for each crop.Advanced tools such as remote sensing (R.S.), Geographic Information System (GIS) and digital elevation model (DEM) were used to produce geomorphology, soil and capability maps. Fourteen geomorphic units were recognized,i.e. Decantation basin, overflow basin, high recent river terraces, low recent river terraces, alluvial fans, levee, out wash plain, rubble terraces, wade bottom, wade plain, wadies, hills, plateau, and island. Using US Soil Taxonomy in 2010, two soil orders were identified- Entisols and Aridisols which it's been represented by five great groups Typic Toriorthents, Vertic Haplargids Vertic Haplocalcids Typic Haplocalcids and Lithic Haplocalcids. Five soil capability classes were recognized in the studied area C2, C3, C4, C5 and C6.

Keywords：*Spatial Multi-Criteria Evaluation, Remote Sensing, GIS, Land Evaluation, Wadi El Assyouty Egypt*

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[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Properties, Genesis, Classification and Sustainable Management of Soils from Ijebu East, South Western Nigeria

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Soils derived from some parent materials in Southwestern Nigeria covering 219,580 hectares of land were mapped at a scale of 1:50,000 using a combination of conventional and remote sensing methods of soil survey. Seven soil series were identified and classified (Kulto series-Typic Paleudalf; Ibeshe series-Typic Rhodudalf; Idesan Series-Fluventic Eutrudept, Iweke Series Typic Udipsamment; Alagba Series Typic Hapludalf; Ondo Series Typic Ferrudalf and Fagbo Series Typic Plinthudult). All the soils are well drained except Idesan Series which was poorly drained. The soils have Dark brown/Dark Reddish or yellowish brown or Black (10YR4/2, 5YR3/3, 10YR4/4 and 10YR2/1, dry) with Loamy Sand/Sandy loam texture on top coming down to Sandy Clay loam/ Sandy clay yellowish Red/Red/Dark yellowish brown/Dark reddish brown Subsoil (5YR5/8, 10R4/6, 10YR4/4, 5YR3/3). Soils of the Ondo and Fagbo Series contain a lot of Iron, Manganese concretions, quartz stones and gravels. The Soils are very Strongly acidic (4.50) to Moderately acidic (5.70). The Soils have moderately low inherent natural fertility with low exchange basic cations, Organic carbon, Cation exchange capacity, total nitrogen but moderate to high micronutrients (Cu, Fe, Mn and Zn). Soils of the sedimentary origin (Alagba, Iweke, Idesan, Kulto, Ibeshe) were observed to be more fertile and more variable in Soil properties than those derived from the basement complex (Ondo and Fagbo Series). Dominant pedogenic processes which influence the rate of soil development within the study area include hydrolytic weathering, lessivation, plinthization, pedoturbation, braunification, induration, leaching, erosion and colluvial deposition. The Soils were classified into Land capability classes. Only Four (I, II, III and IV) out of the eight capability classes were encountered. Recommendations for the sustainable use of these soils are discussed.

Keywords：*Properties, Genesis, Classification,Sustainable management, Southwestern Nigeria.*

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[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

World Soil Classification, The Systems Approach, And Multiscale Gis Mapping

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Applying the systems approach and GIS technologies for providing a framework for soil classification is discussed.
According to the systems approach, soils can be considered in two ways: as self-sufficient systems consisting of genetically interrelated horizons, and as derived elements of systems of higher order - natural landscapes-systems (referred to below as 'landscapes') which are minimal structural units of the earth's landscape envelope. Soils come into existence through the interaction of the basic landscape elements - rocks, air, waters, and organisms. This is an essential character trait of soils. All landscape elements are material substances with homogeneous properties. There are landscapes with and without soils. Soil-free landscapes are formed in cases when properties of one or more basic landscape elements prevent soil forming processes. In our view, consideration of soils as derived elements of natural landscapes has paramount importance for their classification.
It is known that soil classification and mapping, primarily small-scale one, are closely interdependent. Soil mapping is the process of classifying soils. Soil classifications serve as a basis for legends of soil maps, at the same time they draw on and are corrected in accordance with the results of soil mapping. Adequate choice of soil classification criteria is possible only in the process of mapping. Therefore soil classification and mapping are inseparable and must be carried out simultaneously in a single process. This is especially the case for global multiscale soil mapping for the purposes of world soil classification.
We have begun to test the systems approach to a world soil classification using traditional compilation method at first stage and GIS technologies on the next one. The territory of the European Russia (excluding mountains), the Saratov region (RF), and some of municipal districts and farm units of the Saratov region were chosen as pilot areas. Scales of geographical base maps are, and are to be, 1:7,500,000, 1:2,500,000, 1:500,000, 1:100,000, and 1:10,000. Then as far as possible mapping at scales of 1:20,000,000 and 1:5,000 or smaller/larger will be initiated. In the process of the research maximum possible quantity of available thematic and geographical maps (such as geological, Quaternary sediments, geomorphological, agroclimatic, landscape, soil, hypsographical, topographical, and maps of vegetation), text, and remotely sensed data sources are used.
Criteria of a suggested world soil classification based on the systems approach are separate or conditional basic landscape element properties which are directly responsible for the fundamental and conservative soil properties. Initial level of the classification is represented by the earth's landscape envelope - a set of natural landscapes with and without soils. In the process of the classification all landscapes and, accordingly, soils are gradually divided into subdivisions of different hierarchical levels and branches of the classification tree unless reaching separate (individual) landscapes and soils with homogeneous properties. An illustrative list of possible criteria to be used at the higher levels of the classification system is the following: a vertical combination of landscape elements (according to this criterion landscapes and soils are divided into terrain and water bottom ones); type of megarelief - range of altitudes and slopes (the criterion allows to divide landscapes and soils into plain and mountain ones); location on the leeward or windward side of piedmonts; zonal vegetation in connection with macroclimate - effective heat sum and precipitation ratio; presence/absence of seasonal flooding from a river; forms and genetic types of macrorelief in connection with geological structure; genesis, lithology and texture of parent rocks; chemistry and salinity of ground water. Hierarchy of criteria and criteria themselves can vary for separate branches of the classification tree. The process of delineation of landscapes with soils is controlled using information on spatial distribution of soils and their properties.
Mapping units in GIS are labeled by unit identification codes which serve as connecting links between them and the classification. For ease of use, the classification is created as interactive.
From the result of the research, the following two main conclusions can be drawn: (1) the systems approach gives directions for the construction of supra-national world soil classification as a part of a world landscape classification; (2) the construction of world soil classification based on the systems approach is possible only in the process of multiscale GIS soil-landscape mapping.

Keywords：*world soil classification, the systems approach, landscapes-systems, soils as landscape elements, world soil-landscape classification, multiscale GIS mapping*

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[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Classification of Maritime Burozems of the Souther Far East of Russia

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Recent years have brought significant changes to the regional classification of soils in the southern Far East of Russia (SFER). It has been discovered that anthropogenic transformation of coniferous-broadleaved forests is the determining factor of burozem formation in the maritime-insular zone of the Japanese Sea. The transformation intensifies geochemical effect of the Pacific Ocean on the burozems, thus altering burozem alkali-acid ratio and sharply increasing magnesium ions in exchangeable cations. Consequently, humus mobility grows throughout burozem profile, humus accumulation intensifies, and elementary pedogenic processes (EPP) of humus eluviation and humus illuviation begin. Different combination of these EPP with those, characteristic of typical burozems, causes morphogenetic diversity of the maritime burozems and provides a basis for a detailed burozem classification at type and subtype levels. We propose that the territorial burozems be divided into two types - burozems and dark burozems.

In burozems we distinguish subtypes of typical burozems and cinnamon-brown humus-illuvial burozems, and in dark burozems we recognize subtypes of dark typical burozems and dark humus-illuvial burozems. Typical burozems develop under broadleaved and coniferous-broadleaved forests. Profile O-AY-BM-C results from combined humus accumulation and claying EPP. The humus has humate-fulvate composition (Ch/Cf - 0.7-0.8), and profile distribution of the humus has accumulative character. Cinnamon-brown humus-illuvial burozems develop under thin oak forests. Just as typical burozems, the burozems in question have humate-fulvate composition of humus (Ch/Cf - 0.7-0.8), but the humus has far greater mobility in the upper part of a profile, with active illuviation of fulvic acids, especially their aggressive fraction, into the middle of a profile. The resultant EPP imposition - humus eluviation imposes on humus accumulation, and humus illuviation overlaps claying - forms the peculiar profile of the burozems (O-AY-BMH-C). Dark typical burozems develop under very thin grass-shrub oak forests. Profile O-AU-BM-C has a characteristic combination of dark humus and structural-metamorphic horizons. The burozem morphogenetic features are greatly predetermined by fulvate-humate composition of humus (Ch/Cf - 1.1-1.2) and by accumulative character of the humus profile distribution. Dark humus-illuvial burozems develop under steppe grass-shrub thickets. The burozems are characterized by greater humus mobility and by high levels of humic acids (Ch/Cf - 1.2-1.7). Consequently, profile O-AU-BMH-C has a strong (up to 40-50cm) structural-metamorphic-humus-illuvial horizon, coloured dark-grey or grey. The horizon is rich in humus (4-8%), with high levels of black humic acid fractions and their derivatives with fulvic acids.

Furthermore, we have determined that in SFER burozem types should include not only burozems and dark burozems, but relict burozems too.

Relict burozems comprise subtypes of relict profile burozems and polyrelict profile burozems. The first subtype has one upper (modern) elementary soil profile (ESP) and one relict (buried) ESP, while the second subtype has one upper (modern) ESP and

several relict (buried) ESP. In relict profile burozems, the buried ESP formed on eluvium-deluvium of dense rock, and the modern ESP formed on erosion-solifluction deposit of the buried burozem soil mass. The buried ESP formed in the second half of the Little Ice Age, and the modern ESP formed somewhat later, in climatic conditions similar to present-day ones. This contributed to considerable similarity of physical-chemical properties of the upper modern and the relict buried ESP.

Our research also indicates that we can reasonably distinguish one more burozem type - yellow-brown burozems, characteristic of SFER southernmost area. By structure and properties this soil type resembles zheltozems greatly. Yellow-brown burozems develop under cedar-broadleaved forests and are characterized by a humus horizon (8-12cm), sharply transiting into a mineral horizon of bright yellow-brown colour. The burozems are supposedly polygenetic, and their properties are much determined by relict yellow residue on which they develop. We have received data on profile dynamics of spore-pollen spectrum composition and reconstructed paleovegetation and climatic conditions which existed when each genetic horizon of the burozems developed. The data prove our assumptions regarding the nature of peculiar morphological structure, properties, genesis, and classification of yellow-brown burozems of SFER.

Keywords：*classification, burozem, Pacific Ocean, geochemical influence, anthropogenic transformation, vegetation, humus, accumulation, eluviation, illuviation, morphological structure, properties, relict residue*

P3-208

[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Correlation of Gley Soils Classified According to the Croatian Soil Classification with the Wrb

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In the past several years, additional soil research was conducted in Croatia with the aim of developing the correlation relationships between the Gleys soil class of Croatian Soil Classification (CSC) and the World Reference Base for Soil Resources (WRB) classification system. This paper presents the results of these studies and indicates the perceived problems and shortcomings, based on which the appropriate amendments to existing qualifiers in the WRB list are proposed. According to the CSC, the class of Gleys includes three types of soil: Eugley, Humogley and Pseudogley-gley. Most Eugleys and Humogleys may be correlated with the reference soil groups of Gleysols, and pseudogley-gleys with Stagnosols. However, based on the criteria used for separating Eugleys into subtypes, varieties and forms according to CSC, it is not possible to perform a complete correlation with the WRB, i.e. to determine all prefix and suffix qualifiers that can occur in each systematic unit. The reason is that the number of soil characteristics presented within the WRB qualifiers list for Gleysols or Stagnosols are not used as criteria for the separation of systematic soil units in CSC. It is therefore necessary to correlate each lower systematic unit of Eugleys with the WRB separately, taking into consideration all soil features. Considering the fact that gley soils in Croatia may be excessively moistened also by surface water, and not just groundwater, it is proposed to introduce the prefix qualifier Epistagnic into the WRB qualifiers list for Gleysols and to modify the Gleysols prerequisite of a layer 25 cm or more thick within 50 cm of the mineral soil surface, that has a gleyic pattern throughout the soil volume, so that a gleyic color pattern would be present in half or more of the soil volume, as was the case in the WRB (2006) Key to the reference soil groups, before its modification in 2007.

Keywords：*Croatian Soil Classification, WRB, Gleysols, Stagnosols*

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[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Problems of Nomenclature Correlation and Soil Classification in Amur River Basin

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Amur River basin (ARB) occupies adjacent territories of three neighbouring countries – Russia, China, and Mongolia which makes studying the territorial soil cover rather difficult. Presently, a need grows for generating the "Dominant Soils" geoinformation layer (digital coverage (DC)) for the entire basin. The DC supplies information on soil distribution patterns in the territorial soil cover and makes the base for the general-purpose soil map of ARB (Ermoshin, Pshenichnikova, 2008).

The "Dominant Soils" DC for ARB is based on the soil maps of Russia, China, and Mongolia, generated by different soil science schools: the Soil Map of the Russian Soviet Federative Socialist Republic (RSFSR), 1:2.5 M (1988); the Soil Map of the Mongolian People's Republic, 1:2.5 M (1984); and the "Soils of the Northeastern China" DC. Additional sources include small-scale soil maps (Kovda, 1959; Kovda, Lobova, 1971, 1975; The Soil Atlas of China, 1986), monographs (Targulyan, Gerasimova, 2007; Krasilnikov, 1999; Soil Cover and Soils of Mongolia, 1984; Rozov, Strogonova, 1979; Roslikova, 2006), and papers (Andronikova, Rudneva, 1993; Gerasimova, 2004; Lebedeva et al., 2008; Liverovsky, Rubtsova, 1962; Stolbovoy, Sheremet, 1995, 2000).

Making the legend to the "Dominant Soils" DC, we take into consideration the difference between national soil classifications and nomenclatures of the source soil maps and try to fully retain the information from the source soil maps.

For the Russian and the Mongolian parts of ARB the source map information on soil mapping polygons is added directly to the database. The information of the "Soils of the Northeastern China" DC undergoes multistage generalization with regard to the specific character of the territory (Ermoshin, Pshenichnikova, 2009).

The legend to the Soil Map of the RSFSR (1988) has soil names of two nomenclatures – the one (1977) in use when the map was generated and the previous one (Ivanova, Rozov, 1967). The legend also has some newly adopted soil names, either fully retained in later soil classifications of Russia (Shishov et al., 1997, 2004) or provided with partial correspondences. To avoid terminological difficulties, we use soil names of the Soil Map of the RSFSR (Fridland, 1988) in "Soil Name" column of our DC legend.

The soil names for the Mongolian part of ARB generally coincide with those in the legend to the Soil Map of the RSFSR. However, the legend to the Soil Map of the Mongolian People's Republic also has outdated soil names, omitted in later soil nomenclatures. In order to avoid terminological discrepancy, we stick to the original nomenclature of the source soil map of Mongolia.

The soil names for the Chinese part of ARB are not uniform. Many soils, listed in the "Soils of the Northeastern China" DC legend, have complete analogues in Russian soil classifications, and such soil names are retained in our DC legend (e.g. Chernozems, Chestnuts). Some soils in the Chinese soil classification (Chinese Soil Taxonomic Classification, 1994) do not fully correspond to Russian ones, but they have possible correlates among soils of Russia. In the legend to the "Dominant Soils" DC for ARB, the names of such soils are substituted by those, adopted for their Russian correlates. The original Chinese soil names are given in parentheses (e.g. Brownzems (Brown earths)). In a few cases the soil names in the source map legend are traditional Chinese ones. Such soils are correlated to the soils, listed in the Chinese soil classification, and their possible correlates are found in the Russian soil classification. In the legend to the "Dominant Soils" DC for ARB, the names of such soils are substituted by those, adopted for their correlates in Russia. The official and the traditional Chinese soil names are also provided (e.g. Chernozem-likes (Black earth, chetu)).

The soil nomenclature of the "Dominant Soils" DC for ARB is correlated to the soil nomenclature of the World Reference Base for Soil Resources (WRB) on the base of literary data (Targulyan, Gerasimova, 2008) and electronic resources (Stolbovoy et al., 2002). The resultant soil nomenclature of the "Dominant Soils" DC for ARB reflects soil nomenclatures, adopted in Russia, Mongolia, and China, and WRB soil name correlates.

Keywords：*soil, classification, correlation, Amur River basin*

P3-210

[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Suggestion for Modification of the Setting of Salt Affected Soils in the New Wrb Classification Key

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Soils may satisfy the criteria of one or more taxa on the first or lower levels of classification as well, thus priority should be given to the one that is believed / proved to be more important in determining soil functions or limiting ecological services.

Salt affected soils in WRB are classified as Solonetz or Solonchak Reference Soil Groups. Solonetz soils are characterized by high content of exchangeable sodium and/or magnesium content that can restrict soil fertility either directly by Na-toxicity, or indirectly by high pH, peptization, and deterioration of soil physical properties as structure and water management. In modern soil classification systems Solonetz soils are defined based on the presence of a natric horizon with criteria of texture, evidence of clay illuviation, structure, exchangeable Na percentage and thickness.

Solonchak soils have high concentration of soluble salts that limit plant growth by restricting water uptake and nutrient availability. Solonchaks are defined based on the presence of a salic horizon with criteria of electrical conductivity and thickness.

In the recent edition of WRB (WRB Working Group, 2006) Solonetz and Solonchaks are following Vertisols and Fluvisols in the "water influenced" set of the rationalized key.

After detailed literature review of properties of salt affected soils, and taxonomic distance studies based on the NASIS (USDA-NRCS NASIS point database) and WISE (World Inventory of Soil Emission Potentials database 3.1) datasets we found that the properties of both Solonetz and Solonchaks determine more the function of soils than shrinking and swelling high clay content and stratification. Based on our results we propose to set the salt affected soils higher in the new edition of WRB classification key to precede the Vertisol and Fluvisol Reference Soil Groups.

Keywords：*Salt affected soils, WRB, classification key*

P3-211

[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Characteristics and Classification of Soils in Sabah, Malaysia, Borneo

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Sabah has total land area of 7.2 million hectares, only 2.1 million hectares have been identified as suitable for agriculture development, based on their morphology, physical and chemical characteristics. Detailed study and clarify the local soil is essential and urgent. The objectives of this research project are: (a) To determine the physical, chemical, morphological characteristics, soil types and their distribution in the area, (b) To study their genesis and classify the soils according to the current international classification system, (c) to provide a scientific basis for the transfer of soil information between areas with similar environments. The study area consist of swamps, floodplains and moderate hills. The survey area covers a surface of approximately 33 hectares, and is situated in the district of Papar, Sabah. The area is located within longitude 50 31' 36" N and 50 31' 48" N, and latitude 1150 55' 50" E and 1150 56' 25" E. More than half the topografi of Borneo is similar to this study area. Detailed soil survey method (grid system) base on 200 meter x 200 meter was done for this area. Soil pit was dug to make more detailed observation on soil morphologies to the most representative site. Soil samples of each horizon was collected for laboratory analysis for the purpose of soil classification. Before fieldwork, the aerial photographs and topographic map of the area was interpreted to identify landform types and terrain classes of the area in facilitating the lay-out of traverse lines for soil observation. In the field, the traverse lines were made at 200 meter apart and a soil observation was made at every 200 meter on the traverse line. This gives an intensity of one observation point per 4 hectare. The climate of this site is generalised as closest to the "Afi" climate type in Koppen's Classification of Climates (Trewartha 1943). A tropical climatic with a temperature of coolest month above 18ºC, a rainfall of the driest month at least 60 mm, and a range of temperature between the warmest and coolest month of less than 5ºC. Within this climate there is a minimum of seasonal variation in temperature and precipitation, both remaining high throughout the year. The parent material of lower area is alluvium but the hilly zone the parent rocks are predominantly by sandstones of the Crocker Formation. The soils have been described according to FAO Field Legend (1988), Soil Taxonomy (USDA, 2006) as soil units and soil families base on Department of Agriculture Sabah Soil Classification System (Acres, 1975). Seven soil pedons were described, determined and classify. Pedon 1 and Pedon 3 are classified as Koyah Family of Dystric Gleysols (FAO Field Legend) / Typic Endoaquepts-fine, mixed, isohypertermic (USDA Soil Taxonomy) where the soils are deep, poorly drained soils that occur on the flat lowland derived from alluvium and colluvium. Pedon 2 classified as Inanam Family of Gleyic Acrisols (FAO Field Legend) / Typic Kandiudult-fine,kaolinitic, isohyperthermic (USDA Soil Taxonomy). This soil are found on the low lying areas of valley floors, showing gleyic horizons from imperfectly to very poorly drained soils. These soils have undergone sufficient clay illuviation to qualify for Argillic Horizons. Pedon 4 classified as Tenghilan Family of Dystric Fluvisols (FAO Field Legend) / Typic/Aquic Udifluvents – coarse-loamy, siliceous, isohyperthermic (USDA, Soil Taxonomy). They are well to imperfectly drained soil. Soil textures are generally loamy in the upper soil and clayey in subsoil. Pedon 5 and 7 classified as Tanjong Lipat Family of Orthic Acrisols (FAO Field Legend)/ Typic Paleudults – fine loamy, siliceous, isohyperthermic (USDA Soil Taxonomy) where contains 25 to 40 percent clay in the argillic horizons. They are developed on sedimentary rocks of sandstone and mudstone. Pedon 6 classified as Luba Family of Gleyic Cambisols (FAO Field Legend) / Aquic Dystrudepts - fine loamy, siliceous, isohyperthermic (USDA Soil Taxonomy) where this soil having a gleyic horizon. Borneo is the third largest island in the world and the largest island of Asia, so soil information from this study is very important for economic development, particularly to agriculture, eco-tourism and preservation of biodiversity and tropical rainforests.

Keywords：*Keywords: Soil Pedon, Sabah Soils Classification System, FAO-UNESCO Field Legend, subsoil, argilli*

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[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Conceptual Clustering for the Geotechnical Data Analysis

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Soil data analysis is the crucial part of the building foundations design process. Before the construction can be established, the information about the physical properties of the soil is determined. Traditionally, boreholes and geotechnical probes (such as CPT and DMT) are applied in the location of the future construction. They deliver the information used to create soil profiles and calculating geotechnical indexes. Because application of probes is faster and cheaper than boreholes, they became a standard tool for the field tests. Measured quantities (such as membrane pressures for DMT and cone resistance or the sleeve friction resistance for CPT), combined with nomograms identify the particular soil layer, characterized by the set of parameters. Unfortunately, nomograms' applications are limited geographically, therefore data analysis methods are introduced to find new dependencies in collected parameters' values. They supplement knowledge obtained from boreholes.

In this paper the conceptual clustering method for the analysis of geotechnical data is presented. Based on the information from CPT and DMT probes soil profiles are generated and their parameters calculated. The proposed method is the modification of the Cluster/2 system [1]. It was never used before for the analysis of the geotechnical data. The procedure for the geotechnical data analysis presented in this paper includes the following steps: data collection using probes, applying the artificial intelligence method, interpreting results and using them for further calculations. During the first stage, at the predefined depths physical soil parameters were acquired. This way data training sets were prepared, consisting of rows (examples) with two or three parameters each. As nomograms were not used in this experiment, the only reference data about the soil structure comes from the boreholes. There is no information about the expected soil category at any depth, which calls for the unsupervised learning (clustering) methods.

The conceptual clustering is one of possible approaches to the geotechnical data analysis. Multiple methods (such as nearest neighbor [2] or graph clustering [3]) were used before for this purpose. They work on the set of examples to find similar ones and group them into clusters, further labeled by the geotechnical expert. These groups are characterized by parameters, used in calculations to design the optimal foundation structure. The proposed method is based on the covering scheme. It consists in selecting examples from the training set in each iteration and creating a separate category for it. The number of examples in the single cluster should be maximal. The decision about which examples should be covered is made based on the complexes' analysis, which are sets of conditions the example must meet to be covered. As in other unsupervised learning methods the following parameters were determined:

• the number of created soil categories

• the values of thresholds separating examples belonging to different categories

In our research, the first parameter was determined incrementally. New groups were created if, after concluding the algorithm, unclustered examples remained. The second parameter was calculated based on the selected complexes, representing separate groups. Median and averaging filtering were proposed to decrease the number of categories and focus only on the most important ones.

The available data for the algorithm was obtained from three locations in the Warsaw University of Life Sciences campus, where during the didactic buildings construction, measurements using CPT and DMT probes were performed, delivering data sets for analysis. The experiments presented in the full paper allowed for:

• verifying the usefulness of the algorithm for the geotechnical data analysis ,

• comparing clustering results with other approaches, applied before,

• evaluating the versatility of knowledge extracted from the data.

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Keywords：*conceptual clustering, soil classification, in-situ tests*

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[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Research of Pedogenetic Features and Classified Characterization of Calcification Process in Ustic Cambosols Take Ustic Cambosols in Henan Province for Example

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Soils which are weakly developed in Ustic soil moisture regimes, including some are diagnosed with calcic horizon, hypercalcic horizon and calcic evidence, are diagnosed and divided into Ustic cambosols. According to the diagnostic criteria of Cambosol, a large number of soil types belongs to it. Specifically, within these diagnostic criteria, calcic horizon, hypercalcic horizon and calcic evidence characterize the calcification process which is considered as one of the most important soil zonal genesis process and has certain relationship with pedogenesis environment and process. However, according to the keys to Chinese soil taxonomy using now, soils whose genetic process are derived by calcification process are simply diagnosed by cambic horizon and ustic soil moisture regimes. Then they are divided into Typic Hapli-Ustic Cambosols. Apparently, it is not rigorous enough to characterize this kind of soils mentioned above in soil taxonomy. In this paper, 11 soil samples which are belong to Ustic Cambosols were collected and tested according to the definition of calcic horizon, hypercalcic horizon and calcic evidence. Based on the date and calcification process analysis in Ustic soil moisture regimes, the classification framework were reconsidered and advices were proposed.

Keywords：*Chinese soil taxonomy; Ustic Cambosols; Calcification process; Ustic soil moisture regimes;*

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[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Automatic Computer Estimation of Geotechnical Soil Profile Based on Cpt and Dmt Probes

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The paper presents an automated method of the soil profile assessment using the soft computing approach. The method lets to identify of geotechnical layers in unsupervised way. In traditional approach drilling boreholes is required which is more expensive and takes more time in comparison to method presented in this paper. The new method is based on geotechnical probes (including CPT and DMT) and special built algorithm which by means of data generated by mentioned probes is able to assess geotechnical profile without the user interaction. The database is generated using real data derived from real probing by means of CPT and DMT probes. Data has been acquired from different locations at campus of Warsaw University of Life Sciences (WULS). Moreover the results of numerical experiments we have been verified and compared to real geotechnical profile provided by experts. The novel algorithm is based on the two stages. First stage is regarding of number of clusters assessment from the statistical point of view based on numeral data. Number of clusters assessed corresponds to number of geotechnical layers. In this approach we do not know a priori the number of clusters (layers) so we can calculate how many clusters are needed. One method to choose the number of clusters is to use the minimum value of the BIC criterion and this criterion has been applied in this paper. The second stage is assignment data to appropriate cluster (layer) by means of one of the modified agglomerative hierarchical clustering algorithm. In this algorithm is important to collect only neighbour data points which belong to the same cluster. The result of performing of two stages of presented in this paper approach is assignment data to appropriate clusters which corresponds to geotechnical layers. This method has been confirmed by geotechnical experts and can be applied as part of bigger geotechnical system.

Keywords：*soil profiles, soft computing methods,clustering, CTP probe, DMT probes, data mining*

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[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Indian System of Soil Classification Scheme: A Proposed Framework

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The existing soil classification scheme is often subject to interpretation to find some suitable management options. Soil is a non-renewable natural resource, which is subject to production of suitable land use. The level of soil productivity may be enhanced through the process of management. As such, classification scheme must be linked to management options. The Indian soils are classified using USDA Soil Taxonomy, in which soil classification scheme up to Phase level follows 9-10 steps, namely Texture of plough layer (soil type or phase), Series name, Family with five characters, Sub-group and Great group (consisting of Sub-Order and Order). However, in the proposed Indian soil classification scheme, altogether 17 Soil groups are assigned to major soils of India at the highest level followed by Sub-groups (consisting of six potentially viable soil features for each Soil group) and Soil phase (consisting of five distinguishing constraints related to soil productivity). A classified soil may enable to identify the associated limitations for correction through the process of improvement measures in order to assign the most remunerative land use choice preferably in rotation in case of annual crops. Such classification scheme is very simple, easily acceptable and truly adoptable by farming communities, technical personnel and extension workers at all levels as briefly outlined below. The proposed framework/structure of the Indian soil classification scheme thus need validation as well as exhaustive refinement (Mishra 2013).

(a) Inherent soil qualities/characteristics dominantly controlling the suitability of a soil (Highest category: Soil Group)

-Acidisols; Acid environment mostly at high altitude, High H+ and Al3+ concentration, low microbial population with imbalanced nutrient availability

-Calcisols; Calcic in nature with dominantly free CaCO3 (> 40%)

-Desertisols; Soil with low water table and dry LGP (< 90 days) showing water deficiency causing chemical and biological constraints

-Fluvisols; Under active fluvial processes, subject to depositional equilibrium, irregular settling of sediments, washing through flood.

-Halosols; Saline layer with > 25 cm depth from top, osmotically induced chemical deterioration, high electrical conductivity.

-Hydrosols; Marshy and submerged soil with redox limits, reduced chemical environment.

-Microbisols; Mostly sub-temperate forest soils with surface litters rich in microbes, microbial diversity, immobilization and more clay-organic interaction.

-Mixisols; Disturbed, truncated, eroded, mixed and transferred soils (> 25 cm depth from top), subject to attain equilibrium among physical, chemical and biological environments.

-Mollisols; Identical to forest and grassland soils with granular structure and high base saturation, optimal physical, chemical and biological environment.

-Natrisols; Sodicity due to exchangeable sodium adsorption causing physical deterioration.

-Neutrosols; Neutral chemical environment, conducive to optimal management option

-Plinthosols; Iron rich yellow and red soils, low activity clay and humus poor soils.
-Arenisols; Sandy layer, at least >25 cm depth from top, physically and chemically instable.
-Regosols; Imprint of parent materials, shallow gravelly soils with stoniness.
-Siltosols; Silt layer, > 25 cm from top, physico-chemically viable, more available soil water.
-Vertisols; High smectitic clays, swell-shrink properties as in black cotton and tal land soils
-Uttamisols; Undefined soils across the country, diagnostic characteristics to be established for distinction from others with specific nomenclature (separate Soil Group).
(b) Soil potentiality in terms of soil productivity for suitable land use (Soil sub-group):
-Mode of profile arrangement; Stratification, Compactness, Hardpan, Regular.
-Effective depth of soil profile; Shallow (< 25 cm), Slightly deep (25-50 Cm), Moderately deep (50-100 cm), Deep (100-150 cm), Very deep (>150 cm).
-Length of growing period (LGP); Moist (>180 days), Dry and moist (90-180 days), Dry (<90 days).
-Dominant clay minerals; Kaolinite-Halloysite, Illite-Vermiculite, Smectite/Montmorillonite, Chlorite, Mixed.
-Textural arrangement below 25 cm depth; Sandy loam, Loam, Silt loam, Clay loam.
-Slope gradient; Leveled (< 2%), Slight (2-3%), Gentle (3-5%), Moderately (5-15%), Steep (>15%)
(c) Limitation and constraint in association with soil features (Soil phase):
-Soil fertility level; Low organic matter, nutrient availability and their interaction state; I.
-Soil physical constraints; Drainage, water storage capacity, temperature, gravels & stones; II.
-Soil chemical/mineralogical constraints; Low CEC, high reducible Fe2O3, high gypsum, oxide materials, quartz etc; III.
-Soil sickness/predators; Microbial imbalance, termites, protozoa, nematodes, soil borne diseases; IV.
-Risks, uncertainties and doubts; Flood, drought, erosion etc; V.
(d) Specific set of preferred landuse choice (Soil suitability)
-Fluvisol; Stratified, very deep, dry & moist, mixed, loam, gentle; I, II, V; Kalai (Phaseolusmungo) - Maize (Zea mays)-Cheena (Panicum millaccum)

Keywords：*Indian soil classification, Soil Group, Sub-group, Soil phase, Soil suitability*

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[C1.4-2] The Progress in Development and Harmonization of Soil Classifications

Localization Study of Virgin Abies Faxoniana Forest Soil at the Kangding-Tibet, China

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Whether soil developing under coniferous forest in North temperate zone and its corresponding vertical zone of China to be Spodosol or not has been continually debated in soil academia. In this case, a fir (Abies faxoniana) with concave leaves rhododendron (R.davidsonianum) virgin forest, which had the greyish white subsurface horizon, located by the Min river in the east of Kangding-Tibet Plateau was taken as the object. With the field dynamic research methods at this fixed position, the morphological characteristics of soil profile, the micro-morphology composition, the soil minerals and other diagnostic characteristics of its soil were measured. Meanwhile, the movement regularities of typomophic elements on soil formation including silicon, iron, alumina and manganese were determined. Based on a comparison of the experimental results with Spodosol defined in soil taxonomy of USA (ST), it concluded that some features like having an albic horizon, the thickness of Bu2 horizon being 44 ㎝, the content of organic carbon being 2.37% and water soil ratio of 1:1 being 5.66 met their diagnostic criteria defined by spodic horizon. However, the color value, moist, of 10R4/8, the colloidal fraction being dominated by quartz and feldspar and the micro-morphology composition to be automorphic spherical crystal formed by iron oxide failed to meet the characteristic requirements of spodic horizon. Moreover, the reductive and eluviation process of iron was carrying on in the soil markedly. Activated Fe moved while Al was relatively stable. Mn didn't have a significant moving down. The weathering degree of its minerals was superficial. Therefore, the soil of this area was not Spodosol. It should be classified as Gelisols. (Additional: we are grateful to professor emeritus Lin Boqun for the guidance and selfless help.)

P3-217

[C2.1-1] Quantifying Evaporative Fluxes from Terrestrial Surfaces

Relationship between Physical and Chemical Soil Characteristics and Greenhouse Gases Emission in an Indigenous Agroforestry System in Western Honduras

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Agroforestry systems have the potential to reduce net emissions of greenhouse gases (GHG): nitrous oxide (N2O), methane (CH4) and carbon dioxide (CO2); and offset the emissions associated with deforestation and land use change from forest to agriculture (Dixon, 2004). However, data on GHG fluxes between soil and atmosphere in tropical agroforestry systems are limited, including its relation with soil properties (Rondon, 2000). Quesungual Slash-and-Mulch Agroforestry System (QSMAS) is an indigenous agroforestry system practiced in southern Lempira, Honduras, and it is considered a viable alternative to traditional slash-and-burn system. QSMAS has four basic principles: (i) not burning, (ii) minimum disturbance of soil (permanent soil cover and zero tillage), (iii) spot fertilization and (iv) management of natural regeneration (Welchez et al., 2006). Main crops used in QSMAS are maize (Zea mays L.), common bean (Phaseolus vulgaris L.) and sorghum (Sorghum bicolor L.), trees with high value timber as laurel (Cordia alliodora Ruiz & Pav.) and guachipilin (Diphysa robinioides Benth.), and some native fruit trees such as nance (Byrsonima crassifolia L.) and guava (Psidium guajava L.) (Hellin et al., 1999). This study was conducted in farms on the communities of Camapara, El Obrajito, San Lorenzo, Portillo Flor, Gualmuraca and Quesungual, in the municipalities of Candelaria and Gualcince. This region is a tropical dry forest ecosystem (Holdridge classification), average temperature of 25 °C, annual rainfall of 1400 mm (rainy season from May to October), slopes between 5 and 50% and elevations between 200 and 900 masl. Soils are acidic and have low availability of organic matter and phosphorus. Soils are classified as Entisols (Lithic Ustorthents) (USDA classification), igneous and intrusive rocks from Tertiary (Hellin et al., 1999). In this study fluxes of GHG: N2O, CH4 and CO2 between soil and atmosphere were compared in five land uses: (a) QSMAS <2 years, (b) QSMAS 5-7 years, (c) QSMAS >10 years, (d) Slash-and-burn system (SB) and (e) Secondary Forest (SF), using three replicates and a total of 15 plots of 200 m². For GHG sampling, closed chamber technique was used in 16 sampling dates, from July 2005 to July 2006. To determinate physical and chemical soil variables and greenhouse gases, soil and gases samples were collected in each of the plots and then were send it to the laboratories in CIAT in Cali, Colombia. N2O and CH4 concentrations were determined using a Shimadzu GC-14A gas chromatograph, and for CO2, it was used a gas analyzer Qubit System Model S151, with infrared technology. Selected physical variables of soil included in this study were texture, bulk density, porosity, permeability, saturated hydraulic conductivity and susceptibility to compaction; and soil chemical variables included in this study were pH, total nitrogen, phosphorus, potassium and magnesium. Analysis model was adjusted to a completely randomized design in a factorial arrangement. Principal Component Analysis (PCA) was performed to determine the relationships between the selected physical and chemical soil variables and the GHG. Correlations were done to test the relationships between variables found in the PCA and to select variables for the development of models. GHG fluxes showed a seasonal behavior, with higher emissions during rainy season, from May to October. QSMAS and SF were CH4 net sinks, with -102 mg CH4 m-2 year-1 and -36 mg CH4 m-2 year-1, respectively, indicating less disturbed soils and adequate management of soil in QSMAS and SF. The only CH4 net source was SB, with 150 mg CH4 m-2 year-1. All treatments were found to be N2O and CO2 sinks, as a result of natural processes of decomposition. Obtained adjusted models of GHG and selected physical and chemical soil variables were: CH4 = - 360 + 338 (pH) - 18.5 (Susceptibility to Compaction), r = 0.58 and N2O = - 258 + 684 (Bulk Density), r = 0.46. Soil variables that explain more the differences in fluxes of CH4 were pH and susceptibility to compaction, and in the case of N2O, were bulk density, total porosity and air permeability. In general, soil variables related to porous space such as bulk density, susceptibility to compaction and soil porosity were the most useful to explain the behavior of GHG.

Keywords：*greenhouse gases fluxes, carbon dioxide, methane, nitrous oxide, agroforestry, soil properties*

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[C2.1-1] Quantifying Evaporative Fluxes from Terrestrial Surfaces

Lysimeter Use to Evaluate Drought Effects on Water Consumption and Growth of Trees

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Broad areas of the north eastern German lowlands are characterised by low precipitation and periods of summer drought. Scenarios of the climatic development for the next decades indicate an increase in weather extremes threatening the existence of the current ecosystems. In this region, forest hydrology research is investigating the influence of differently structured forests on the landscape water balance. A focus lies on the water consumption and growth of trees when water resources decrease.
The ways of adaptation to the forecasted climate are still largely unsolved. The examination of their gaining capacity in dryness and heat is a professed research objective. The use of lysimeters is one innovative yet approved method. To investigate the impacts of intensified drought on forest regeneration, field experiments were carried out with different lysimeter types; this has, in this region, a tradition of more than 100 years. In 1972, nine new large-scale lysimeters with a depth of 5 m and a surface area of 100 m2 (10x10 m) were installed near Eberswalde and planted with the tree species Scots pine, European beech, European larch and Douglas fir at plant spacing corresponding to those adopted in forestry practice.
1994 we developed a new type of lysimeter which is weighable featuring an undisturbed soil monolith to quantify the competition effects of small trees in mixed stands and to evaluate drought risk with an accuracy of 0.1 mm.
In connection with this we designed the open field laboratory “Drylab”. The field laboratory enables investigations of the effects of drought on the growth and vitality of forest trees in the open field under largely controlled conditions. Eight lysimeters with a surface area of 2 m² were installed at ground level in isolation from the surrounding soil, and fitted with an automatic retractable roof to eliminate precipitation from the site. The focus of the research is the investigation of the cause-effect relation of a different drought and soil warming to water consumption, growth reaction of trees and fine root development as a function of the soil water availability. The decrease in the evapotranspiration is connected to the reduction of the radial increment; with oak and beech showing different reactions.
The following indicators are used to evaluate the water stress:
- Meteorological drought (climatic water balance)
- Relative soil water availability of the decreasing soil water quantity
- Physiological reaction of the trees (leaf turgor pressure, leaf water potential)

A decrease in tree increment is likely if dry summers precede according to the climate scenarios. This could lead to a conflict of decreasing sustainability in future forestry.
Critical loads of the soil water quantities on the tree growth were derived.
Lysimeters are indispensable tools to investigations water consumption of young forest trees of different origin in the face of increasingly limiting water resources arising from climate change.
The consequences of drought and heat on tree growth are in the focus of the presentation.

Keywords：*lysimeter, tree species, drought risk, water balance, tree growth*

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[C2.1-1] Quantifying Evaporative Fluxes from Terrestrial Surfaces

Characteristics of Stem Sap Flow of Apple Trees in the Loess Tableland

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Transpiration is an important part of the evapotranspiration process, and a major mechanism of the water cycle and balance in the atmosphere. But there were few reports about the water consumption of economic forests related to sap flow rate, especially for apple trees in the Loess Tableland. In this study, a thermal dissipation probe (TDP) was used to continuously measure the sap-flow rate of apple tree in Changwu County in Loess tableland area of China from July to October, 2012. The purpose is to ascertain the characteristics of water consumption of apple trees and the relationship between the sap-flow rate and meteorological factors. The results showed that diurnal variation of the sap-flow rate of apple tree was a single peak curve in both sunny and rainy days. On sunny day, the sap-flow started more early and stopped more lately than on rainy day. The sap-flow rate of apple tree was positively correlated with solar radiation, vapor pressure deficit (VPD), atmospheric temperature and atmospheric relative humidity with a linear equation, and negatively correlated with air relative humidity. The dependency of sap-flow rate on various meteorological factors on the sunny day was more significant than on the rainy day. In addition, the sap-flow rate of apple tree varies distinctly in different environment conditions of soil moisture. Under the water stress condition, the sap-flow rate was significantly lower than that under the moist soil condition. The change of sap-flow rate showed a broad-peak curve, indicating that the transpiration was higher under the moist soil condition. Our study may provide local farmers and forest managers with valuable information about the transpiration and water consumption of apple trees in the study area, which is conductive to the scientific management of local economic forest eco-system.

Keywords：*sap flow velocity; thermal dissipation probe(TDP); meteorological factors; soil water content; trans*

P3-220

[C2.1-1] Quantifying Evaporative Fluxes from Terrestrial Surfaces

Separating Evapotranspiration and Precipitation from Noise - A New Filter Routine for High Resolution Lysimeter Data

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Weighing lysimeters yield the most precise and realistic measures for evapotranspiration (ET) and precipitation (P), which are of great importance for many questions regarding soil and atmospheric sciences. An increase or a decrease of the system mass (lysimeter plus seepage) indicate P or ET. These real mass changes of the lysimeter system have to be separated from measurement noise (e.g. caused by wind). The typical way to filter noisy lysimeter data is (i) to introduce a smoothing routine, like a moving average with a certain averaging window w, and then (ii) to apply a certain threshold value d, accounting for measurement accuracy, separating significant from insignificant weight changes. Thus, two filter parameters are used, namely w and d. Especially the time variable noise due to wind and strong signals due to heavy precipitation pose challenges for such noise reduction algorithms. If w is too small, data noise might be interpreted as real system changes. If w is too wide, small weight changes in short time intervals might be disregarded. The same applies to too small or too large values for d. Application of constant w and d lead either to unnecessary losses of accuracy or to faulty data due to noise. The aim of this contribution is to solve that problem with a new filter routine, which is appropriate for any event, ranging from smooth evaporation to strong wind and heavy precipitation. Therefore, the new routine uses adaptive w and d in dependence on signal strength and noise (AWAT - Adaptive Window and Adaptive Threshold filter).

The AWAT filter, a moving average filter and the Savitzky-Golay filter with constant w and d were applied to real lysimeter data comprising the above mentioned events. The AWAT filter was the only filter which could handle the data of all events very well. A sensitivity study shows that the magnitude of the maximum threshold value has practically no influence on the results, so that only the maximum window width must be predefined by the user.

Keywords：*evapotranspiration; precipitation; weighable lysimeters; data filtering; noise reduction*

P3-221

[C2.1-1] Quantifying Evaporative Fluxes from Terrestrial Surfaces

Simple Consistent Models for Water Retention and Hydraulic Conductivity in the Complete Moisture Range

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The commonly used hydraulic models only account for capillary water retention and conductivity. Adsorptive water retention and film conductivity is neglected. This leads to erroneous description of hydraulic properties in the dry range, which is especially important in evaporation processes. The few existing models, which account for film conductivity and adsorptive retention are either difficult to use or physically inconsistent. A new set of empirical hydraulic models for an effective description of water dynamics from full saturation to complete dryness is introduced. The models allow a clear partitioning between capillary and adsorptive water retention as well as between capillary and film conductivity. The number of adjustable parameters for the new retention model is not increased compared to the commonly used models, whereas only one extra parameter for quantifying the contribution of film conductivity is required for the new conductivity model. Both models are mathematically simple and thus easy to use in simulation studies. The new liquid conductivity model is coupled with an existing vapor conductivity model to describe conductivity in the complete moisture range. The new models were successfully applied to literature data, which all reach the dry to very dry range and cannot be well described with the classic capillary models. The investigated soils range from pure sands to clay loams. A simulation study with steady-state water transport scenarios shows that neglecting either film or vapor conductivity or both can lead to significant underestimation of water transport at low water contents.

Keywords：*water retention; hydraulic conductivity; water adsorption; film conductivity; evaporation modeling*

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[C2.1-1] Quantifying Evaporative Fluxes from Terrestrial Surfaces

Trends of Soil Evaporation over the Past 30 Years in South Korea

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Soil evaporation and reference evapotranspiration (ETo) were computed using E-DiGOR and FAO-56 Penman-Monteith models, respectively, for the 17 meteorological stations of South Korea from 1980 to 2009. In simulations, the same soil was considered for the study sites to compare their climatic conditions. The quantitative contributions of the major climatic variables such as radiation, temperature, relative humidity and wind speed to the trends of potential soil evaporation (Ep) were also evaluated. On the annual average of the selected locations, Ep increased gradually during the study period. On the other hand, Ep rates were lower than ETo values (Ep=0.8xETo). Magnitude of actual soil evaporation (Ea), as simulated with the E-DiGOR model, reached a level of about 60% of Ep. Furthermore, Ea accounted for 30 to 50% of total precipitation over the country. Annual precipitation tended to increase according to trend line. However, partial drought occurred about once every six to seven years based on the ratio of annual precipitation to potential evapotranspiration, referred to as aridity index by UNESCO.

Keywords：*Evapotransportation, Soil evaporation, E-DiGOR, Penman-Monteith model, aridity index*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Water Retention Characteristics of Soils over the Whole Moisture Range: Evaluation and Comparison of Laboratory Methods

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The exact characterization of the water retention curve is of great relevance for various purposes such as estimating plant-available water or simulating water and solute dynamics in variably saturated soil. Various laboratory methods for the determination of the soil water retention characteristics are frequently applied. No currently available measuring device allows the determination of the retention curve over the whole soil moisture range. But to avoid error-prone extrapolation of the water retention curve it is important to have information over a large range of pressure heads. This makes the combination of different methods necessary and reasonable. Evidently, for the combination of different methods, it is important that the methods yield reliable and compatible results. In a number of studies inconsistent results about the agreement of retention data obtained by different methods were found.

To get insights into the reliability and comparability of retention data obtained by different methods, we evaluated and compared four standard laboratory methods. The four applied methods were (i) the hanging water column and (ii) the simplified evaporation method (HYPROPⓒ) for wet to moderate moisture ranges, and (iii) the pressure plate and (iv) the dew point method (WP4C PotentiaMeter®) for moderate to dry moisture ranges.

Eight soils from different parts of Germany and one from Israel, covering a wide range of soil textures (sand, silt, silt loam, clay loam and clay), were used to test the consistency of the four methods. A large number of replications was made to strengthen the results. All four methods determine the drying branch of the retention curve, whereas with the dew point method the wetting branch can be determined as well. This method was used to determine whether hysteresis is important in the dry pressure head range.

The combination of the four methods provided retention data within the whole soil moisture range from saturation to air dryness. Generally, retention data from the different methods matched quite well. Replications of the evaporation measurements showed a remarkably good agreement; this is especially worth noting as undisturbed soil samples taken from field sites where used, which exhibit a large natural heterogeneity. Retention data obtained by the suction plate method had a considerably wider spread. This confirms the greater reproducibility and reliability of the evaporation method. Also, the transient evaporation method is much faster because no hydrostatic equilibration is needed. Data from these two experiments, which cover the wet to moderate soil moisture range, agreed well for fine textured soils, whereas for sandy soils suction plate data lay below evaporation data. One explanation for this difference could be dynamic non-equilibrium.

Drying-curve data obtained with the dew point method generally provided a well-matched continuation of the evaporation data for the dry range. Hysteresis determined by the dew point method in the dry soil moisture range was observed for all soils, but was small or negligible in most cases. However, it was pronounced for clay loam. Water content data obtained with the pressure plate method sometimes matched well with those obtained by the dew point method, but sometimes were found to be slightly but systematically larger. Possible reasons for this could be that the soil samples on the pressure plates had not reached equilibrium, or the loss of contact between soil sample and porous plate. Because these factors cannot be easily controlled, the correctness of data obtained with the pressure plate method cannot be blindly trusted, and results must be interpreted with care.

For a reliable and convenient determination of retention data over the full suction range and in a reasonable expenditure of time, we found the combination of the evaporation method for the wet to moderately dry range and the dew point method for the dry range most convenient and reliable.

Keywords：*evaporation method, hanging water column, pressure plate, dew point method, HYPROPⓒ, WP4C®*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

The Constructed Catchment ´chicken Creek´ as a Tool to Disentangle Feedbacks Between Soils, Surface Structures, Vegetation and Hydrology during Initial Ecosystem Development

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Over a period of eight years, we investigated the initial development of the constructed catchment ´Chicken Creek´, south of Cottbus, Germany (Gerwin et al., 2009). Since the boundary conditions and inner structures of the hillslope are well known and documented (Gerwin et al., 2011), the site offers unique possibilities to study the relevant processes of ecosystem development interacting with various structures and patterns.

We observed considerable changes within the catchment (Elmer et al., 2013). Both internal and external factors could be identified as driving forces for the formation of structures and patterns in the artificial catchment. Initial structures formed by the construction process and initial substrate characteristics were decisive for the distribution and flow of water. External factors like episodic events triggered erosion and dissection during this initial phase, promoted by the low vegetation cover and the unconsolidated sandy substrate (Schaaf et al., 2013). With time, secondary structures and patterns evolved and became more and more important. Invading biota and vegetation succession initialized feedback mechanisms resulting in pattern and habitat formation, and generally in increased differentiation, heterogeneity and complexity that are typical characteristics of ecosystems (Schaaf et al., 2011).

The processes and feedback mechanisms in the initial development of a new landscape may deviate in rates, intensity, and dominance from those known from mature ecosystems. It is therefore crucial to understand these early phases of ecosystem development and to disentangle the increasingly complex interactions between the evolving terrestrial and aquatic, biotic, and abiotic compartments of the system.

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Keywords：*ecosystem development, obervatory, structures and patterns*

P3-225

[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Using Water Footprinting to Reduce the Impact of the Use of Agricultural Water and Agrichemicals on Water Resources

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Being the largest consumer of the world's water resources, agriculture has widespread impacts on both freshwater quantity and quality. Crop development programmes in recent years have lead to highly productive cultivars that require intensive management and high inputs of fertilizers, other agrichemicals, and irrigation. Nonetheless, the soil has the capacity to filter, buffer and immobilize the organic and inorganic chemicals to a certain extent. However, applying heavy loads of chemicals leads to the leaching of them to groundwater thereby causing environmental, social and economic problems. The water footprint (WF) metric has been proposed as means to indicate the level of water use and the impacts of the production system on the quantity and quality of water resources.

The impact of the potato production on water resources was assessed using a mechanistic modelling supported by field measurements in the Manawatu region of New Zealand. The hydrological water-balance method for the WF was used as this account for all the inflows and outflows to and from water resources. It quantifies the net use of groundwater as the blue-WF, and that of the soil-water as the green WF. The change in soil water content was measured using Time Domain Reflectometer (TDR) probes installed at three different depths in the soil profile. The net blue-water recharge was quantified by measuring drainage below the root zone using tension fluxmeters. To quantify the grey WF, the concentration of the leached agrichemicals was determined by analysing the drainage from the fluxmeters. Measurements were incorporated into the Soil Plant Atmosphere System Model (SPASMO) to quantify the water footprint by taking into account some 40 years of weather data.

The green-WF was found to be negligible, as there was no net-change in soil water content. The blue-WF was actually negative at -72 L/kg, indicating that the groundwater resource is recharged under this land use. Thus rain-fed potato production has no deleterious impacts on the water quantity in the region. The grey-WF is taken as the freshwater needed to 'dilute' the pollutants to the drinking water standard. Considering nitrate nitrogen (NO3--N) as the main pollutant, the grey WF was calculated at 56 L/kg of potato harvested. The average leached NO3--N concentration of 11.3 mg/L, is just at the limit of the drinking water standard, and the loading of 27.8 kg-N/ha/y from the cultivation phase indicates that a single application of nitrogen fertilizer at the time of planting may have had some impact on water quality. As an option to reduce the impact on the quality of water resources, three fertilizer application scenarios were modelled. These scenarios were of two splits, three splits and late application at 55 days after planting reduced NO3-N concentrations and loads in the leachate. The NO3-N concentrations were simulated to be at 10.5, 10.3 and 9.5 mg/L respectively, and the loading rates were 25.6, 25.2 and 24.3kg NO3-N/ha/y. Potato yield was not compromised. The grey WF would therefore be reduced to 50.6, 50.9 and 48.9 L/kg respectively. Therefore, water footprinting can effectively be used to quantify the impact of a production system, and also to identify improvement options to reduce the impacts, if the right protocols based on rational hydrology are used.

Keywords: *Environmental impacts; water quality; nutrient leaching; footprinting*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Self-Calibrating Heat Flux Plate Improves Measurement of Soil Heat Flux Density

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Soil heat flux plates have been used extensively to measure the heat flux density (G) under field conditions, yet previous studies have reported mixed results and some potential errors. The objective of this study is to evaluate the performance of three types of soil heat flux plate using the gradient method as a standard. The change of G at 6-cm depth was estimated from the product of the soil thermal conductivity and soil temperature gradient, which were monitored with a 3-needle heat pulse probe. These data were then compared with the G measurements of the model HFP01SC, HFP01, and 610 heat flux plates placed at the same depth. The results indicated that the HFP01SC plate, which was able to automatically correct for errors due to the non-perfect matching of the thermal conductivity of sensor and soil, and due to variations of the thermal conductivity of the soil caused by varying moisture content, performed best with a deviation of 6-9%. The HFP01 and 610 plates, on the other hand, underestimated G by 30-43% and 47-53%, respectively. Nonetheless, there were good linear relations between the HFP01 and 610 data and that of the gradient method. We conclude that with the self-calibrating function, the HFP01SC plate can provide reliable G measurements. As for the HFP01 and 610 sensors, precedent linear calibrations are necessary for accurate soil heat flux density measurements.

Keywords：*Heat flux density, Self-Calibrating heat flux plate, Gradient method, Heat-pulse technique*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Comparison of Time Domain Reflectometry, Capacitance Methods and Neutron Scattering in Soil Moisture Measurements

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An accurate, precise, fast and ease as well as the ability for measurements in depth are the characteristics that are desirable in measuring soil moisture methods. To compare methods (time domain reflectometry and capacitance) with neutron scattering for soil water monitoring, an experiment was carried out in a randomized complete block (RCB) design (Split Split plot) on tomato with three replications, on the experimental field of IAEA (Seibersdorf-Austria). The treatment instruments for the soil moisture monitoring (main factor) consist of neutron gauge, Diviner2000, time domain reflectometer (TDR) and an EnviroScan and different irrigation systems (first sub factor) consist of trickle and furrow irrigations and different depths of soil (second sub factor) consist of 0-20, 20-40 and 40-60cm. The results showed that for the neutron gauge and TDR the amount of soil moisture in both of trickle and furrow irrigations were the same, but significant differences were recorded in Diviner2000 and EnviroScan measurements. The results of this study showed that the neutron gauge is an acceptable and reliable means with the modern technology, with a precision of ±2mm in 450mm soil water to a depth of 1.5 meter and can be considered as the most practical method for measuring soil moisture profiles and irrigation planning program. The TDR method in most mineral soils, without the need for calibration, with an accuracy ±0.01m3m-3 has a good performance in soil moisture and electrical conductivity measurements. The Diviner2000 and EnviroScan are not well suitable for the above conditions for several reasons such as much higher soil moisture and a large error measurement and also its sensitivity to the soil gap and to the small change in the soil moisture in comparison with the neutron gauge and the TDR methods.

Keywords：*Irrigation, Soil Moisture, Neutron Gauge, TDR, Diviner2000, EnviroScan*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Influence of Soil Electrical Conductivity and Dielectric Dispersion Parameters on Time-Amplitude Characteristics of TDR Reflectograms

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One of common techniques used for fast and accurate soil water content determination is the time-domain reflectometry (TDR). Its operating principle is based on the analysis of a waveform reflected from a probe inserted into the soil. The signal emitted in the form of a voltage step or a pulse travels through a waveguide, usually in the form of two or more parallel rods. The propagation velocity of the signal depends on dielectric properties of the material into which the probe is inserted. The electrical conductivity of the medium influences the propagation velocity only slightly. Since dielectric permittivity of soil is determined mostly by its water content and to a lesser extent by its density, the measurement of the propagation velocity of a TDR signal allows calculating water content with a satisfactory accuracy of about 2% in a wide range of soils without the need of a soil specific calibration. There are several commonly used calibration functions which connect the TDR-determined apparent dielectric permittivity of the soil to its water content measured by the thermogravimetric method. The analysis of a TDR waveform also allows determining soil electrical conductivity from the attenuation of the reflected signal.

Dielectric permittivity is a complex frequency-dependent physical quantity. A typical frequency band of a TDR pulse is up to 1 - 2 GHz. In this range the frequency dependence of soil dielectric permittivity can be significant, especially in saline and clayey soils with high water content. Therefore, dielectric permittivity calculated from the pulse propagation velocity is an apparent quantity, also averaged over the volume of the probe sphere of influence in the case of an inhomogeneous medium such as soil. However, dielectric dispersion additionally influences the shape of the reflected pulse, i.e. its amplitude, half-width and asymmetry.

The objective of this work is to examine the dependence of the amplitude and half-width of a reflected TDR signal emitted in the form of a Gaussian pulse on dielectric properties of a tested material and its electrical conductivity. The possibility of determining dielectric relaxation time, in addition to apparent dielectric permittivity and electrical conductivity from a single TDR waveform is discussed for a variety of liquid and porous materials of different electrical conductivities and dielectric properties. The results are also compared to the complex dielectric permittivity spectra measured in a broad frequency range using a vector network analyzer and customized dielectric sensors.

The determination of the half-width of the TDR pulse, in addition to its propagation velocity and amplitude commonly measured by modern commercial TDR moisture meters, could provide significant information on the properties of the tested soil. Furthermore, it may possibly improve water content calibration functions, especially in the case of soils with high dielectric dispersion.

Keywords：*time-domain reflectometry, dielectric dispersion, soil electrical conductivity*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Porous Ceramic Plate Sensor for Effective Non-Rainfall Tdr Measurements

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In arid and semi-arid regions the amount of water supplied to the soil due to the existence of fog, dew, hoarfrost and direct water adsorption from the atmosphere can exceed that of rainfall. For this reason, the effective non-rainfall can be the main source of liquid water for plants and other living organisms in continuously or temporarily dry ecosystems. On this account, the measurements of the amount of water thus added to the soil, as well as investigations of the diurnal distribution of effective non-rainfall intensity, i.e. the dynamics of its formation and evaporation, are of crucial importance from the ecological perspective.

Several devices and methods were proposed for measuring the effective non-rainfall intensity. However, the international standard for measuring the effective non-rainfall input into the soil was not hitherto established. Therefore, there still exists the need for automated devices of high resolution, because the non-rainfall intensity and increase rate are usually very low.

The time-domain reflectometry (TDR) technique was employed in order to achieve the desirable resolution and accuracy of the effective non-rainfall measurements. The TDR sensor designed and made especially for the purpose was equipped with a water collector in the form of a plate made of corundum ceramics, whose porosity was about 25%. The plate was placed between a flat surface made of laminate covered with copper, which was impermeable to water, and a copper wire. The metallic layer and the wire formed an untypical parallel waveguide. Both elements of the waveguide closely adhered to the ceramic plate in order to eliminate the formation of air gaps, what enhanced the accuracy of the measurements.

The properties of the porous material used for manufacturing the plates do not change in time, which ensures high measurement repeatability. Moreover, the results are obtained immediately due to rapid and uniform non-rainfall water absorption by the material's capillaries, and hence the dependence of the measurement results on environmental conditions is minimized. The porosity of the material of the plates allows taking the effect of water adsorption on the phase boundary into account more accurately than in the case of non-porous deposition elements.

The aim of the research was to test the sensor for the effective non-rainfall intensity measurements and to define its measuring range and detection level. In order to achieve this goal eight sensors with ceramic plates, which were 192.3 mm long, 28.7 mm wide and whose thicknesses were between 4.1 mm and 9.5 mm, were tested in the laboratory. After saturating the particular ceramic plate with water each of the sensors was placed on a scale and connected to the TDR meter. Both measuring devices were controlled by a custom written PC application with a data logger function. During water evaporation from the porous material the automated readings of mass and TDR time were collected simultaneously every minute. Thus for each of the plates the TDR time was correlated with the water content of the medium. Moreover, the temperature calibration of the probes was made on the basis of the measurement data obtained at several ambient temperatures.

The performance of the produced sensors was also tested during field measurements. The outdoor readings taken simultaneously with a set of eight sensors with different porous plates thicknesses allowed obtaining a wide measuring range while maintaining a high level of detection. Additionally, the conducted field measurements revealed that the designed sensor is also capable of measuring the rainfall of very low intensity, which is less than approximately 1 mm per hour. The obtained results were compared with the TDR effective non-rainfall measurements in an actual soil sample.

Keywords：*effective non-rainfall measurements, time-domain reflectometry technique*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Errors and Improvements in Thermogravimetric Measurement of Soil Water Content

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The standard method for the measurement of soil water content is the thermogravimetric or loss on drying method. With this method, a soil sample is dried in an oven at 105 C for 24 to 48 hours and the difference in mass before and after drying is the mass (or volume) of water in the sample. Unfortunately, the effect of ambient vapor pressure is not accounted for with this method, despite clear theoretical consequences in the measured water content. Additionally, variable drying time is known to affect the endpoint water content, but this is generally ignored in practice. In this paper, we control the atmospheric vapor pressure and examine the effects on equilibrium water content. We also measure sample mass throughout the drying process and examine the effect of drying time variability on measured water content.

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Tum Critical Zone Observatory

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TUM-CZO will operate at the watershed scale (carbonatic Ammer Catchment, alpine Ammer Mts. and foreland; crystalline Otter Catchment, mid-mountainous Bavarian Forest) involving long term environmental research sites (Höglwald, Scheyern, etc.) processed by TUM-CZO people. Moreover TUM-CZO is in cooperation with TERENO PreAlpine.

TUM-CZO people are a diverse group of researchers and educators who study the physical, chemical and biological processes shaping and transforming Earth's Critical Zone. This research spans a wide range of disciplines including geomorphology, [hydrology,] microbiology, ecology, soil science, [and engineering].

Within TUM-CZO. researchers can access and integrate data in a way that allows isolation of environmental variables and comparison of environmental effects across gradients of time, lithology, human disturbance, biological activity and topography.

TUM-CZO is a natural laboratory and one of those super-sites, where terrestrial processes and systems can be studied through detailed field observations and in situ measurements in specially designated areas. This type of cooperative research is particularly suitable for studies of the CZ, in which techniques from several disciplines must be coordinated to collect data sets that are spatially dense and temporally extended. Above all, TUM-CZO allows to any alignment on tactical scientific activities.

In first approximation TUM-CZO will operate at the watershed scale and will investigate processes occurring in the Critical Zone in designated areas. Our work will be motivated by science, not simply by data gathering and characterization. Our purposes will be guided and implemented by both field and theoretical approaches, each providing the impetus for advances in the other.

Projects will include an integration of efforts in several subfields addressing near surface processes. Potential subfields include (but are not limited to) biology, geomorphology, geochemistry, pedology, climatology and ecology. Connections to hydrology and remote sensing may be included but may not be the primary focus of TUM-CZO.

Our aims are measuring fluxes in geo-, bio-, hydro- and atmosphere, to observing it over a longer period in order to isolate key forcing that influence the TUM-CZO sites. Contemporaneously, the influence of identified key forcing (e.g. extreme metereological phenomena in steep alpine areas) will be cross-checked in geoarchives in order to validate and adjust CZ-processes. This knowledge should help justifying and calibrating prognostic scenarios and models.

(all referring to criticalzone.org)

Keywords：*Critical Zone Observatory, Ammer Mountains and prealpine foreland, Technische Universitaet Muenchen*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

The Mechanism of Subsurface Flow Generation at a Hillslope Farmland of Entisol, Sw China

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The exact mechanism of water flow generation and plant water use strategy still need study under various hydrological conditions such as the hilly area of purple soil SW China. At an agricultural catchment, soil water content, water potential, water flow rate from hillslope and catchment outlet was simultaneously measured during three storms. Isotopic composition of Deuterium and Oxygen-18 in rainwater, soil water, groundwater, hillslope flow, stream water and stem water from corn were also determined. Results showed that the local meteoric water line is δD=8.3δ18O +18.3 (R2=0.94, n=119) indicating the evaporation vapor has important effect on the local rain. Bulk soil water and lysimeter water showed significant differences in isotopic composition under low soil water content or in the top soil layer. The water collected with the suction lysimeter represented the mobile fraction of the pre-event water in the soil, which effectively participates in the generation of subsurface flow. Newly infiltrated rainwater did not well mix with stationary pre-event water in the soil. The surface flow had basically the same δ18O value as the coinstantaneous rainfall, indicating that it was a Hortonian overland flow. The two end-member separation model showed that pre-event water accounted for a large proportion of the hillslope subsurface flows and streamflow especially during the initial stage. The first sample of subsurface flow always contained significant rainwater, indicating that macropore flow was prevalent in this Entisol. Event water dominated the peak streamflow and accounted for 70.4%, 95.6% and 80.4% of the peakflow amount during the three storm events. In general, the results suggested that pre-event water dominated the initial stage of stormflow generation and that event water dominated the peakflow. During the recession period, hillslope subsurface flows were the main source of the streamflow, as indicated by the similar volume-weighted δ18O value in subsurface flows and stream water. Corns tend to absorb the immobile soil water which lead to the corn stem water was different to the stream water which is a mixer of various water sources. The results of this study are revealing to understand the exact water flow generation mechanism and built an accurate hydrological model.

Keywords：*Hillslope hydrology; Stable isotopes; subsurface flow; generation mechanism.*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

The Evaluation of Soil Hydraulic Conductivity Using Fractal Dimension of Soil Particle Size Distribution and Geostatistics

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Fractal geometry and geostatistics have become an effective tools for quantifying spatial variability of soil physical and hydraulic properties. The fractal dimension of psrticle size distribution values play important in agriculture. Soil particle size distribution resulting from human activities and geophysical process impact the spatial variability of particle characteristics and fractal features especially in the surface soil. Soil particle size distribution data used widly to identify soil texture and predict soil hydraulic conductivity. Hydraulic conductivity is one parameter important for predicting the movement of water and contaminants dissolved in the water through the soil. Spatial and temporal variation in soil hydraulic properties may affect the performance of hydrological models. The cost of determing soil hydraulic property by field or laboratory methods makes alternative indirect methods desirable. The partitioning between infilteration and runoff, temporary water loggin in the root zone, rate of solute transport and several other agricultural and enviromental processes are dependent on the soil saturated hydraulic conductivity. In this research, fractal dimension of particle size distribution was used to explain the spatial distribution of saturated hydraulic conductivity and saturation moisture in paddy soils. In 120 top soil samples, particle size distribution curve, organic carbon, bulk density, saturated hydraulic conductivity and saturation soil moisture were measured. In this paper, fractal dimension of particle size distribution and relationship with soil basic properties and also spatial variability of these properties were considered. There was a good correlation between D values and the content of sand and clay fractions. Organic caron had strong spatial correlation, and D values, sand, clay and saturated hydraulic conductivity contents had moderate spatial correlation. Coefficient of variation used to qualitatively ascertain the magnitude of the spatial variability. Sand, organic carbon and saturated hydraulic conductivity had high variability, but silt and clay had moderate valiability and fractal dimension, bulk density and saturated moisture had waek variability. The kriging and inverse distance weighted were used to convert point samples to a continuous region of soil properties. The interpolation maps showed that there was a spatial correlation between sand, clay, organic carbon, bulk density, saturated hydraulic conductivity, saturation moisture and fractal dimension. In areas with high fractal dimension,the ability of soil increased to hold water and decreased saturated hydraulic conductivity.

Keywords：*fractal dimension, saturated hydraulic conductivity, saturation soil moisture, particle size distrib*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Soil Freezing and Thawing Processes of Three Landscapes in the Middle Reaches of Heihe River Basin, China

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An understanding of soil freezing and thawing processes in seasonally frozen soil is important for many agricultural and environmental issues, especially under different landscapes in terms of land use and climate change. To study soil freezing/thawing cycles under three typical landscapes (i.e., farmland, forest, and desert) in the middle reaches of the Heihe River Basin, a comprehensive field monitoring study of measuring total soil water content, liquid soil water content, soil temperature, frost depth, and groundwater level was conducted from December, 2011 to May, 2012. Both Neutron Moisture Meter (NMM) and Time Domain Reflectometry (TDR) techniques were used to investigate the total and liquid water contents, respectively, and further based on to calculate soil frozen water contents. The greatest freezing cycles were observed for the farmland, characterized with the deepest frost depths, the highest frozen water ratios, and the largest upward heat fluxes, followed by the forest, and then the desert. These differences were primarily attributed to different initial soil water contents, soil surface covers and groundwater levels under the different landscapes with minimal effects being attributed to soil physical properties. Profiled water redistribution was obviously observed in the forest, but neither in the farmland which was very wet or in the desert which was very dry. The frozen soil processes had a beneficial effect on soil water conservation for all landscapes, e.g., evaporation and seepage could be reduced significantly, and high water content could be maintained even higher than the field capacity when soil were freezing/frozen, which could be useful for plant germination the following spring.

Keywords：*freezing, thawing, water content, frost depth, temperature*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Saturated Field Hydraulic Conductivity, Ksat Estimation of Tropical Peat in Sarawak, Malaysia Using Modified Auger Hole Method and Empirical Formulas

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The hydrologic and hydraulic behaviour of peatlands could be analyzed according to two functional sub-domains, the hydraulic and physical properties of the peat materials and hydrologic setting of the basins. These sub-domains occur and co-exist to form peat basin particularly in the tropics. Literature searches agreed that these landscape features have significant control over water table and groundwater flow system hence the lifespan and the productivity of the peat ecosystem. One of the most dominant governing hydraulic parameter of peat catchment is its hydraulic conductivity value. The understanding on magnitude and dimensionality of the hydraulic conductivity particularly for different peatland landscape would enable us to address several environmental issues dealing with the conservation, development and productivity of this resource. Identifying the suitable scientific method and technique for hydraulic-related study of tropical peat is one of the major constraints being faced by soil scientist in the tropics. This is due to the facts that most established technique and procedures and equipment in soil physics are developed based on mineral soil as well as temperate peat. Consequently, scientific publication on tropical peat is scarce and limited. The present paper reports the major finding from our research effort to determine the representative hydraulic conductivity value for peatland of different landscapes found in the state of Sarawak, Malaysia. The field hydraulic conductivity tests were conducted at four different sites of different peat ecosystems, namely oil palm plantation (S1), mixed peat swamp forest (S2), Alan Bunga forest (S3) and Alan Batu forest (S4), by using modified auger- hole method. The auger-hole method is a rapid, simple and reliable method for measuring hydraulic conductivity of soil below the water table. Nevertheless, the original version of the method is based on a radial flow that seeped into the round-shaped hole by which the water table rise rates are used for Ksat calculation. Instead of using small diameter round-shaped auger hole that is normally used by previous researchers, a large rectangular-shaped dig-wells of 1.3 m width, 2.1 m length and 1.4 m depth were used in this study before the standard auger-hole Ksat determination procedure was performed. The establishment of a small diameter round-shaped auger hole was not possible due to the fibrousness and woodiness of the peat profile found in the tropics. Alternatively, the Ksat of different ecosystems were estimated by using empirical formulas. Several important findings were notified as follows: (1) The square-shaped auger hole method was able to give the average Ksat of different peat landscapes. (2) The performance of empirical formulas for estimating Ksat of tropical peatlands. (3) The rate of Ksat varied according to different peat landscapes and was in the following order; S4>S3>S2>S1. Such findings will be further confirmed by the physical characteristics of the peat samples.

Keywords：*Tropical peat, saturated hydraulic conductivity, auger hole, empirical formulas*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

The Effect of Biochar on Water Vapor Movement in Soil during Winter Period Revealed with Stable Isotope Technology

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Water movement in freezing soils is an important link of water cycle in nature, and it's also important for agriculture, water resources and environmental systems. Biochar additions to soils can have consequences on soil physical and chemical properties. Pores and particles in different sizes of biochar will impact energy balance, vapor transport, and water movement of soil in field condition. Micro-plot experiment was set up to test the effect of biochar on soil moisture in wintering period, and the effect of biochar on soil water osmotic potential as well. The amount of sublimation and upward moving water was calculated using stable isotope techniques and Isotopic Mass Balance (IMB) method.

Biochar additions have obvious effect on surface soil water content of wintering period in field condition, and these effects are different in soils with different textures.6% biochar addition increase 24%,14%,10% of water retention capacity before winter and 13%,22%,7% of water retention capacity after winter of sand, loam and clay.

The phenomenon of water increase in soil after frozen occurs significantly in surface soil during wintering period, mainly in the 20-30 cm layer. Biochar additions can depress the water increase, and the decrease range is sand > clay > loam. For sand, the water increase in soils with 3% and 6% biochar addition is 6% and 0%, both less than 19% in no biochar added soil; for loam, the water increase in soils with 0, 3%, 6% biochar addition is 19%, 14%, 17%, respectively; for clay, the corresponding water increase is 44%, 14%, 24%.

Soil water δ 18O values of different treatments during wintering period varies significantly, which means soil water also varies. According to the results of IMB, the order of the account of upward moving water (kg/m2) is clay (6.9)> sand (4.3)> loam (3.3) with no biochar addition; with 3% biochar addition, clay (6.9)> loam (4.5)> sand (1.8); with 6% biochar addition, clay (5.8)> loam (5.2)> sand (-0.6). The water increase in soil after frozen depends mainly on the upward moving water, and biochar additions decrease the water increase in soil after frozen.

Biochar additions also affect the osmotic potential. Biochar addition increase the osmotic potential of below 20-30cm layer of all three kinds of soil with different texture, and 6% biochar addition increase the osmotic potential more obvious.

Keywords：*Biochar, winter season, vapor movement, isotope mass balance*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Characterisation of Hydro-Mechanical Properties of Soil Using Ultrasonic Waves

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The compaction is considered as one of the major factors of physical degradation of agricultural soils and results from the traffic of increasingly heavy machines. Strongly influenced by the soil moisture, this leads to a reduction of the soil porosity. From a hydro-ecological point of view, the compaction phenomenon has harmful consequences. The reduction of micro-porosity affects the soil fertility by preventing the capture of air, water and nutriments by the plants and perturbing the respiration of micro-organisms. The infiltration of water is also affected leading to an increase of the soil erosion susceptibility. The compaction phenomenon is mainly related to the soil type, the hydraulic status and the agricultural practices. This phenomenon is quasi irreversible in the subsoil for any agricultural practices. Furthermore, it is hardly reversible in the topsoil for simplified agricultural techniques without ploughing. It is therefore crucial to characterise the soil compaction level and its susceptibility. Nowadays, the main methods used for the quantification of soil compaction are mainly based on the measurement of the preconsolidation stress which remains a long and expensive process.

In order to develop a rapid and non-destructive method for the quantification of the compaction level of agricultural soils, the propagation of ultrasonic waves in soil can be investigated. The study of wave propagation in unsaturated soils is a complex task. The Biot theory shows the existence of different wave modes, namely compression and shear waves. Furthermore, the heterogeneities of the medium are also the source of multiple diffractions which result in the superposition of different waves forming the propagated signal. This signal can be therefore related to the texture of the medium. Recent studies have shown some correlations between the velocity of acoustic waves and the water content, the porosity and the stress state of soil samples [1-5], concluding that the ultrasonic waves are a promising tool for the rapid characterisation of unsaturated soils.

In the present contribution, correlations are determined between the acoustic signatures of different types of agricultural soil in function of their hydro-mechanical properties. In order to reproduce different compaction levels in laboratory, triaxial tests are performed on unsaturated soil samples. Several types of ultrasonic waves (sine, pulse and chirp) are considered to maximise the transmitted signal in function of the attenuation of the medium. The propagated signals are treated in both time and frequency domains in order to determine their propagation velocity, their attenuation and the shape of the propagated wave. These signal properties are here correlated to the water content and the compaction level.

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Keywords：*unsaturated soil, agricultural soil, ultrasonic characterisation, compaction, water content*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Comparison of Field Measured Unsaturated Hydraulic Conductivity with Four Estimating Models Based on Texture for Two Soils in Khuzestan, Iran

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Measurement of soil hydraulic properties and the application in unsaturated flow models in basic for solving some of the water management problems. These properties are usually represented in the form of soil moisture characteristic curve and hydraulic conductivity functions. In this research unsaturated hydraulic conductivity at 2 places having different texture was measured. Four soil hydraulic models Rawls and Brakensiek, Wosten, Wosten et al. and Vereecken et al. Were evaluated using These data. Soil were siltyclay and loamy texture. soil moisture retension was measured with a sand box for tensions up the one meter and with pressure plate for tensions above one meter. Data was fitted to Van Genuchten model using RETC software. It was found that RETC could match the data very well ( ). unsaturated hydraulic conductivity was determined using internal drainage profile method and Hillel method was used for a 45 day period. During this period soil moisture was measured for 9 day intervals in 10 cm steps by TDR instrument. Soil moisture tensions for each moisture values was derived from soil moisture characteristic curve. At the same depth and flux at each depth was measured leading at the calculation of unsaturated hydraulic conductivity. Statistical analysis was used compare the results SPSS, RMSE , RE , GMER and GSDER were used. It was shown that at site (1) Rawls and Brakensiek model with saturated hydraulic conductivity from the model of Wosten et al and model with saturated hydraulic conductivity from Wosten model gave results very close in the measurement values at site (2) Wosten model with saturated hydraulic conductivity of by the same model. Also gave results that were very close to the measured values.

Keywords：*Rawls and Brakensik, Wosten, Vereeken, Instantaneous profile, RETC, TDR*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Variability in Water Footprints: A Case Study of New Zealand Wines

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Freshwater is the most essential of natural resources, yet freshwater systems are directly threatened by human activities. Agriculture is, by far, the largest freshwater consumer, accounting for more than 70% of all withdrawals. Because of agriculture's huge water usage and its significant contribution as a source of chemical emissions into fresh water, it is considered central of future attempts to address global stress on water quantity and quality.

Water Footprints (WF) of primary products have been proposed as an indicator of the impacts of a production system on freshwater resources. The WF approach was used to assess the impacts of grape and wine production on local freshwater resources, both in terms of water quantity and its quality. We calculated the local water balance of the vineyard and winery by accounting for both the inflow and outflow of soil water store (green water) and groundwater (blue water). This approach is compared with an analysis based solely on consumptive water use, which is commonly used for the WF. The system boundary of the bottle of wine is from the vineyard through to the winery gate in Marlborough. This region produces 52% of New Zealand wine. Our results show that the majority of water consumption and recharge lies within the vineyard. There is a large variation in the WF in the region depending on local climate, mainly rainfall plus soil type and vineyard practices. Our analyses indicate that the impact of growing vines on green water resources is negligible as year-to-year variation in soil-water storage is minimal. The water balance for some high-rainfall locations (>670mm/y) showed that the local water resources under vineyards are being recharged by drainage of water beyond the root zone of the grapes. This results in a negative blue-water footprint for some vineyards. The grey WF, as indicated by the water required to dilute the nitrate-nitrogen (NO3--N), were highly variable depending on the soil type and local rainfall. The weighted average grey WF based on area under production in different soil types was 42.4 L/Kg of grapes. However, the average concentration of NO3--N in the leachate was well within the drinking water standard of 11.3 mg/L. We emphasize the importance of considering the local hydrology in the WF analysis to assess the impact of production system on freshwater resources. Furthermore, highly variable climatic conditions, even over short distances, coupled with the heterogeneous nature of soils across the landscape, bring a large variability to the WF.

Keywords：*: hydrological impacts; water footprints; groundwater; water quality; water quantity*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Mulching Influences on Soil Water, Temperature, and Frost Depth are Related to Crop Sequence in a No-Till Maize/soybean Rotation

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Seasonal freezing and thawing occurs frequently in Northeast China and affects the thermal, biological, and hydrological process in the soil. In this study we investigated the features of soil water content (θ), temperature (T), and frost depth (D) as affected by mulch under a no-till maize/soybean rotation system. The experiment was established in 2011 in a Mollisol located in Lishu of Jilin province, China. Standing maize stubble (1.2×10^4 kg ha^{-1}) and leveled soybean residue (3.5×10^3 kg ha^{-1}) was left on the soil surface after crop harvest. Soil unfrozen water content (θ_U) and T was monitored continuously in the winter/spring periods of 2011/12 and 2012/13 crop seasons. In 2012/13, snow depth and total water content (θ_T) were also measured. The results indicated that comparing to the soybean residue covered plots, the corn residue covered plots had higher T, which led to shallower D values. The maximum D difference between maize stalk plots and soybean straw plot was 10 cm and 70 cm in the 2011/12 and 2012/13 seasons, respectively. During soil freezing time, a significant upward movement of soil water was observed, as indicated by the larger θ_T. On the other hand, θ_U decreased gradually with freezing process and increased with soil temperature in the springs. An increase of soil water storage in the 0-50 cm layer was observed in the maize stubble plots in the freezing period of 2012/13, but dropped to the original level (before frozen) as soil was thawed. No significant θ_U change was observed at depths deeper than 50 cm. For the soybean residue plots, soil water storages increased progressively with the development of freezing in winter. At the end of thawing process, apparent water storage increase was also observed at soil depth greater than 50 cm. Our results suggest that standing maize stubble captures more snow on the soil surface, creates a better thermal condition, and enhances water accumulation in the top layer, which may have applications in studying soil properties and processes, and in the development of no-till technology in Northeast China.

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Comparing Water and Nitrogen Use Efficiencies under Different Cropping Systems in the North China Plain Based on Model Approach

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Water scarcity and nitrate contamination in groundwater are serious problems in the North China Plain (NCP). It is very important to recommend sustainable agricultural management practice for farmers in NCP. The objectives of this study were to compare water and nitrogen use efficiencies (WUE, NUE) and their environmental impacts in the NCP under three different cropping systems: (i) traditional winter wheat (Triticum aestivum L.) and summer maize (Zea mays L.) rotation system under farmer's practice (FP) and reduced water and nitrogen input (RI) practice, (ii) three harvests in two years (HT): spring maize monoculture system followed by winter wheat-summer maize rotation system under reduced input condition, and (iii) continuous spring maize monoculture system (CS) under reduced input condition. After a Water and Nitrogen Management Model (WNMM) was calibrated and validated based on the data collected from the experimental field, the yields, evapotranspiration, amounts of drainage and nitrate leaching, WUE and NUE for all treatments were all calculated. The results showed that the difference of the irrigation amounts between the FP and RI treatments was small, while the difference of fertilizer application rate is significant, the amounts for RI (540 kg N ha-1) was only half of that of FP (1100 kg N ha-1). The annual average yields under FP and RI practices were 11579 and 11748 kg ha-1, respectively, their difference was not significant. The WUE and NUE for FP were 1.65 kg m-3 and 15 kg kg-1 N-1, respectively. While the WUE and NUE was increased by 5.7% and 60% separately under RI treatment. N leaching and NH3 volatilization were the main pathway of N loss. Amounts of N leaching were 407 and 68 kg N ha-1 for FP and RI, respectively, and NH3 volatilization was 282 and 104 kg N ha-1 for FP and RI, respectively. For the three cropping systems under reduced conditions, the irrigation amounts were 720, 545 and 265 mm, respectively for RI, HT and CS, While the rate of N fertilization were 540, 335 and 165 kg N ha-1, respectively. The total yields (two years) for the RI, HT and CS treatments were 23496, 20050 and 17976 kg ha-1, respectively. The differences of drainage among three copping systems were not significant. Amounts of N leaching were in the order RI>>HT CS, and NH3 volatilization were in the order: RI>HT>CS. Compared with that under the RI treatment, the WUEs were increased by 3.6% and 30% separately, and NUEs were increased by 33% and 50% under HT and CS treatments. However, the irrigation amount and fertilizer N input for CS was only one-third and 50% of those under RI practice, respectively. Therefore, the CS cropping system should be recommended to farmers in order to reduce the risk of over-exploitation of groundwater and to develop sustainable agricultural production in the NCP.

Keywords：*water and nitrogen management, cropping system, yield, N leaching, water and N use efficiencies*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Application of Penta-Needle Heat Pulse Probe for Variably Saturated Water Flux Estimation

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The potential for using heat pulse probes for estimating soil water flux as well as soil thermal properties has received more attention this past decade. Among these, many studies were carried out in saturated conditions, while few studies were reported for unsaturated water flow. The purpose of this study was to apply heat pulse probe measurements to both saturated and unsaturated water flows in soils, and to investigate its applicability and limitations.

The Penta-needle heat pulse probe, which has a central heater needle surrounded by two pairs of orthogonally arranged thermistors, was used to estimate two directional water flux. Steady-state saturated water flow and unit-gradient unsaturated water flow experiments were conducted in Tottori dune sand and Mie Andisol. To achieve saturated conditions, the sand was packed in a water–filled column at a bulk density of 1.62 g/cm3. The Andisol was packed in the column with a bulk density of 0.98 g/cm3 and afterward it was saturated by applying water from column bottom. A glass filter was located at the bottom of the column. Water was applied from the top of the column at fixed rates using a peristaltic pump, and outflows from the bottom were measured by a scale. The flow rates were decreased stepwise from fast (around 500 cm/day) to slow rates (around 10 cm/day) and heat pulse measurements were conducted at each step. Using faster flow steps, steady state saturated water flows were developed. Steady state conditions for unit-gradient - unsaturated water flow were developed by controlling suction at the column bottom, in which water contents were uniform and water flowed by gravity. Heater-thermistor needle spacings of the penta-needle heat pulse probe were calibrated by applying an analytical solution to temperature rise data measured under a saturated and static condition. Each experiment, including packing soil and water flow testing, were repeated a few times.

In saturated conditions, water fluxes estimated by the heat pulse probe agreed well with independently measured water flux for Tottori dune sand ($R2 > 0.95$). For unsaturated conditions, estimated water fluxes agreed well with actual fluxes under some conditions. However, for some of the unsaturated flow experiments, underestimations by more than 100 cm/day of actual fluxes were found. In particular for overlapping flow rates where both saturated and unsaturated water fluxes achieved 130 cm/day the underestimation for unsaturated flow was found to be around 100 cm/day. The observed temperature rise data for this unsaturated condition showed an inverse relation where upstream temperatures were higher than downstream temperatures. We believe this result comes from an inhomogeneous distribution of diverging and converging pathways of the water- and air-phases within the probe measurement area. For example, if water content at the downstream thermistor is larger than at the upstream thermistor, temperature rise can be lower due to larger volumetric heat capacity below. For Mie Andisol, estimations of unsaturated water flux indicated better agreements with actual fluxes than in the case of the sand. Since the pore size of Andisol is smaller, the change of soil water content due to drainage was smaller than the sand for the same water flux. The reduced inhomogeneity of water- and air-phases in finer textured soils potentially results in better estimation of unsaturated water fluxes.

Keywords：*penta-needle heat pulse probe, unsaturated soil water flux*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Assessment of Agricultural Land Capability Using Gis and Radar Imagery, Central Province, Papua New Guinea

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Accurate and reliable spatial data on soil types is very limited in Papua New Guinea. The only regional digital dataset available is the Papua New Guinea Resource Information System (PNGRIS). This dataset is a highly extrapolated modelled GIS dataset which provides only a coarse and broad interpolation of probable soils which does not provide realistic on ground soil representation.

Using a 10 m Digital Elevation Model (DEM) derived from GEOSAR Radar data a four class Topographic Position Index was generated using Land Facet Tools Extension for ArcGIS (Jenness et. al 2011). This extension divided the topography into Ridges, Upper Slopes, Gentle Slopes and Valleys. Using this classification ”Lower Slopes” of less than and equal to 10o were selected as potential suitable sites for intensified arable agriculture. Slopes above 10o gradient are more susceptible to rill and sheet erosion due to the intense high precipitation events experienced during the wet season.

This broad topographic based classification was further constrained by the bedrock geology underling the previously identified lower slopes. The soils best suited to intensive agricultural production were identified as those areas underlain by intermediate or mafic rocks e.g. basalt, gabbro and other igneous rocks high in ferro-magnesium minerals and iron oxides and their derivatives which provide the potential for the development of more productive and sustainable agricultural soils.

This broad first pass classification identified 41,533 hectares of land for potential agricultural expansion within the Rigo District in the coastal lowlands and foothills centred about the town of Kwikila some two hours by road southeast of the capital Port Moresby. Of the 41,533 ha identified some 10,632 ha is identified within PNGRIS as being prone to waterlogging and inundation of varying duration and severity. Most observed current agriculture land also falls within this first pass classification.

The coastal lowlands and adjacent elevated areas are known to have highly variable topography, including coastal plains, steep escarpments and dissected uplands/plateaux. Soils are also variable, with substantial areas of the coastal lowlands susceptible to inundation and steeper slopes overlain by shallow soils being susceptible to erosion (Bleeker 1983, Hanson et al 2001). For expansion of agriculture in Central Province, more detailed understanding of the location of suitable soils and their topographic limitations is needed. Historically, this would have been achieved through soil surveys, however, modern tools of GIS and radar imaging provide for rapid assessment of land capability for particular purposes. This assessment can be followed by ‘ground truthing’ and coupled with existing knowledge from, for example, field trials of crops and field data on soils, to assist in final

assessment and decision making regarding agricultural development. This paper reports on the assessment of land capability in one potential area for agricultural development in Papua New Guinea, the Rigo district to the south east of Port Moresby.

Clearly, there are significant areas of land available for agricultural development in Rigo district, and by extrapolation, other areas of Central Province and beyond. However, for effective development, appropriate agronomic practices will need to be developed; these being part of other work being conducted by the authors and other colleagues. Land tenure issues notwithstanding these data will assist the sustainable agricultural development process in PNG and increase employment and business prospects for local farmer cooperatives.

We recommend using high resolution radar generated topographic coverage's in combination with soil parent material classification based on the mapped bedrock lithology as a base to generate more reliable land suitability maps and show national and local government development bodies, aid agencies and the village farmer cooperatives the areas available for land use intensification and sustainable national agricultural development. The maps would then be combined with other local data to provide a sound basis for development decisions and to guide agronomic practice.

Keywords：*PNG, radar, GIS, DEM, slope, land capability, soil*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Soil Water Carrying Capacity for Vegetation in a Small Watershed on the Loess Plateau of China

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The Loess Plateau is characterized by the extensive degradation of ecosystem due to the severe soil erosion. The revegetation was proved to be effective approach to rehabilitate the degraded ecosystem in the Loess Plateau. However, the ecosystem in the Loess Plateau is limited by the availability of soil water, while the relationship between soil water carrying capacity and plant growth is fundamental for the revegetation in the region. To provide a quantitative approach and make recommendations in planning and managing vegetation construction in small watersheds on the Plateau, we present the definition of soil water carrying capacity for vegetationas the limits that are the largest density of vegetation community when soil water consumption is equal to or smaller than soil water supply in the root zone from which plant roots can extract water on an annual basis under reasonable management system. The empirical model and process model were used to assess soil water carrying capacity for vegetationas in a small watershed in the northern Loess Plateau. The process model, which was developed coupling hydrological with bio-geochemical processes, was better in terms of mechanisms, prediction, and application. The predicted averaged water carrying capacity were 3.46 t ha-1, 4.23 t ha-1 and 1.57 t ha-1 for Caragana korshinskii, Salix psammophila and Medicago sativa, respectively, in the small watershed. These values can be references for vegetation recovery for small watersheds on the Loess Plateau.

Keywords：*Soil water carrying capacity; small watershed; the Loess Plateau*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Evaluation of Least Limiting Water Range by Vegetative and Physiological Parameters of Pistachio Seedlings

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Continuous availability of soil water is an important factor for plant growth. Both lack of adequate access to water in soils, or adequate oxygen in saturated soils, may reduce or even stop plant growth. In order to study the behavior of pistachio seedling at various moisture levels and to determine non limiting water range for its growth, a greenhouse experiment with two levels of compaction at six moisture levels with three replications was conducted. After transferring the pistachio seedlings (Pistachio vera L.) into soil cylinders and their establishment, six different volumetric water contents for each compaction level were applied. Stomatal conductance in the third mature leaf, proline content, leaf relative water content (RWC) and leaf area were determined. The effect of moisture levels on all growth parameters were significant ($P<0.01$). With bulk density of 1.5 g cm-3, the seedlings faced with vegetative and physiological limitations at the range of 7 to 14 percent volumetric water content. Thus non-limiting water range for pistachio seedling at this bulk density level ranged from 14 to 43 percent volumetric moisture. In the compacted treatment (bulk density of 1.8 g cm-3) the seedlings, both vegetative growth and physiological activities were considered within the range of 8-19 percent water content due to moisture deficit, at the range of 23-32, soil poor aeration led to growth retardation. Also non-limiting water range at this compaction level ranged from 19-23 percent water content. The least limiting water range predicted from Dasilva et al. model at the two Db of 1.5 and 1.8 g cm-3 were 11- 25 and 20- 22 percent, respectively. The differences between the predicted range and range obtained based on the seedling response implies the need for the calibration of the predicting model for each particular soil and plant.

Keywords：*Leaf stomatal conductance, Non limiting water range, Proline, Relative water content.*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Determination Moisture Stress Pistachio Tree by Using Sap Flow Measurement

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Traditionally, methods to estimate irrigation needs and scheduling worldwide have been based on soil measurements and meteorological data. However, they do not take into account plant responses to water deficit and over- irrigation. Both methods do not reflect accurately the actual water status or uptake by the plant. To determine the onset of water stress on pistachio tree, by using the monitoring sap velocity ,the field experiment were conducted on pistachio tree (11 years old), in the agricultural and natural resources research center, East Azarbaijan, Iran.The moisture of one plot (including one tree), were retained at field capacity in the depth of 0 to 50 cm during the experiment. In other plot (including one tree), the soil was saturated in the depth of 0 to 50 cm and allowed to reduce the soil moisture to the permanent wilting point and lower. The velocity of sap flow was determined in two trees. The first steps of the experiments were continued until the differences between the sap flow velocity of two treatments were appeared. Then second round of experiment started. Sixteenth day of in the first repeat and fifteenth day of at the second repeat, the difference between the two treatments was apparent in the sap velocity. Soil moisture were 8.7% and 8% in these days, respectively. The results showed that nearly, close to 8% volumetric moisture, precedes deficit water for pistachio tree.

Keywords：*pistachio, sap flow velocity, soil moisture, stress*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Estimating Precipitation and Actual Evaporation from Precision Lysimeter Measurements

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Lysimeters are excellent tools for obtaining reliable data about seepage water quantity and quality. Large weighable lysimeters furthermore permit the quantification of the water balance of the soil and the precise measurement of water exchange at both the soil-atmosphere interface, by rain, dew, fog, and rime, and the flux below the root zone toward the groundwater. If well embedded into a similarly vegetated environment, they avoid errors made by traditional measurement systems, such as the wind error of Hellman rain samplers, or the island error of class-A pans, or the heterogeneity error that affects any readings from in situ instrumentation of soil water state variables. If the amount of seepage water is recorded separately, the time series of the lysimeter mass represents the remaining parts of the water balance equation: increasing mass indicates precipitation, decreasing mass evapotranspiration. Whereas the soil water mass balance (precipitation minus actual evapotranspiration) is always accurate in lysimeter systems, a particular problem arises if both, precipitation and evapotranspiration, is estimated from the lysimeter, because increases and decreases in weight in specified time intervals are affected by random fluctuations in lysimeter weight, which might be caused by wind or other disturbances. The analysis of precipitation, evapotranspiration and the change of stored water volume from the time series of the lysimeter mass will therefore need a strategy where a threshold parameter is applied that integrates random noise from different sources (technical noise, wind velocity …). The contribution demonstrates with synthetic and real measured data from large lysimeters, which strategies of data management can be applied, and which degree of accuracy can be reached when estimating the actual soil-atmosphere boundary fluxes and the soil water balance from lysimeter data.

Keywords：*evaportranspiration, soil water balance, lysimeter*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Estimation of Soil -Water Characteristic Curve Using One-Point Measurement

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Quantitative knowledge of soil hydraulic properties such as the soil moisture characteristics curve (SMC) and the hydraulic conductivity curve is crucial for flow and transport modeling supporting hydrologic and agricultural engineering. However, many laboratory and field methods are currently available for direct measurement of the soil hydraulic properties but, most or all of direct methods are too time consuming and costly. Chin et al. have developed a one parameter method for estimation Fredlund and Xing SMC model using regression analysis. This method needs one-point measured for prediction of SMC. This study was carried out for evaluation of this method for estimation SMC and available water (AW). Forty five soils from UNSODA database and forty two soils from Iranian soils with wide range of hydraulic properties were selected. Smallest root mean square error (RMSE) was obtained when the basic point of SMC set at the matric suction of 33 and 50 kPa. Large coefficient of determination (R2=0.96) and small RMSE (0.026) between estimated and measured soil moisture content confirmed that the current approach is a suitable method for estimation of SMC in quite divers soils. Small RMSE and positive and significant correlation between measured and estimated available water showed that current approach properly estimates the AW as well. Comparison of the results demonstrated that one parameter method is more accurate than the several previous developed pedotransfer functions for the Iranian soils.

Keywords：*Available water, Fredlund and Xing SMC model, One- point measurement, One parameter SMC model*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Assessment of Soil Chemical Properties (EC, SAR, pH) in Downstrems of a Qanat and Well (case Study: Meibod)

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Qanat has been the most cost-effective, and ecologically method of exploitation of groundwater during last 30 centuries. Eextensive drilling of deep and semi-deep wells in the last fifty years as well as excess pumping of water has disturbed the water table and lowered it to a considerable extent in the Yazd-Ardakan basin. At present many of the qanat in Iran are dried. In this study, soil chemical properties in the downstream of a well (Drpayab, Amirabad) and a qanat (Eshratabad) in Meybod are analyzed. Considering some indices such as distances, shadowing, and etc), some soil profile were taken in the orchards irrigated with qanat water (3 samples on each horizon A, B1, B2), orchards irrigated with well water (3 samples on each horizon A, B1, B2), wheat farmland irrigated by well water (one soil sample) and qanat water (one soil sample), barley farmland irrigated with well water (one sample) and qanat water (one soil sample). In addition, three soil samples on each horizon A, B1, B2were taken from an area outside of the well and the qanat as the control samples (3 samples). Also, four water samples in order to analysis of chemical pollution and EC, SAR, pH, phosphate, nitrate, were taken from the qanat and analyzed. Soil samples were analyzed in the faculty laboratory and other water asmpled were examined in the laboratory of the Biology Department. A number of physical and chemicals analysis such as EC, SAR, pH, gypsum, lime, calcium - magnesium, organic matter and soil organic carbon measurements were done on the soil samples. Results were analyzed using descriptive and inferential statistics methods. Fifty questionnaires were filled out by the region farmers to gather some information on crop surface area, crop type, and land management. The aim of this study was to evaluate the ecological sustainability of the study area in irrigation and agriculture. General results indicate qanat water or well water for irrigation has not significant effects on soil chemical properties such as EC, SAR, pH. Between wheat and barley crops and non-irrigated land (bare), there is significant differences between EC, SAR. Significant changes in the area under cultivation in the qanat and wells lands have not occurred during recent years.

Keywords：*Arid Lands, Qanat, wells, Soil*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

A Multi-Frequency Approach to Inexpensive, Accurate Dielectric Measurements of Soil Water Content

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The greatest challenge in estimating soil water content from dielectric measurements derives from the dependence of soil permittivity on,a number of additional environmental (such as salinity, temperature) and structural (bulk density, texture etc.) parameters besides water content. The ideal relationship between soil dielectric permittivity and water content (sometimes referred to as universal relationship) is one that performs satisfactorily under all possible instances of the additional variables. We show that when permittivity is measured at a single frequency, an ideal relationship does not exist. This is true in spite of conventional wisdom suggesting that those effects can be mitigated by increasing the measurement frequency. As a consequence, high frequency techniques, such as TDR, are often believed to provide the greatest accuracy. However, this is only partially true. While soil permittivity is indeed only slightly affected by salinity in the frequency range characteristic of TDR, the effects from texture are much more pronounced there compared to lower frequency techniques. This is due to the dielectric properties displayed by bound water (abundant in fine textured soils), which differ substantially from those of free water (predominant in coarse soils). Multivariate statistical analysis suggests that a much more robust predictor for soil water content can be obtained from permittivity measurements at multiple frequencies. As an alternative to classical broadband spectroscopy, which appears too sophisticated and expensive for most practical applications, we provide an example of dielectric measurements at three different frequencies, combined with soil electrical conductivity and temperature, as an alternative predictor for water content. Such measurements are conveniently obtained with a traditional capacitance sensor through a slight modification of circuitry. The proposed method was tested for four different soils (sand, sandy loam, silt loam and clay) and four salinities (pore water from 0 to 15 dS/m). The regression analysis with multi-frequency predictors was carried out through an artificial neural network. Results show considerable improvement of the proposed multi-frequency approach over conventional single frequency measurements.

Keywords：*soil moisture, water content, multi-frequency analysis, saline soils*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Using Hyper-Spectral Data to Estimate the Van Genuchten-Mualem Soil Hydraulic Properties

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Summary
Soil hydraulic properties are mandatory for describing and predicting soil hydrologic behavior using hydrologic, hydro-geologic and solute transport models in the vadose zone. Direct measurements of soil hydraulic properties are costly, time consuming, invasive, user and method dependent. In the past three decades, many studies have indicated the capability of pedotransfer functions, PTFs, to estimate soil hydraulic properties from easily available soil data. In the last years, several studies have addressed the potential of soil spectroscopy to provide predictors to estimate a large number of basic soil properties. However, very few studies have been conducted using spectral data to estimate soil hydraulic properties using Vis-NIR-SWIR soil spectroscopy. This study aimed to estimate van Genuchten-Mualem, vG-M, hydraulic parameters (i.e. α*, n, Ks* and θs) using laboratory measurements of soil spectral reflectance in Vis-NIR-SWIR (350-2500 nm) range. Consequently, a large number of soil samples with various soil textures were collected from Zanjanrrood sub-watershed region, northwest of Iran. Soil water retentions were measured at twelve pressure heads (0, 5, 10, 50, 100, 330, 1000, 3000, 5000, 10000 and 15000 cm) using sand-box apparatus and pressure plate extractor. Using nonlinear least-squares optimization, the van Genuchtent retention function was fitted to observed data to estimate parameters α, n and m. Saturated hydraulic conductivity of undisturbed soil cores were measured using constant and falling heads methods in the laboratory. Spectra of soil samples were recorded in Vis, NIR and SWIR range using a portable spectroradiometer apparatus. An average spectrum for each soil sample was generated by arithmetic averaging the 20 spectra for each soil sample. The statistical analyses were performed with the continuum removed spectra after applying a Savitsky–Golay smoothing with a second order polynomial in segments 3 points. We considered three different types of spectral aggregation scenarios including scenario I (ASD full spectrum), scenario II (EnMAP bands) and scenario III (Sentinel-2 bands) and derived three sets of parametric spectral transfer functions, STFs, to estimate vG-M parameters. Spectral reflectance values were then correlated with MvG parameters. The widely used stepwise multiple linear regression method, SMLR, was used to relate the hydraulic parameters with spectral attributes to derive the STFs. The derived STFs were finally validated using a subset of the whole dataset.
The obtained results indicated that modeling with scenario I and II resulted in higher prediction accuracies. R2 values for α* and n in scenario I and II were equal to 0.30, 0.34, 0.39 and 0.31, respectively. R2 values were highest for Ks* in scenario I and II with values equal to 0.58 and 0.57, respectively. Using scenario III led to low coefficients of determination. In all scenarios, the lowest R2 values were obtained for θs with values around 0.10. The significant (1% level of significance) spectral wavelengths to estimate soil hydraulic parameters occurred close to 552 nm, 687 nm, 877 nm, 1417 nm, 1932 nm, 2277 nm, 2307 nm, 2317 nm, 2427 nm and 2447 nm (scenario I). The significant spectral bands in estimating α*,n,Ks* and θs were including 16, 44, 79, 192, 201, 226, 230, 235 and 244 band number (scenario II) and also band number of 1, 3, 5, 9 and 11 (scenario III). These results suggest that hydraulic parameter estimation by scenario I and II can be used to indirectly estimate the hydraulic properties of soil. Scenario II and III may be suitable for large scales applications and further investigations through EnMAP and Sentinel-2 satellite remote sensing. According to these results, spectral reflectance over visible, near-infrared and shortwave infrared range has the potential of being used as only input variables of PTFs for estimating MvG hydraulic parameters. However, soil hydraulic properties cannot be estimated precisely by the soil spectroscopy techniques, but they can still be characterized with good agreement. This can be especially helpful for soil hydraulic properties that do not have direct relationships with spectral reflectance data. However, we caution against the use of derived STFs in other areas without validation, because the potential difference in soil properties could hinder its performance (e.g. wet condition of soil, organic soils, gypsiferous soils, saline soils).

Keywords：*Soil hydraulic properties; Spectral transfer functions; EnMAP sensor; Sentinel-2 sensor*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Water Content Extraction in Eucaliptus Plantation

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The Eucalyptus forestation is growing fast in south Brazil, mainly on sandy soils with natural grass grazing. The substitution of soil use from natural Grass grazing involving beef cattle by plantation of forest, especially Eucalyptus has rising much controversial discussion about soil water use and soil conservation concerns. Studies have been conducted to explore and try to answer how much water is extracted by Eucalyptus as compared to natural grass in Alfisols. The strategy includes the use of areas side by side of Eucalyptus grandis forest and natural grass and an experiment with four planting spaces (3,50X3,50; 3,50X1,75; 1,75X1,75 e 1,75X0,87 m) of Eucalyptus dunni Maiden. Soil water content has been monitored down to 1 m using an automated system using TDR, data loggers and soil probes measuring water content every 1 hour for each soil layer instrumented. Other soil physical and plant parameters are being measured to better understand the soil water dynamics. The substitution of natural fields with grass by Eucalyptus forest has not been altered soil bulk density and porosities and the main water storage has been similar to both soil conditions. However soil planting spacing, as expected has shown differences in water use.

Keywords：*water content, water use, Eucalyptus*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Retrieving Soil Surface Water Content from Envisat/asar Radar Data

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Soil moisture is a critical element in the global hydrologic and energy cycle. Monitoring soil moisture is highly important to study the impacts of climate change in Iran. Soil moisture can be measured accurately by in-situ measurements. Direct measurements of soil moisture at large scale, from regional to global scale, are costly, time consuming and often infeasible. Indirect techniques such as active and passive microwave remote sensing have attracted more attentions due to high sensitivity to soil moisture. ScanSAR modes as the ENVISAT ASAR global mode (GM) provide medium spatial and temporal resolution which is a suitable method for monitoring soil moisture at agricultural field. Theoretically, retrieving soil moisture from radar backscattering data could be obtained by an exact solution of Maxwell's equations. Because of the complexity of soil surfaces, this is impractical. Only approximate solutions that are based on some assumptions can be provided analytically. In this study, we used a method to retrieve and monitor soil surface water content. The study was aimed to derive a simple model for bare soils from ASAR GM data, which operate in C-band and horizontal-horizontal (HH) polarization. Consequently, a number of radar images, from January 2012 to March 2012, were provided by European space agency (ESA) for Zanjanrood watershed, northwest of Iran. Exploring the relationship between soil moisture measurements and backscattering coefficient requires a number of preprocessing steps comprising geo-coding, radiometric correction, re-sampling and local incidence angle normalization. Total backscattering coefficient ( ) contributed by soil was calculated. The relationship between processed RADAR signals and TDR sensor based soil surface water content measurements was investigated using spatial autocorrelation (Moran's Index) and modeling spatial relationships (ordinary least square, OLS). A significant (1% level of significance) coefficient of determination (R2=0.68) was observed between both volumetric water content and total backscattering. Cross validation of the results indicated that the model has a performance with the RMSE and relative error of 0.032 cm3 cm-3and 11%, respectively. However, the proposed model had tendency to slightly underestimate (MBE=0.011 cm3cm-3) the estimations. The validation of the remotely sensed soil moisture extracted from ASAR GM data has proven that neglecting roughness effects can be regarded as a valid assumption and operational use of ASAR GM data for soil moisture retrieval using the derived model is possible.

Keywords：*Backscattering coefficient; global mode (GM); regression model; Iran;*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Monitoring of Water Fluxes by Sp and Tdr in the Unsaturated Vadoze Zone during an Intense Cyclone

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Reunion is an island located 700 km east of Madagascar in the southern Indian Ocean region. The Colimacons research station is located on the western slope of Piton des Neiges at 800 m ASL (21°07'47 S and 55°18'19 E). The soil studied at the Colimacons research station was located in the middle of a toposequence in which Andosols prevail. It was classified as an andic Cambisol, which included: (i) a surface A horizon (0-40 cm) altered to a shallow depth (<50 cm) by anthropedogenic processes, and (ii) an andic B horizon (40-200 cm). A pit dug down to 9 m showed that the subsoil is constituted by altered fissured and fractured rocks. The subsoil is composed of three types of rock levels. The first type of rock is hard and very compact, very little altered but cracked. Mineralogy was determined by optical microscopy and polarized light and natural XRD: 65% plagioclase (labrador), 15% Augite, Olivine 10% and 10% oxides (Illmenite, Magnetite and Hematite). They correspond to plagioclase basalts. The pit dug down to 9 m was equipped and protected against weather. The pit was equipped ca. each meter from the floor to the surface (-9, -8, -7… -1 and -0.4 m) with instruments to monitor water contents and fluxes. Time Domain Reflectometry (TDR) probes (CS616, Campbell Scientific) and Self-Potential (SP) probes were connected to a datalogger (CR10X-2M, Campbell Scientific) that recorded measurements on a 10-min basis from January 2007 to the end of March 2007 (day 1 to 80). This study was aimed at assessing whether (i) a continuous measurement with time of self potential and humidity allows us to follow water fluxes in the unsaturated zone and, (ii) which internal and external phenomenon could explain these variations of self potential and humidity during a cyclone period. The strategy adopted was, at first, to analyse simultaneously humidity signal from TDR probes and self-potential signals recorded before and after a cyclone (360 mm in 3 days). During the cyclone Gamede and during the following two weeks, the humidity measurements deducted from TDR probes have all increased. The more they are close to the surface, the more moisture measurements increased earlier and quickly. During this same period, the signals of SP probes showed a coherent and different dynamic. No major signal was observed despite a water flux of 360 mm in three days. The minima of the signals from sensors SP 2 to 10 are offset in time. As the depth increases, the signals of SP probes reach their minimum later. However, these fluctuations have remained low over the entire signal (a few mV to ten mV) throughout the period.

Keywords：*self potential probe, TDR probe, continuous measurement*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Fdr Probe Structure Influence on the Soil Dielectric Spectrum Measurement

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The soil dielectric spectrum are related to the soil physical properties, and those are affected by the structure of the probe too. In order to determine how the probe structure influence the soil dielectric spectrum measurement, we measured the two kinds of soils at four water content level by 10mm and 14mm spacing needle at 28mm probe length, 28mm and 45mm length needle at 10mm spaceing. It has been confirmed that the probe spacing has no effect on the soil dielectric spectrum measurement above 31.2MHz by comparing the dielectric spectrums, and the length of the probe can affect the real or imaginary part of the soil dielectric spectrum in the range of 1M-3GHz. The research show that the spacing of needle is not the key factor to the soil dielectric property measurement within a certain spacing, and the length of the probe had a greater influence on the soil dielectric property measurement. The smaller of the probe length, the larger of the dielectric relaxation frequency. Therefore, the probe length is the important factors that affect soil dielectric measurements. The FDR probe should be shorter, it is good to improve the measurement accuracy and enironmental adaptation.

Keywords：*Soil Dielectric property, FDR, Probe structure*、*Dielectric Spectrum*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Multi-Season, Continuous Measurements of Redox Potential. Value, Methods and Challenges

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The redox potential is an important parameter for chemical speciation, biological processes like greenhouse gas emissions and degradation of organic molecules and matter. In nature its value ranges from -1000mV to + 1000mV, when compared to the standard Hydrogen Electrode. The measurement of the redox potential is usually performed by using a high impedance millivolt meter, connected to a standard reference electrode and a non reacting metal like Platinum. Since the 1970-ies, many researchers have done manual measurements, with varying results. A large issue is the socalled drift in manual measurement, when the redox potential doesn't seem to become stable.

Recent developments have shown that it is well possible to perform semi-continuous measurements, both in water and in soil. The drift here can be seen to be natural variation in time. The measurement is easy in water, and saturated soils. Experiences in the unsaturated zone are promising, showing a lot of natural variation in several sites. Two examples will be presented, using probes made specifically for soil application and an independently running multichannel measurement device (Vorenhout et al, 2011). Good contact with the measurement medium is crucial, and long term stability of the measurement device. The first example is a multi-year monitoring project in an urban soil (Bergen, Norway), aiding the study of organic degradation underneath housing. Here, the redox potential, temperature and soil moisture is studied in a soil profile, down to several meters deep.

General hydrological measurements help interpreting the results. The second example is that of an Asian floodplain, polluted with Arsenic (Araihazar, Bangladesh). Here, the measurement of the redox potential in two profiles down to 5 meters shows that possible spatial and temporal variation in As behavior in groundwater.

The continuous measurement of the redox potential in soils and sediments give new insight in natural variation of processes and influences from abiotic parameters like soil moisture on the production of greenhouse gases. The large amount of data gathered does pose new challenges in terms of analysis of these time series.

Keywords：*Redox potential, spatial heterogeneity, soil moisture, ecology, GHG*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Estimation of Soil Moisture Content in Corn Field Using L-, C-, X-Band Scatterometer Data

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Corn is widely cultivated throughout the world and a staple food in many regions of the world. Soil moisture plays a major role in the global hydrologic cycle, modeling of ecosystem processes, and flood and drought monitoring. Microwave remote sensing is used to estimate soil moisture based on the large contrast between the dielectric properties of wet and dry soil. A ground-based polarimetric scatterometer has an advantage for continuous crop growth and soil moisture content using multi-polarization, multi-frequencies and various incidence angles. In this paper, ground-based multi-frequency (L-, C-, and X-band) polarimetric scatterometer system capable of making observations every 10 min was developed. This system was used to monitor the soil moisture conditions in corn field over an entire growth cycle. Measurements of volumetric soil moisture were obtained and their relationships to the backscatter observations were examined. L-band backscattering coefficients were higher than those observed using C- or X-band during the growth period. The VV backscatter observations were higher than the HH observations during the initial growth stages (till early-July, DOY 155). HH observations were higher than VV observations in the later stages of the growth cycle. Time serious of soil moisture content was not a corresponding with backscattering over the whole growth stage, although it increased relatively until early July (DOY 160). We conducted the relationship between the backscattering coefficients of each band and soil moisture content. Backscattering coefficients for all frequencies were not correlated with soil moisture content when considered over the entire stage ($r \leq 0.48$). However, L-band HH polarization (L-HH) had a good correlation with soil moisture ($r=0.85$) when a threshold of Leaf Area Index (LAI) < 2 was used in the analysis. Our previous investigation had indicated that this frequency had the strongest relationship to soil moisture in a soybean field. The correlation coefficient between soil moisture and radar backscatter observations decreases with an increase in frequency, which was expected since high frequencies are not likely to penetrate the canopy. Based on the observed relationships between backscattering coefficients of three bands and soil moisture contents, prediction equations were developed using the L-band HH-polarization data. Relation between L-HH and soil moisture shows linear pattern and related with soil moisture content ($R2=0.77$). Results from this study show that backscattering coefficients of radar scatterometer appear effective to estimate soil moisture content.

Keywords：*Corn, soil moisture content, polarimetric scatterometer, backscattering coefficients, growth stage*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Satellite Remote Sensing-Based Evapotranspiration in Northeast Asia

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The terrestrial evapotranspiration (ET) is the sum of evaporation from soil surface and transpiration from vegetation. It is a fundamental component to understand the land surface water cycle and the energy interaction between land surface and atmosphere. Thus, the quantification of ET is important to improve our understandings such as the terrestrial water budget as well as water management. Accurate estimation of ET is very difficult due to complex interactions between atmosphere-vegetation-soil. There are lots of flux tower measurements sites to monitor ET variations for various biome types in Northeast Asia. Numerous studies to monitor ET have been conducted, though the regional scale studies on ET are still few in Northeast Asia. Satellite remote sensing technique provides an opportunity to estimate ET at the large scale area. In this study, therefore, we present the methodology for estimating ET based on the satellite remotely sensed data under clear and cloudy sky conditions in Northeast Asia. Various atmosphere and land products produced from the Moderate Resolution Imaging Spectroradiometer (MODIS) were used to estimate ET. However, frequent cloud cover results in a substantial loss of remote sensing information, limiting the capability of continuous ET monitoring for the monsoon region such as the Northeast Asia. For this reason, the gap-filling processes were conducted for meteorological and land surface variables. The missing data for the temperature variables derived from MODIS products was filled by integrating the brightness temperature produced from the Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) sensor. The radiation components including downward shortwave radiation and longwave radiation were estimated using MODIS cloud properties product under cloudy sky conditions. The effects due to cloud contamination were corrected for the land surface products including leaf area index and albedo. The operational MODIS ET algorithm, which considers the vegetation transpiration, the soil evaporation, and the evaporation from wet canopy surface, was applied to estimate the terrestrial ET in Northeast Asia. The satellite-based input variables and ET estimates was evaluated using the flux tower measurements at eight sites over study domain. The satellite-based input variables for estimating ET showed good agreements in comparison with flux tower observations. The resulting ET calculations showed generally favorable agreement (RMSE < 1.3 mm day-1) with respect to in situ measurements from eight regional flux tower sites. The estimated mean annual ET for three years from 2006 to 2008 was approximately 360 mm yr-1 over the Northeast Asia domain. ET rates were generally higher at the cropland in China, while it was lower at the grassland in Mongolia. The research period to estimate regional ET using satellite dataset will be extended from 2003 to 2010. Our preliminary results showed that the satellite remote sensing data can be successfully applied to estimate ET. In addition, this study showed the potentials to estimate ET under clear and cloudy sky conditions by applying the gap-filling methods such as the multiple sensors integration, and can offer a good chance to improve our knowledge on the land surface energy balance.

Keywords：*evapotranspiration, remote sensing, MODIS*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Automated Irrigation System Using Soil Moisture Sensor in Horticulture

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With increasing interest in sustainable agriculture, efficient irrigation became one of the critical techniques to utilize the limited fresh water resources in horticultural crop production. Recently developed soil moisture sensors can provide real-time information about the moisture and general nutrient status of soilless substrates, to help growers make more informed irrigation and fertigation decisions on a daily basis. Using a suitable program with dataloggers and sensors, a better described soil moisture status and electric conductivity can be monitored and controlled, thus efficient irrigation could be followed. Efficient irrigation helped ornamental growers to produce better quality crops with less inputs such as water, fertilizer, and labors. In container nursery production in Georgia (USA), this system reduced water usage by 83% with quality hydrangea production, and reduced root disease for gardenia crop production along with shortening the production cycle. In research for drought physiology of plants, this system could be used to understand the plant responses at a specific soil moisture level, which can describe the drought level in a practical way. Practical production with this system could impose a mild drought acclimation for bedding plants, which can help the plants to have a better performance in landscape with a healthy crop growth. Overall, the automated irrigation system with soil moisture sensors has a great potential for crop production as well as research.

Keywords：*dielectric sensor, datalogger, efficient irrigation, volumetric water content*

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[C2.1-3] Hydro-Ecological Observatories and Advances in Soil Measurements and Sensors

Comparison Pore Structure and Physical Properties between Anthropogenic Paddy Field Soil and Natural Soil

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Human influence on soil formation has dramatically increased as the development of human civilization and industry. Anthropogenic soils are defined in USDA soil taxonomy as 'soils that have their major properties derived from human activities'. Increase of anthropogenic soils induced research of those soils; classification, chemical and physical characteristics of anthropogenic soils. However there has been no report on soil pore properties from anthropogenic soils so far. This study hypothesized that anthropogenic paddy field soils may have different physical properties than ones from natural paddy field soils. Therefore the objectives of this study were to characterize physical properties of anthropogenic paddy field soils and to find differences between natural and anthropogenic paddy field soils. Soil samples of a natural paddy field were taken from Ansung, Gyeonggi-do (Ansung site) and samples of anthropogenic paddy fields were from Gumi, Gyeongsangnam-do (Gasan) and Naju-si, Jeollanam-do (Ichang), Korea where paddy fields were remodeled in 2011-2012. Bottom of anthropogenic soils were buried by river sediments and then covered by about 50cm of original paddy field soils. Samples were taken at three different depths; top (0~20 cm), interference (50~60 cm) and bottom (> 60 cm) for the anthropogenic soils and top (0~20 cm), ploughpan (20~30 cm) and bottom (> 50 cm) for the natural soil. Samples were analyzed for routine physical properties and computer tomography (CT) scans. The CT scan provided 3 dimensional images to calculate pore size, length, tortuosity of soil pores. Pore morphological properties were measured by pore network model. Fractal analysis was applied to quantify pore structure within three dimensional soil images. The results of measured physical properties (bulk density, porosity) did not show differences across depths and sites, but hardness and water content had differences. The interference and ploughpan layers had greater hardness and smaller water content than top or bottom layers across sites. These differences repeated within the results of pore morphology. Top soil samples from all sites had greater pore numbers and sizes than others. Fractal analyses showed that top soils had more heterogeneous pore structures than others layers. The bottom layer of the Gasan and Ichang site showed more degradation of pore properties than ploughpan and bottom layer from the Ansung site. These results concluded that anthropogenic soils may have more degraded pore properties as depth increases. The remodeled paddy fields may need more fundamental remediation to improve physical conditions.

Keywords：*Anthropogenic soil, Computer tomography, Pore structure, Fractal dimension*

P3-261

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Sub-Milli Observation of Reduction and Reoxidation of Flooded Soil with Different Water Flow Rate

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Nitrogen and carbon cycle in paddy field is regulated by redox condition of soils. Understanding formation process of reduction and reoxidation layers in flooded soils is important. However, detailed observation of the reoxidation layer had been limited, since it is usually formed as relatively thin layer near soil surface. On the other hand, the recent development of sensors has enabled sub-millimeter observation of redox potential (Eh) and dissolved oxygen concentration (DO) of soil water. To clarify effects of water flow on the reduction and reoxidation processes near soil surface, we performed column experiment using the micro Eh and DO sensors. The soil used in this study was collected at experimental field of Mie University in May, 2012. The experimental field had been managed as a paddy field for decades. The soil was passed through a 2-mm screen and mixed with 5 mg-glucose for 100 g-dry soil. To obtain a homogenous soil bulk density (1.4 g/cm^3 as under field conditions), the soil was packed in 2.5-cm increments into an acrylic column with an inner diameter of 5 cm and a height of 15 cm. The micro Eh and DO sensors with spatial resolution of 500 micrometer were set at 0.2 cm depth from soil surface. Another Eh sensors with spatial resolution of 1 cm, water pressure meters, and four electrode EC sensors were also set at 2.5 cm and 7.5 cm depth, respectively. After the soil was saturated by supplying distilled water from bottom of the column, water was applied to the top of the column with a 1 cm constant head maintained by the Mariotte bottle, and bottom of the column was opened to the atmosphere to allow water flow. The water flow rate was estimated by monitoring weight change in the Marriotte bottle and amount of the drainage water. The Eh and DO of water prior to the infiltration were 280 mV and 6.5 mg/L, respectively. At several times during experiment, the micro sensors were vertically inserted from soil surface with 10 micrometer/second, and profiles of Eh and DO of the surface soil were measured by 100 micrometer intervals. The experiment was conducted at 25 °C constant temperature room. Different flow rate were observed even if the same experimental condition was given to identical samples. The flow rate was constant at 0.02 cm/d in Run 1, while it increased to 10 cm/d in Run 2 after 4 days elapsed. This may come from unpredictable clogging of soil pores by H_2 bubble arising from organic decomposition. The Eh at deeper than 2.5 cm in both Run 1 and 2 steeply decreased to 300 mV just after ponded, kept constant for one or two days and increased to about 100 mV, and then gradually decreased. This corresponds to consumption of oxygen, electron and H_2 emission associated with organic decomposition, and reduction of oxide in the soil. In contrast, the Eh near surface (0.2 cm depth) was relatively high and unstable, and varied by the water flow rate. In Run 1, the Eh at 0.2 cm depth increased from -300 mV to 100 mV for 24 hour after ponded and kept constant for more than 10 days. In Run 2 (high flow rate), meanwhile, the Eh at 0.2 cm depth increased after 5 days and 0.6-cm thick of surface reoxidaized layer with Eh > 400 mV and DO > 2 mg/L was formed. It is considered that an adequate amount of oxygen against the microbial consumption had supplied by the water flow. Coupled glucose and oxygen transports was also calculated and the shape of Eh and DO profiles near soil surface was discussed.

Keywords：*redox potential, dissolved oxygen, water flow rate, soil surface*

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2. Soil Organic Carbon: Dynamics, Stabilization, and Environmental Implications

Assessing Organic Carbon Dynamics in Salt-Affected Soils Amended with Gypsum and Plant Residues

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Osmotic stress caused by high salinity has been shown to adversely affect water uptake by plants and microbes and therefore reduce both plant growth and microbial activity. Organic carbon stocks in salt affected soils are thus influenced by two contrasting factors: (i) reduced carbon input due to decreased plant growth which would reduce organic C levels and (ii) reduced decomposition rates which would increase C stocks if organic C input is constant. The physico-chemical properties of salt-affected soils have been well-studied, however little is known about the effects of salinity and sodicity on C dynamics and therefore C accumulation or loss from these soils. This study aims to determine the quantity and quality of organic carbon in salt-affected soils with different physical and chemical properties amended with gypsum and finely grounded wheat residues.The soils were collected from 0-30 cm different sites in South Australia with dry Mediterranean climate and South East Queensland with a sub-tropical monsoon climate and differ in salinity, texture and vegetation cover. The following properties were measured: texture by Hydrometer method, EC, pH, and sodium adsorption ratio (SAR) in 1:5 soil water extract, total organic C with mass spectrometer (GV Isoprime, Manchester, UK), respiration by trapping the CO2 released from incubated samples in NaOH and microbial biomass carbon (MBC) with Fumigation extraction method. The unamended soil samples were alkaline (i.e. pH=9.2) and pH markedly decreased with the addition of both wheat residues and gypsum (PG). Gypsum is a source of Ca2+ and addition of it to sodic soils leads to either precipitation of Ca2+ as CaCO3/Ca(HCO3)2 and proton generation which results in a decrease on pH. Decomposition of organic material and the production of organic acids in plant residue amended soils decreased the pH in these soils. Increasing in partial pressure of CO2 as a result of increased soil respiration is another reason of decreased pH in organic material amended soils. Gypsum increased the EC in both soils and addition of organic material slightly increased EC. Addition of plant residues alone increased the EC most likely because of either increased ion concentration in the soil solution, or the formation of organic acids or both. Similarly gypsum and residue addition influenced the SAR of soil extracts ($P<0.05$). The least SAR values were observed in gypsum amended soils which indicates Ca2+ replaced exchangeable Na+ ions. Low rates of respiration and low MBC were found in unamended soils. In general, in gypsum-amended soils similar or slightly lower respiration rates than the unamended soils were observed. Maximum respiration was observed in soils amended with both gypsum and plant residue (PG). MBC was significantly higher in residue amended soils.

Keywords：*Salt-affected soils, Carbon, sodic soils*

P3-263

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

In Vitro Phosphate Solubilization Study by Phosphate Solubilizing Microorganisms Isolated from Citrus Rhizosphere

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Microorganisms are important component of soil. Soil bacteria and fungi mediate soil processes such as decomposition , nutrient mobilization and mineralization, storage release of nutrient and water , nitrogen fixation and denitrification. Phosphate solubilizing microorganisms include different types of microorganisms that convert insoluble phosphatic compounds into soluble forms. Important genera of phosphate solubilizing bacteria are Bacillus and Pseudomonas. Aspergillus and Penicillium are important phosphate solubilizing fungal genera. It has been observed that high proportion of phosphate solubilizing microorganisms are concentrated in rhizosphere of plant. Since phosphate activities are found to be much higher in rhizosphere soil than in bulk. Inorganic phosphorus solubilizing microorganisms are more concentrated in rhizosphere plants than in bulk soil.

The objective of this research was to evaluate the biochemical and physiological characteristics of indigenous citrus rhizosphere Phosphate solubilizing microorganism and to develop a better understanding of the accurate mechanism of P solubilization by correlating all the determined parameters.

Phosphate solubilizing capacity of 3 PSB and 3 PSF was determined in 100 ml PKV broth medium.0.25 g/l insoluble phosphate (in the form of tricalcium phosphate) was added to 100 ml broth before sterilization then 0.5 ml suspension of each microbial culture was added. A control without any PSm was also maintained. The organisms were allowed to grow for 5 days at 30 degree celsius. The supernatant was collected in 100 ml volumetric flask and volume was make up to 00 ml with distilled water. While in case of fungi the centrifuged solution was filtered and clear solution was made upto 100 ml with distilled water. Thus extract of each solution was prepared and avaliable phosphorus was determined.

Several phosphate solubilizing microorganisms were isolated from citrus rhizosphere (Nagpur mandarin) on the basis of acid production. From these species, three best bacterial species viz., Pseudomonas fluorescens, Bacillus mycoides and Bacillus polymyxa and fungal species viz., Aspergillus awamorii, Trichoderma harzianum, Trichoderma viridi were selected for the study. A control was kept against these experiment so as to compare acid production as pH drops. Change in pH of these isolates showed abrupt changes during seven days of incubation in Pikovskayas agar and broth medium consisting of phosphate compounds. The ability of all microorganism to solubilise phosphate varied from species to species. This was evaluated by determining the pH drop and acid production. Several organic and less amount of inorganic acids were produced in the medium. Among these bacterial species Pseudomonas fluorescens showed maximum acid production since there is large pH drop as compare to other bacterial species. In fungal isolates Trichoderma harzianum gives best invitro results giving maximum pH drop as compare to control and other two fungal species. Overall study of these phosphate solubilizing organism showed Trichodema harzianum, fungal species gives best results in vitro.

Pseudomonas fluorescens showed maximum acid production since there is large pH drop as compare to other bacterial species. In fungal isolates Trichoderma harzianum gives best invitro results giving maximum pH drop as compare to control and other two fungal species. Overall study of these phosphate solubilizing organism showed Trichodema harzianum, fungal species gives best results in vitro.

Keywords：*Phosphate solubilizing microorganism (PSM), Phosphate solubilizing fungi (PSF), , Phosphate solubilizing bacteria (PSB), acid production.*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Optimization of Environmental Factors Affecting Biodegradation of Chlorpyrifos in Soil Slurry by Enterobacter Sp. Swlc2

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Chlorpyrifos is one of the most extensively used organophosphorus insecticide in agriculture contaminating soil, wetlands and groundwater and is a significant threat to human health and biodiversity. In this study we used a previously isolated bacterial strain Enterobacter sp. SWLC2 to test its biodegradation potential in soil slurry containing chlorpyrifos residues and to optimize culture conditions for achieving accelerating biodegradation of chlorpyrifos in soil slurries. Factors that were investigated included soil texture, soil: water ratios, initial inoculum size, pH, incubation temperature, aeration, and the use of additional sources of carbon/nutrients like organic sugars, organic acids and amino acids. The results showed that chlorpyrifos degradation was most effectively achieved at an initial inoculum size of 800 µL (OD= 0.80), incubation temperature of 30 oC, in aerated slurries at pH 7, in sandy loam soil. Under these conditions, the bacterium removed up to 87% of spiked chlorpyrifos (100 mg L-1) after 18 days. Abiotic degradation in non inoculated control medium within same incubation period was about 14%. Biodegradation of chlorpyrifos varied in different textured soils, being more rapid in course textured soil than in fine textured soil. Increasing the soil contents in the slurry above 15% resulted in less biodegradation of chlorpyrifos. Exogenous application of glucose, yeast extract and organic acids (succinic acid and citric acid) had stimulatory effect but manitol, acetic acid, nutrient broth and amino acids (arginine, alanine and lysine) had inhibitory effects on biodegradation of chlorpyrifos. This study demonstrates that inoculation of contaminated soils with chlorpyrifos degrading bacterium Enterobacter sp. SWLC2 under optimized conditions provides an efficient bioremediation approach.

Keywords：*Biodegradation, Chlorpyrifos, Enterobacter, Factors, Optimization*

P3-265

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Evaluation of Phosphorus Bioavailability Using Soil Enzyme Activities: Comparison with Chemical Extraction Methods and Crop P Content

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Andisol occupies about half the area of agricultural upland fields in Japan. Phosphorus (P) availability is low in the Andisols because of their high P sorption capacity due to high concentrations of active Al and Fe. Heavy application of P fertilizer, therefore, has been conducted to maximize crop productivity in the Japanese Andisols. However, because global P reserves are limited, there is growing concern about exhaustion of the high-quality phosphate rock. The application of P fertilizer in excess of crop requirement would also cause water eutrophication. Precise evaluation of the P bioavailability in the soils is indispensable for conducting more sustainable and P efficient farming practices. In the present study, P availability was evaluated using chemical extraction methods and the resource allocation model for extracellular enzymes in Japanese cultivated Andisols.

Soil samples (Andisol) were collected from the long-term upland field experiment under fourteen fertilizer management practices at Nagano Vegetable and Ornamental Crops Experimental Station in Shiojiri, Nagano Prefecture, Japan. The fourteen managements were unamended control, NK, PK, NP, NPK, low rate of NPK, high rate of NPK, very high rate of NPK, compost, compost + NK, compost + PK, compost + NP, compost + NPK, and high rate of compost + NPK. Availability of P in the soil was evaluated using chemical extraction methods (Truog and modified Bray-2 tests, and modified Hedley sequential procedure), the resource allocation model for extracellular enzymes proposed by Sinsabaugh and colleagues, and crop (Brassica oleracea L. var. capitata) P content. The P limitation in soil microbial communities was also assessed by examining the effects of P addition on the microbial activity.

Truog-P, modified Bray-2P, and H2O-Pi + NaHCO3-Pi in the modified Hedley procedure were significantly and positively correlated with each other ($P < 0.01$), and also with the amount of P applied as chemical fertilizer and rice straw compost ($P < 0.001$). Crop P content show significant positive correlations with Truog-P ($r2 = 0.90$, $P < 0.001$), the modified Bray-2P ($r2 = 0.90$, $P < 0.001$), H2O-Pi + NaHCO3-Pi ($r2 = 0.92$, $P < 0.001$) and also with the amount of P applied as chemical fertilizer and rice straw compost ($P < 0.001$). From these results, it seems that these methods would allow evaluation of the P availability in the soil. Truog-P and available Pi estimated by the Hedley procedure showed the highest concentrations in plot added with PK + compost, while Bray-2P showed the highest value in plot added with very high rate of NPK. For the modified Hedley procedure, NaOH-Pi and -Po dominated among P fractions across all the management practices, and were significantly correlated with the amount of P applied ($P < 0.001$). Inorganic P accounted for 67-81% of total P in the soil samples, and was increased with the amount of P applied. Acid phosphatase activity was negatively correlated with soil pH ($P < 0.001$) and H2O-Po ($P < 0.01$), whereas alkaline phosphatase activity was not correlated with any P fraction ($P > 0.05$). Both ratios of acid phosphatase to β-D-glucosidase activities and alkaline phosphatase to β-D-glucosidase activities showed significant negative correlations with the available Pi estimated by the Truog and the modified Bray-2 tests and the modified Hedley procedure in the samples ($P < 0.05$), suggesting that the microorganisms might preferentially expend resources in the form of phosphatase synthesis rather than β-D-glucosidase synthesis to acquire P in the P-limited soils. To confirm the hypothesis that these relations were due to increased synthesis of phosphatases by microorganisms in response to P limitation, the effects of addition of C or C + P on dehydrogenase activity, which reflects overall microbial activity, were examined in the soil samples. Response ratio of dehydrogenase activity in C + P amended soil to that in only C amended soil was negatively correlated with available Pi concentration, supporting this hypothesis. The ratio of alkaline phosphatase to β-D-glucosidase activity significantly increased with decreasing crop P content ($P < 0.05$), demonstrating the validity of enzyme assays for evaluating the P availability in the soils from a more biological point of view.

Keywords：*Phosphorus, Andisol, Andosol, soil enzyme, phosphatase, resource allocation model*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Efficacy of Auxin Producing Bacillus Strains in Changing the Root Architecture of Arabidopsis Thaliana and Growth Promoting Ability in Wheat Plant

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Rhizospheric bacteria involve themselves by playing an imperative role in development and growth of plant by diverse mechanisms, among which auxin production is well studied for its effect in changing the plant root morphogenesis. Three strains PNS-2, PNS-12 and PNS-13 were isolated from rhizospheric region, characterized biochemically and further identified by I6S rRNA gene sequencing. These isolates were screened for auxin production by salkowski's method and further confirmed by high performance liquid chromatography coupled with mass spectrometry. The PNS-2, PNS-12 and PNS-13 strains were found to produce 84, 79.6 and 85μg/ml auxin respectively by Salkowski's method. Effect of these auxin producing strains on root architecture was evaluated by using model plant Arabidopsis thaliana by designing a sand system to observe the root architecture up to tertiary level which was not possible in soil system. Auxin producing rhizobacteria caused the significant ($P<0.05$) increase in the primary root length and changed the pattern of secondary roots by increasing their numbers. Efficacy of these strains was further checked on wheat plant growth under laboratory and field conditions. All strains were found to cause the significant ($P<0.05$) improvement in the growth parameters of the wheat plants as compared to the un inoculated one's under laboratory conditions. But application of these strains further in field experiments showed the variable results. These strains increased the number of tillers, grain weight and grain yield over control significantly ($P<0.05$). In the present study the sand system was used as a model system close to the natural environment to check the root architecture of the plants without damaging the delicate root as compared to MS media and soil system. Moreover, our results revealed the fact that field experiments may helpful in selecting the best candidates as PGPR for future purposes along with in vitro screening procedures.

Keywords：*Bacillus, Auxin, Arabidopsis thaliana, Wheat*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Soil Ph and Ammonium Concentrations Affect Acid Soil Microbial Nitrification Process

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NH_4^+ and soil pH are two important factors affecting soil nitrification. Numerous studies have focused on the correlation of soil nitrification dynamic with single abiotic factor, whereas the integrated effect of environmental factors on soil nitrification are largely unknown. Here, using two acid soils with different land use patterns (Anhui soil, a forest soil; Jiangxi soil, a brushland soil), we used molecular ecology techniques to investigate the interactive effects of pH and NH_4^+ on nitrification activity in soil microcosms, including the time-dependent kinetics of NH_4^+ and NO_3^- concentration, soil pH, and the amoA gene abundance of ammonia-oxidizing bacteria (AOB) and ammonia-oxidizing archaea (AOA). amoA encodes the subunit A of ammonia monooxygenase which catalyzes the first step in the oxidation of ammonia to hydroxylamine. NH_4^+ was added with $(NH_4)_2SO_4$ at a rate of 250 mg N kg^{-1}. The pH of both soils was increased by adding $CaCO_3$. The addition of only $CaCO_3$ did not change the nitrification of either soil. Two treatments, low pH+NH_4^+(treated with NH_4^+ addition), and high pH+NH_4^+ (treated by addition of 1 g $CaCO_3$ kg^{-1} soil, and NH_4^+), both enhanced nitrification in Anhui soil but not in Jiangxi soil, and the enhanced effect of high pH+NH_4^+ was more pronounced than that of low pH+NH_4^+. NH_4^+ concentration decreased significantly in Anhui soil under low pH+NH_4^+ and high pH+NH_4^+ treatment by 76.1 and 189.6 mg kg^{-1}, NO_3^--N production increased by 80.0 and 195.5 mg kg^{-1}, respectively. With the extending of culture time, soil pH was decreased from 4.53 to 4.03 under low pH+NH_4^+ treatment in Anhui soils, and from 4.91 to 3.86, up to 1.05 units under high pH+NH_4^+ treatment, respectively. However, for Jiangxi soils, no matter how the initial pH change, pH changed little during the incubation. The amoA gene copy number of both AOB and AOA was much more in Anhui soil than in Jiangxi soil. The amoA gene copy number of AOB was induced more significantly under high pH+NH_4^+ than under low pH+NH_4^+ during culture, while that of AOA showed similar changes under low pH+NH_4^+, and high pH+NH_4^+. In Anhui soil, changes in denaturing gradient gel electrophoresis fingerprint patterns of bacterial amoA genes are paralleled with the amoA gene copy number of AOB changes. However, bacterial amoA was not detected in Jiangxi soil. These results suggested that the higher activity of AOB and AOA contributed to the stronger nitrification in Anhui soils than Jiangxi soils, while the stronger nitrification of Anhui soils under high pH+NH_4^+ compared with low pH+NH_4^+ was mainly due to the enhancement of AOB but not AOA.

Keywords：*Nitrification, $CaCO_3$, amoA, ammonia-oxidizing bacteria, ammonia-oxidizing archaea*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Molecular Diversity and Colonization of Arbuscular Mycorrhizal Fungi Associated with Rhizosphere of Cowpea (vigna Unguiculata (l.) Walp.) as Affected by Edapho-Climatic Conditions

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The symbiosis between arbuscular mycorrhizal fungi (AMF) and terrestrial plants is one of the most widespread plant-microbe relations. It is perceived as an important soil biological factor which may stimulate different growth response in crops in farmers' fields. Consequently, in agriculture and horticulture, many studies are being carried out to better understand this symbiosis with various crops. In the present study, roots colonization of cowpea (Vigna unguiculata (L.) by arbuscular mycorrhizal fungi (AMF) species was assessed to determine abiotic and biotic factors influencing this plant-microbe interaction. The molecular diversity of AMF species colonizing roots and rhizosphere soils of cowpea was investigated to test the hypothesis that community diversity in rhizosphere soil is similar to the one in cowpea roots. Twenty-eight farmers' fields located in seven agro ecological zones of Benin were grown with cowpea and soils were sampled at flowering and fruition. The 5' end of the large ribosomal subunit (LSU) of the Glomeromycota enclosing the variable domains D1 and D2 regions were directly amplified from soil extracted DNA. The amplification products were subjected to cloning, sequencing and phylogenetic analysis. Results indicated that, at fruition (pod at level III), frequency of mycorrhizal infection (F) was unaffected ($F= 0.99$; $p = 0.46$) by agro ecological zone but at the same time, there were significant differences ($\chi 2 = 17.36$; $p < 0.015$) in intensity of arbuscular mycorrhizal colonization (M) between the zones. Furthermore, multiple regression analysis showed that the main factor affecting mycorrhizal frequency (F) at flowering was available phosphorus ($R2=0.78$; $p<0.0001$). Phylogenetic analysis revealed that one hundred of the sequences obtained clustered in twenty-five phylotypes belonging to two families (Glomeraceae and Gigasporaceae). The AMF diversity colonizing roots of cowpea in Benin was high and similar to the one of rhizosphere soils but with prevalence of the Glomeraceae (96 and 92% in rhizosphere soils and roots, respectively). Despite the absence of strict host specificity in mycorrhizal symbiosis, there was a preferential association between some AMF species and IT96D-610 cowpea cultivar.

Keywords：*agro ecological zones, Benin, diversity, fungi, mycorrhiza, Vigna*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Which Biotic Agent Responsible for Ammonia Oxidation in the Pine Forest Stand of Jinyun Mountain, Chongqing?

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Background and Aim: The occurrence of nitrification in some forest acid soil is still a subject of debate. Even the main nitrification pathway in forest acid soil is still a major study concern, since both autotrophs and heterotrophs contribution to nitrification remains uncertain. Moreover, the main biotic agent responsible for ammonia oxidation in a forest soil is still a major study concern, since both ammonia-oxidizing bacteria (AOB) and archaea (AOA) contribution to nitrification remains uncertain.

Method: Acidic yellow soil (Oxisol) samples were selected to test whether nitrification can occur or not in a subtropical acid pine forest ecosystem. Nitrapyrin ($C_6H_3Cl_4N$) was used to inhibit autotrophs, and thus the relative contribution of autotrophs and heterotrophs to nitrification was studied. Also, analyze the abundance of both AOA and AOB amoA gene copies.

Results: NH_4^+N concentration decreased and NO_3^-N concentration increased significantly indicated that nitrification did take place in the subtropical acid soil, especially in the first week of incubation. Calculated net nitrification rate was 0.21 mg N kg^{-1} d^{-1} for the first week of incubation. The inhibitor application resulted in a significant reduction of the nitrate concentration to a rate of 54% in the first week. Therefore, the autotrophic nitrification rate was 0.14 mg N kg^{-1} d^{-1} and the heterotrophic nitrification rate was 0.07 mg N kg^{-1} d^{-1} in the first week. Without the application of inhibitor, the AOB showed no significant increase in the control, but nitrapyrin amendment had a significant reduction on AOB *amoA* gene copy numbers throughout incubation. Whereby, in the control the AOA showed no significant increase in the second week and significant increase in the fourth week; but the application of the inhibitor had the AOA *amoA* gene copy numbers to significantly decrease in the second week and insignificantly increase in the fourth week.

Conclusion: Results indicated that nitrification did take place in the present subtropical acid pine forest soil, and autotrophic nitrification was the main nitrification pathway in the subtropical pine acidic forest soil of Jinyun Mountain, Chongqing. Both AOA and AOB being the active biotic agents responsible for autotrophic nitrification in the subtropical acid pine forest soil of Jinyun Mountain, Chongqing. This study provides an additional insight in determining the important biotic agent responsible for regulating N cycling in a forest ecosystem

Key Words: Net Nitrification; Nitrapyrin; Heterotrophs; Ammonium Oxidizing Bacteria (AOB); Ammonium Oxidizing Archaea (AOA)

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Rhizobium Inoculation for Mitigating the Salinity Stress in Maize (zea Mays) under Gnotobiotic Conditions

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Salinity is one of the major factors which affect overall food production of the world, especially in arid and semi arid regions. Rhizobium can improve growth and yield of legumes by fixing atmospheric dinitrogen and cereals by producing various hormones and enhancing the availability of nutrients under salinity stress. A growth pouch experiment was conducted to study the effectiveness of rhizobium inoculation for inducing salinity tolerance in maize under axenic conditions. For this purpose, 60 rhizobial strains were isolated from the nodules of four different legumes(mung bean, cow pea, chick pea and lentil) collected from different agroclimatological zones of Pakistan. These rhizobial strains (15 from each legume) were tested in vitro for osmoadaptaion. On the basis of osmoadaptaion, 40 salinity tolerant rhizobial strains (10 from each legume) were selected for evaluating their plant growth promoting potential under saline conditions. Maize seeds inoculated with selected rhizobial strains were sown in growth pouches and four different salinity levels i.e. 0.94 (original), 4, 8 and 12 dS m-1 were maintained by using NaCl salt in Hoagland solution (half strength). Results revealed that salinity stress negatively affected the maize growth but different rhizobial strains significantly improved the maize growth at variable rate as compared to uninoculated control at respective salinity level. Four rhizobial strains from mung bean, three from cow pea, five from chick pea and three from lentil were significantly better as compared to other respective rhizobial strains for improving the growth, K+/Na+, and relative water content. It might be concluded that rhizobial isolates may be used for improving the growth of maize under saline conditions.

Keywords：*Rhizobium, salinity, maize, legumes, Inoculation*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Screening Of Bacterial Endophytes for Carbonic Anhydrase Activity and Drought Tolerance of Wheat

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Global food production has been recognized as major challenge for conventional agriculture due to water scarcity. Endophytic bacteria containing carbonic anhydrase can be an attractive alternative to enhance plant growth and its survival under stress conditions. In the present study, endophytic bacteria were isolated from various tissues of wheat plant grown under different agro-ecological zones and purified by subcultures repeatedly. These isolates were screened for drought tolerance using different levels of PEG-6000 including 0, 5, 10, 15 and 20% respectively. Consequently, selected drought tolerant isolates were further characterized for carbonic anhydrase (CA) activity in CA producing medium. Results showed that maximum bacterial endophytes were recovered from root tissues compared to stem and leaf tissues. Furthermore, drought tolerant isolates showed positive correlation with CA activity and exhibited high CA activity compared to other isolates. CA activity up to 12.45 µmol mL-1 was observed in drought tolerant strains. Hence, it is concluded that bacterial endophytes having high carbonic anhydrase activity might be good candidate for improving plant growth and development under drought stress. Further investigation is in progress to understand exact mechanism.

Keywords：*Water deficit, PEG-6000, Endophytic bacteria, CA activity, Wheat*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Abundance of Root Seedling Michoryza Infection in Tragulasi Coastal Forest Vegetation Area Alas Purwo National Park Banyuwangi

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Micorhyza is a symbiotic association between plant and microfungi. This association provide excellent benefits for soil and host plant which is where the fungus to grow and reproduce. The principal of micorhyza is infect the host plant root system, producing so intensively interwoven hyphae containing mycorhizal plants will be able to increase capacity in the absorption of nutrients. Mycorhiza acts as an agent that connects plants with rhizosphere Symbiosis occurs in plant roots where the fungus colonizes the apoplast and the cell cortex to obtain carbon from the photosynthesis of plants. To determine the type of infection on seedling plants in coastal forest vegetation, conducted research on mycorrhizal infection in the area of the National Park Alaspurwo Banyuwangi Triangulation. This study was conducted using transects and length slide staining method kromanik and McGraw's (1982). Nine samples of roots was found that a total of mycorrhizal infection vesicles with 100% degree of infection. Root infection by mycorrhizal roots is influenced by structure, type and amount of nutrients produced the host plant and the fungus to adapt to the environment such as the physical properties and chemical properties of the soil.

Keywords：*Mycorhiza; Root Seedling; Forest Vegetation.*

P3-273

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Phosphorus or Nitrogen Limitation in Microorganisms in Some Japanese Forest Soils

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Mineralization of soil organic matter is primarily mediated by microorganisms in soils. Thus, soil microorganisms play a central role in recycling of nutrients such as phosphorus (P) and nitrogen (N) in terrestrial ecosystems. Soil microorganisms are usually energy (carbon) limited. However, microorganisms may be limited by other nutrients such as P and N, depending on the nutrient status in soils. In our previous studies, it was indicated that microbial activity is P limited in some Japanese forest soils with low pH (Kunito et al., 2012a, 2012b). In the present study, we examined the temporal variation in nutrient limitation (P or N limitation) of microorganisms in forest soils.

Soil samples were collected from stands of larch Larix kaempferi at compartments 3 and 7 in Terasawa-yama Station, Education and Research Center of Alpine Field Science, Shinshu University, Nagano Prefecture, Japan. The soils were classified as Haplic Brown Forest soils (Inceptisols). Sampling sites were located at altitudes between 1,050 m and 1,250 m. The mean annual precipitation and air temperature was 1,479 mm and 9.0°C, respectively. Each soil sample was sieved through a 2-mm mesh and homogenized. A portion of each sample was air-dried for chemical analysis, while the remainder was maintained field-moist at 4°C for measurements of microbial properties. Soil pH ranged from 4.8 to 5.6 in the samples. Soil respiration was estimated by titration: CO_2 evolved from a soil sample amended with or without nutrient was absorbed in NaOH in a closed jar, and then determined by HCl titration. Availability of P in soils was evaluated using a modified Hedley sequential extraction procedure.

Most of the soil samples showed low concentration of P in H_2O and $NaHCO_3$ fractions, compared with other forested Inceptisols in Japan. This result suggested that the P availability was low in these soils. The low availability was partly due to the low concentration of total P in these soils.

For soil samples collected in July 2011, microbial activity, estimated by soil respiration measurement, was limited by P at one plot in the compartment 3 of the Terasawa-yama Station, and was limited by N at one plot in the compartment 7. For soil samples collected in October 2011, microbial activity at one plot was limited by P, one was limited by N, and one was colimited by P and N in the compartment 3, whereas one plot showed N limitation in the compartment 7. In contrast, no limitation of P or N was observed for all the samples collected from both compartments 3 and 7 in November 2012. Thus, it seems likely that the nutrient limitation of microorganisms is temporarily varied in the forest soils.

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Keywords：*phosphorus limitation, nitrogen limitation, forest soil, soil respiration*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

The Potential of *flexibacter* Sp. Isolated from an Oil Palm Plantation on Peat in Sarawak, Malaysia as a Biological N_2O Mitigation Strategy

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Background

Globally, agricultural soils are a major source of anthropogenic N_2O and indisputably the use of nitrogen (N) fertilizer and manure is driving the atmospheric N_2O increase. N_2O emission from soils is thought to be caused by the microbial transformation of mineral forms of nitrogen. Therefore, it is important to find biological agents to mitigate N_2O-emitting soils. One promising approach is the introduction of a nitrous oxide reductase (N_2OR) gene (*nos*) into the soil microbial communities that are active as N_2O-emitting consortia. The enzyme N_2OR, which is naturally found in complete denitrifying bacteria, is responsible for catalyzing the final step of the denitrification pathway that converts N_2O to nitrogen gas (N_2). We therefore screened some N_2O quenchers among soil bacteria, specifically those adapted to acidic, tropical peat soil, for an enrichment culture of N_2O quenchers.

Methods

By adapting the method of the N_2O emission assay using soil-mimicking soft gel medium adjusted to pH 5.0 (10 mL), these isolates were measured for their N_2O-quenching ability by supplementing N_2O at standards of 10, 100, 800, and 3000 ppmv into the headspace (22.57 mL) prior to incubation at 25°C for 5 days. The N_2O level in the headspace was monitored daily by ECD-GC analysis. For the higher N_2O supplementation assays, 800 and 3000 ppmv in the headspace, a system was also established using the soft gel medium for production of N_2O by known potent N_2O emitters isolated in our previous work. Additionally, an acetylene inhibition assay was conducted with 10% acetylene injected into the headspace and incubated in the same manner. In the present study, potent N_2O-quenching denitrifiers were successfully isolated and identified as *Burkholderia* sp. and *Flexibacter* sp. from soils collected at various depths from an oil palm plantation on peat in Sarawak, Malaysia. In a further evaluation, we measured the quenching ability of *Flexibacter* sp., using a N_2O quenching assay in artificial culture medium in a gas chromatographic vial, and further investigated its genetic and physiological traits. The whole-genome sequence of *Flexibacter* sp. was determined using an Illumina HiSeq pyrosequencer and unassigned ORFs were annotated to conduct a BLAST search for N_2O-quenching genes, including the gas transporter genes.

Results

Initial supplementation with approximately 10 ppmv of N_2O standard gas showed that three isolates are able to quench exogenous N_2O. In fact, 5 days after the incubation, the exogenous N_2O level was less than zero, which meant there was less than the atmospheric level (300 ppbv). Although many N_2O quenchers are also denitrifiers reported to reduce exogenous N_2O, *Flexibacter* sp. showed an extraordinarily active N_2O quenching activity. This bacterium was able to eliminate as much as 3000 ppmv of the supplemented N_2O in the headspace within 3 days. Furthermore, when subjected to the 10% acetylene inhibition assay, no acceleration of N_2O production was observed. Additionally, the *nosZ* gene was not detected by PCR assay, using degenerate primer sets for both typical and atypical *nosZ* genes.

Conclusion

This preliminary study will serve as a platform in formulating a novel biological mitigation strategy to reduce N_2O emission, not only from reclaimed tropical peatlands, but also from many other agricultural soils and N_2O flux sources.

Keywords：*Tropical peat soil, Denitrification, Nitrous oxide reductase gene*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Invasive Plants Enrichment of Soilborne Pathogens Affecting Native Plant Species

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A side effect of insect/pathogen interactions which drove successful biocontrol that dramatically reduced stand density at several locations within Theodore Roosevelt National Park in North Dakota, U. S. A of the deep-rooted perennial invasive plant Euphorbia esula/virgata was a legacy of pathogens left in the soil. The synergistic interaction of root-feeding larvae of Aphthona spp. with soilborne plant pathogens has been shown to be the essential mechanism through which infestations of E. esula/virgata were controlled. Native forb diversity has failed to recover at post-biocontrol sites in the park (as documented by several studies, done from early post-biocontrol in the park to recently). Our hypothesis was that this failure of native dicots to reestablish is attributable to the insect-pathogen interaction causing increased pathogen inoculum in the soil. Seedlings of several native forbs and grasses were transplanted into plots at five different locations within the park where E. esula/virgata had been controlled. Disease surveys of the plots were conducted. Native forbs showed the most apparent disease; among these, the native species Ratibida columnifera, Aster ericoides, and Helianthus pauciflorus had the highest incidence of root and crown disease from which Rhizoctonia, Fusarium and Pythium spp. were isolated. When these soilborne pathogens were tested on a range of native forbs and grasses, most of the native forbs were susceptible to half to 80% of the isolates of R. solani. Species that were not susceptible to R. solani were susceptible to the other two soilborne fungi. The cause and effect of pathogen enrichment by successful biocontrol through insect-pathogen interaction and the failure of native dicots to reestablish is confirmed.

Work on the effects of salt cedar biomass on forbs is based on 1) observations by scientists of the U. S. Dept. of Agriculture, European Biological Control Lab of a lack of understory plants where salt cedar was dense in the native range (Eurasia) and 2) a study showing that shrubs of a Tamarix spp. on field borders stimulated high populations of a Fusarium oxysporum f. sp. radicis-lycopersici that caused higher incidence of a root disease of tomato in nearby fields. Fusarium spores were transported to the tomato fields from Tamarix spp. trees on field edges by irrigation water or rainfall. The objective was to investigate whether invasive Tamarix ramosissima (salt cedar) would similarly affect native grasses and/or forbs by enriching for Fusarium spp. pathogenic to some common native species of short grass prairie in Montana, USA Soil samples were taken from 1) foliar debris 2) soil from under the drip line and 3) soil from at least 10 meters away from the shrubs. A location was chosen as ideal for this study based on there being sufficient space between trees to attempt to obtain meaningful samples for the third treatment. A total of 11 predominant (occurring at the highest population levels in each soil sample) Fusarium spp. isolates were tested on 8 native grasses and 8 native forbs. None were pathogenic to the native grasses, while 7 native forbs were susceptible to 7 different Fusarium spp. predominant isolates from foliar debris or drip line soils and 4 predominant isolates from soils between shrubs were pathogenic to 5 native forbs. Echinacea angustifolia was not susceptible to any of the predominant Fusarium spp. isolates associated with invasive salt cedar. These results indicate a significant negative feedback effect on native forbs associated with invasive salt cedar.

Keywords：*restoration, plant-soil feedback, negative feedback*

P3-276

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Effect of Cd Contamination on Soil Microbial Community Structure in Flue-Cured Tobacco Rhizosphere

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Soil microorganisms play an important role in rhizospheric soil ecosystems. The bacteria and fungi community structure of flue-cured tobacco rhizospheric by adding different content of Cd (2, 4, 8 and 16 mg/kg) were studied based on the PCR-DGGE analysis.The results were as follows:(1) The bacteria bands of Cd at 4mg/kg level were significantly less than other treatments. Some bacteria disappeared with the Cd concentration increasing. Some special bacteria had a stronger restoration capability at higher Cd contamination level (16mg/kg). The sequencing results showed the bacteria community was divided into 8 clusters. The Bacterium ellin, Acidobacteria bacterium ellin and Mycobacterium had strong resistance and adaptability to Cd contamination of different concentration. The Leptolyngbya had strong adaptability to Cd contamination of moderate concentration, which could become dominant population at this level. (2) The fungi community diversity in rhizosphere with different concentration of Cd had a significant difference compared with the bacteria. Some fungi appeared with the increase of Cd concentration, but some fungi disappeared at the moderate level of 8 mg/kg. Sequencing results showed the fungi community was divided into 4 clusters. The Fusarium and unknown species were the dominant fungi community, which existed in all treatments and had strong adaptability to different Cd concentration. The Acremonium sclerotigenum was sensitive to Cd contamination, but the Rhizopus appeared at Cd concentration of more than 8 mg/kg, which showed its addiction to higher Cd concentration.

Keywords：*Cd contamination, flue-cured tobacco, soil microbial community structure, rhizosphere*

P3-277

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Development of Soil Microbial Community Structure at the Primary Developing Stage of Parent Material of a Mollisol by Different Land Uses and Aggregate Sizes

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Soil microbial communities play significant roles in soil ecosystem functioning such as soil development and susceptible to changes in land use and soil management. However, most of the knowledge is derived from well-developed soils and it remains unclear at the initial stage of soil development. It was hypothesized that soil microbial community structure varied by land use, soil depth and aggregate size due to the differences in tillage and organic C (OC) inputs. Using an eight-year experiment to examine how soil ecosystem develops under different land uses and fertilization practices, the objectives of this study were: 1) to characterize soil microbial communities by phospholipid fatty acid (PLFA) profiling in both bulk soil and aggregate fractions; 2) to elucidate the shifts of soil microbial community structure in relation to the parent material (PM) and an adjacent mature Mollisol (BS); and 3) to relate the shifts to physico-chemical soil properties and identify the driving factors. There were significant effects of field treatment, aggregate size on the measured soil physic-chemical and microbial properties, with more profound effects of field treatments in bulk soil than in aggregate sizes. All the soil properties except for soil bulk density (SBD) and pH increased in bulk soil compared with PM and only the concentrations of OP and EK in the soils with mineral fertilization increased compared with BS. Principal component analysis (PCA) of PLFA profiles in bulk soil demonstrated that the tilled soils and the no-tilled soils were contrastingly separated from PM, with the tilled soils similar to BS under cropping, indicating of microbial resilience under the same land use. Among the tilled soils, the soils without OC input were more similar to BS, while the soils with different amount and quality of OC input were separated in two different directions for BS. These separations were associated with chemical properties (pH, AN, OP and EK) in PC1s through their impacts on bacteria, and with physical properties (SBD) in PC2s through its influences on fungi, actinomycetes and G(-) bacteria. In addition, aggregate stability and EK were associated with the separations in both PC1 and PC2 for PCA including all treatments, indicating the effect of weathering and aggregation. The PCA of PLFA profile in soil aggregate sizes demonstrated that soil microbial community structure was affected by aggregate size, with >2 mm size closer to <0.053 mm, and 2-0.25 mm closer to 0.25-0.053 mm size for all the field treatments except for no-tilled natural fallow. The separations among the aggregate sizes were more profound than those among the field treatments. These results suggest that the development of soil microbial community structure may be more affected by soil physical habitats than by nutrient resources at the initial stage of soil formation.

Keywords：*Soil formation, Soil microbial community structure, Phospholipid fatty acid, Aggregate fraction, Organic C inputs, Mollisol*

P3-278

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Genetic and Physiological Structures of Bacterial Communities in Agricultural Soil Irrigated with Untreated Wastewater for more than 40 Years

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Soil pollution is a major risk to farmland ecosystem functioning. Various pollutants can affect the growth and breeding of plants and animals, food safety, soil texture and properties, as well as soil microbial communities. People typically pay more attention to the first two aspects, whereas the other two factors are often ignored. However, soil quality and the resident microbes are even more important because they are essential for the growth of plants and animals. The disturbance of soil microbial communities may decrease soil fertility and safety, and in the long term, significant consequences to human health may be imposed. Therefore, the shifts of soil bacterial communities' genetic and physiological structures are very important and even used for soil quality and contamination assessment.

The current study was conducted in Hunpu wastewater-irrigated area, Liaoning Province which located northeast of China. The study sites are the major grain crops growing areas and cover many industrial bases. The area receives low amounts of precipitation (1/3 of the national average), while wastewater rich in nitrogen, phosphorus, potassium (NPK) and other nutrients is available. For these reasons, wastewater had been widely used to irrigate the agricultural fields in the area since the 1960s until 2002. The irrigation river was supplied initially by domestic wastewater, and gradually substituted by industrial wastewater along with the development of modern industry in the 1980s. This industrial wastewater contains high loads of diverse pollutants because it is composed of more than 0.4 million tons of domestic sewage and industrial wastewater from Shenyang and from 78 large- and medium-size enterprises. Given that untreated wastewater with high amounts of toxic and hazardous components leads to serious environmental contaminations, which in turn results in several social and economic problems, sewage irrigation was prohibited by the local government in 2002. This area is irrigated by sluicing water at present.

In this study, top soils were collected from four upland and four paddy fields between the main wastewater disposal channel and Shenyang City, the bacterial community composition in the samples was investigated to reflect the pollution caused by long-term wastewater soil irrigation. For this purpose, DGGE and real-time PCR were used to quantify bacterial composition and abundance, whereas Biolog EcoPlate was implied to determine bacterial metabolic capacity. Statistical analysis was performed to evaluate the effects of wastewater on the genetic and physiological structures of the bacterial communities.

The results showed that the pollutants still existed in the soils with various degrees despite wastewater irrigation were banned in

2002. Moreover, HM contamination in the upland soils was higher than that in the paddy soils. And soil microbial community-level metabolic rates in paddies exceeded that in uplands. Remarkably, paddy pattern was superior to upland pattern in contaminated soil remediation. In brief, different tillage patterns influenced soil restoration under pollutants. Organic pollutants such as saturated hydrocarbons and polycyclic aromatic hydrocarbons had significant effects on soil bacterial compositions ($p < 0.05$). Different HMs disturbed the microbial communities in different ways, arsenic (As) and lead (Pb) shifted the community composition and decreased microbial diversity; copper (Cu) reduced soil bacterial abundance; and cadmium (Cd) and chromium (Cr) lowered the bacterial metabolic capability. Especially, arsenic (As) and mercury (Hg) were the most toxic pollutant for soil microorganism, because they changed soil microbial community composition, decreased the bacterial abundance, and weakened soil microbe metabolic capability. The results also demonstrated the complex synergistic effects among basic soil properties, contamination, tillage patterns, and soil bacterial community persistence. Our study suggested that more attention should be paid to the variations of agricultural soil bacterial community under long-term contamination.

Keywords：*wastewater irrigation, soil bacterial community, agricultural soil, environmental pollution*

P3-279

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

An Investigation on Whether the Presence of Mycorrhizae Influences the Response of Cocoa Seedlings to Water Stress

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A greenhouse experiment was conducted to determine whether mycorrhiza reduces the impact of water stress on cocoa seedlings. The effects of two factors – mycorrhizae and watering – on growth and physiology of cocoa seedlings were examined for 10 weeks. Four treatments were derived from combinations of these factors as follows: -M-W (without mycorrhizae + water stress); -M+W (without mycorrhizae + regular watering); +M-W (with mycorrhizae + water stress) and +M+W (with mycorrhizae + regular watering). These treatments were applied to 4 months old cocoa seedlings; each treatment had 9 replicates. Mycorrhizae inoculum used was rootgrow™. Watering was done with 500 ml of water every 3 days and 6 days for the regularly watered and water-stressed treatments, respectively. Plant parameters monitored were: seedling height, new leaf appearance, leaf area, chlorophyll content, stomatal conductance (gs), transpiration rate (E), photosynthetic rate (PN), instantaneous water use efficiency (WUEinst) and plant biomass. Results of the study show that mycorrhizae did not colonize roots of cocoa seedlings and hence did not influence their response to water stress. High P content of the soil was likely to have been the main reason for absence of mycorrhizal colonization. Water stress negatively influenced most plant parameters, though significance ($p < 0.05$) of its effect was more noticeable in seedling height. Interactions between the factors were insignificant ($p > 0.05$). Nutrient composition of water-stressed soils differed from those of regularly watered soils. A soil with low or moderate P content would be required to study whether mycorrhiza reduces the impact of water stress on cocoa seedlings.

Keywords：*mycorrhizae, water stress, cocoa seedlings, soil properties*

P3-280

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

The Role of Characteristic Archaeal Community in Nitrogen Circulation of the Boreal Forest Bed Soil

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Background: Climate change is a critical issue throughout the world. Vegetation is subject to the effects of moderate change of climate, particularly in the subarctic zone. It is predicted that forest limits will move north because of the force of global warming. The moving of the forest limit toward the arctic can be a factor leading to the marked variation not only of vegetation but of elemental circulation in the ecosystem, including nitrogen circulation. However, the ramifications of this climate change are still unclear. Moreover, there is an inexplicable phenomenon called the "missing link of nitrogen circulation in boreal forest ecosystems," also known as an imbalance in the nitrogen budget, which makes it difficult to predict the impact of global warming on ecosystems, and nitrogen circulation within the ecosystems. This is particularly true with respect to nitrogen supply; which is one of the most important limiting factors for tree growth along the boreal forest limit. Rising atmospheric temperature due to global warming will promote decomposition of organic substances, leading to an enrichment of available nutrients in soil. In this study, we speculated that the global warming would lead to an enhanced supply of available carbon to forest bed soil ecosystems via an increase in water-soluble organic carbon (WSOC). We therefore investigated responses of the boreal soil microbial consortia to available organic carbon sources at different concentrations, leading to acceleration or repression of nitrogen fixation as a function of acetylene reduction.
Materials and Methods: The study sites were a tundra open forest of European spruce along the forest limit in Finland (Pallas, 68°02′N 24°04′E) and an artificial larch forest in Hokkaido, Japan (Tomakomai, 42°26′N 141°47′E). The soils were sampled from A or B horizons at each site. Winogradsky's nitrogen-poor mineral medium (gellan gum 0.3% as gel matrix) containing seven different concentrations of a carbon source (sugar and organic acid mixture) in the range of 0.02~2.0% were used. An acetylene reduction assay was conducted using these cultured media as a primary index for nitrogen fixation. Subsequently, DNA extracted from the microbial community in the cultured medium was analyzed by bacterial and archaeal 16S rRNA gene-targeted denaturant gradient gel electrophoresis (DGGE).
Results: Both Pallas B1 and B2 soils showed the highest acetylene reduction at 0.1% carbon concentration (30 nmol C_2H_4 $vial^{-1}$ h^{-1}). The carbon concentration of this culture is relatively low as an optimal acetylene reduction condition. On the other hand, Tomakomai A1 soil showed the highest acetylene reduction at 0.5% carbon concentration, and activities at all concentrations were higher than those in the Pallas samples. For these cultured media, we conducted a microbial community analysis using DGGE. Bacterial 16S rRNA gene-targeted PCR-DGGE for DNA from the Pallas B1 and B2 soil culture showed DNA bands of *Clostridium* sp. with a high band intensity, particularly in the cultured medium that had high acetylene reduction. In addition, *Sporolactobacillus* sp. concurrently appeared with acetylene reduction inhibition in the B2 soil culture. In the Tomakomai A and B soil cultures, DNA bands of *Arthrobacter* sp. and *Massilia* sp. were observed with high band intensities in the soil culture that had high acetylene reduction. *Clostridium* sp. in Pallas and *Arthrobacter* sp. and *Massilia* sp. in Tomakomai seemed to occupy a similar niche to nitrogen-fixing bacteria in each microbial community. Unknown archaea of the phylum Thaumarchaeota were detected in both Pallas and Tomakomai soils by archaeal 16S rRNA gene-targeted PCR-DGGE. Specific primers were designed from DGGE bands in order to decode the full-length of the 16S rRNA gene. Pallas B2 horizon soil-derived sequence (1.3 kbp) showed 94% identity with "*Candidatus* Nitrosotalea devanaterra", which is reported to be an ammonia oxidizer from acidic agricultural soils.
Discussion: These results suggest that global warming leading to increased WSOC supply in soil ecosystems may change total nitrogen fixation activity by the microbial community in a boreal forest bed. Some ammonia oxidation-related archaea of the phylum Thaumarchaeota found in the soil archaeal communities strongly suggest that Thaumarchaeota community members frequently play key roles in nitrogen circulation in boreal forest bed soils to respond to climate change.

Keywords：*Thaumaechaeota, DGGE, nitrogen fixation, forest limit, global worming*

P3-281

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Effects of Agricultural Practices and Crop Residue Management on Earthwrom Communities and Soil Physico-Chemical Properties in Cultivated Fields (belgium)

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Earthworms are known to play important roles in soils, and are often referred to as ecosystem engineers due to their ability to alter soil environment. Since earthworms influence a wide range of critical physical and chemical soil properties, it is important to understand how earthworm communities are impacted by tillage systems and crop management. Our study was conducted in Gembloux, Belgium. Earthworms and soils were collected from wheat cultivated fields under four treatments : (1) conventional tillage with crop residues left in the field (CT/IN); (2) conventional tillage with crop residues removed from the field (CT/OUT); (3) reduced tillage with crop residues left in the field (RT/IN) and (4) reduced tillage with crop residues removed from the field (RT/OUT).

The results indicated that penetration resistance was significantly higher in RT compared with CT, but no significant difference was observed due to cropping management (IN and OUT). Although no significant difference was observed between both tillage systems ($P > 0.05$), earthworm abundance and biomass were significantly influenced by crop residue management ($p < 0.05$) suggesting that lack of wheat residues negatively impacted earthworm dynamics.

Data showed high endogeic category and species N. c. caliginosus in all treatments. Earthworm abundance and biomass influence soil chemical properties (K, Mg, Ca and P), electric conductivity and hot water carbon. Soil properties were generally higher in the first centimeters of soil. These results were attributable to earthworm activity and wheat residues, suggesting that earthworm participate to nutrient dynamics, particulary in the soil depths.

Keywords : *Tillage, Crop management, Earthworms Abundance, Biomass, Diversity, Physico-chemical properties*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Degradation of Iprodione and 3,5-Dca by Degrading Bacteria Isolated from Ryegrass (lolium Perenne) Rhizospheric Soils

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Important worldwide efforts to investigate bioremediation strategies have been encouraged to reduce environmental impact caused by pesticide application in the last years. In this way, the rhizodegradation process in cooperation of pesticide-degrading bacteria might be an adequate alternative to avoid point source contamination by iprodione fungicide [3-(3,5-dichlorophenyl)-N-isopropyl-2,4-dioxoimidazolidine-1-carboxamide] and its metabolite 3,5-dichloroaniline (3,5-DCA). Therefore, the objective for this study was degrade iprodione and 3,5-DCA by degrading bacteria isolated from ryegrass (Lolium perenne) rhizospheric soils. Rhizospheric soil samples were collected from ryegrass (Lolium perenne) grassland with and without historical iprodione applications. Representative samples from both grasslands were disposed to rizhobacterial isolation through two enrichment types. The former had a liquid mineral medium (MM) supplemented with 10 mg L-1 of iprodione as sole carbon and nitrogen source and incubated with shaking (150 r.p.m) for 7 d at 30 °C. The latter enrichment had a MM supplemented with 10 mg L-1 of 3,5-DCA under the same conditions. Rhizospheric bacterial isolates were obtained by serial spread plating on the final day of incubation on solidified MM plus 10 mg L-1 of iprodione for the primary enrichments, and MM plus 10 mg L-1 of 3,5-DCA for the secondary enrichments. Followed, every selected bacterial strain was tested for their ability to grow and degrade 10 mg L-1 iprodione and/or 3,5-DCA through a screening assay. Thereby, significant differences in cell growth and degrading activity, measured through the optical density (OD600) and a spectrophotometric method respectively, allowed select the strains with the best performance to be evaluated through a kinetic assay. Therefore, those effective strains were evaluated to degrade iprodione (20 mg L-1) and 3,5-DCA (10 mg L-1) in MM incubated with shaking (150 r.p.m) for 10 d at 30 °C. Thus, the degradation was measured by HPLC-DAD method and cell growth was determined by measuring the OD600 and converting it to unit forming colonies (CFU) per mL of sample medium (CFU mL-1) using a standard calibration curve every day of assay. From the enrichment, a total of 191 bacterial strains were isolated from both evaluated soils, and only two strains (C-2.7 and A-1.4) showed the best iprodione and/or 3,5-DCA degradation in the screening test. These strains were isolated from soil samples without historical iprodione applications and showed a scarce cell growth in both screening treatments. However, A-1.4 strain showed the higher 3,5-DCA degradation activity (27.78%) and C-2.7 strain showed the higher iprodione degradation activity (50.42%) at final screening day. In the kinetic assay, newly both strains showed a scarce cell growth. Therefore, A-1.4 strain was able to grow from 3.58x105 at 4.86x105 CFU mL-1 and C-2.7 strain only was able to grow 3.27x105 at 4.30x105 CFU mL-1 at the final day in the iprodione treatment. Similarly, A-1.4 strain only grew from 9.14x106 at 1.6x107 and C-2.7 strain grew from 9.93x106 at 2.34x107 in the 3,5-DCA treatment. However, despite of their scarce cell growth, C-2.7 strain was able to achieve 96.9 % iprodione degradation and 23.6 % of 3,5-DCA degradation from initial concentration on 10 days of assay. On the other hand, A-1.4 strain was able to degrade 3,5-DCA in 33.5 % at the same assay time and no degradation of iprodione was observed. Finally, these results could represent the first report describing the isolation of iprodione- and/or 3,5-DCA-degrading bacteria from ryegrass (Lolium perenne) rhizospheric soils, which interestingly were isolated from soils without previous iprodione applications

Acknowledgements: The authors acknowledge the financial support from FONDECYT project N° 1120963, CONICYT scholarship N° 21110817 and the Centro de Investigación y Desarrollo para la Gestión de Residuos Orgánicos, CIDGRO.

Keywords：*Iprodione, 3,5-dichloroaniline, Rhizospheric degrading bacteria*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

The Study of Indigenous Thyme Plant Rhizosphere Bacterial Isolates in the Availability of Iron in Calcareous Soils

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Despite the abundance of iron (Fe) in the earth's crust and soil, plants usually have limitations to access to this essential element especially in calcareous soils with high pH. One of the strategies used to supply the available Fe content in calcareous soils with high pH is using soil rhizosphere microorganisms in calcareous soils. This study aimed to assess the potential of indigenous bacterial isolates from thyme plant rhizosphere in the availability of iron in Iranian calcareous soils. For this purpose, soil samples were taken at 0- 20 cm depth from different thyme cultivated soils provided from the rhizosphere of dry farm lands in Isfahan region, Iran and different bacterial strains were isolated on Nutrient Agar medium from these soil samples. After purification, evaluating the potential of the isolates for siderophore production and analyzing some physical and chemical properties of the soil samples, an inoculum of the superior strains were prepared and the populations were adjusted to 108/ml. A greenhouse experiment was designed in a randomised complete block replicated three times. Air dried 500 g soil was filled into plastic pots and the prepared bacterial inoculums were inoculated to the pots and they were incubated at 30°c for 60 days to study the solubilization of insoluble Fe compounds in calcareous soil sample. The extractable iron content was measured at intervals of 15 days in the presence of 0.05 M DTPA, 0.01 M TEA and 0.01 M CaCl2. The results showed that all isolates have the potential of increasing the available iron content at the first 15-day, however compared with other isolates, isolate 3 which was an aerobic, gram negative bacilli was the most potent isolate to increase the available iron content from 12 mgkg-1 to 23.54 mgkg-1. So in comparison to the control treatment which was 19.52, isolate 3 had increased 4.02 mgkg-1 of available iron and it is concluded that by providing the proper conditions, this isolate can be used for the increase of the available iron content in calcareous soils.

Keywords：*Thyme, available iron (Fe) content, rhizosphere microorganisms, incubation*

P3-284

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Beneficial Effects of Phosphate-Solubilizing Bacteria Isolated from Acid Sulfate Soils of East Coast of Peninsular Malaysia on Rice Seedlings Grown at Different Aluminium Concentrations

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In Malaysia, acid sulfate soils mainly occurred in the coastal plains of Peninsular Malaysia and Sarawak (Borneo Island). The soils are characterized by the presence of pyrite (FeS2), which releases high acidity and Al, resulting from its oxidation on exposure to the atmospheric condition. Rice is being cultivated in these soil but with very low yield. Under acid soil conditions, Al3+ restricts the growth of roots either by inhibition of cell division, cell elongation or due to both. There are only a few acid-tolerant plant species and microbes that are able to survive in these soils. It is well known that microorganisms perform a major role in nutritional chains that are an important part of the biological balance in soils. Beside chemical treatment, addition of microbes may improve nutrient availability in soils (especially phosphorus) and to reduce Al toxicity. A study was conducted to determine the occurrence of phosphate solubilizing bacteria (PSB) in acid sulfate soil and evaluated their beneficial traits and performance on enhancing growth of rice seedlings under low pH at different levels of Al. Soils and rice root samples were randomly collected from 4 sites in the study area and analyzed for soil chemical properties and microbial population. Isolated bacterial strains were identified using molecular techniques. Seven-days-old MR 219 rice seedlings were grown in Hoagland solution adjusted to pH4 containing different concentrations of Al (0, 50 and 100 μM). Rice seedlings were harvested after 21 days of sowing. Bacterial population, plant dry biomass, solution pH and organic acids were determined soon thereafter.

Results showed that the topsoil pH and exchangeable Al ranged from 3.3 to 4.7 and 1.24 to 4.25 cmolc kg-1, respectively, which were considered unsuitable for rice production. Higher microbial populations were found in the rice rhizosphere compared to non-rhizosphere. Total bacterial and actinomycetes population in the acidic soils were found to be higher than fungal populations. A total of 19 N2-fixing bacteria and 21 phosphate-solubilizing bacteria (PSB) strains were isolated. Using 16S rRNA gene sequence analysis, three potential PSB strains based on their beneficial characteristics were identified (Burkholderia thailandensis, Sphingomonas pituitosa and Burkholderia seminalis). The isolated strains were capable of producing indoleacetic acid (IAA) and organic acids that were able to reduce Al availability via chelation process. These PSB isolates had solubilized P (43.65%) existing in the growth media within 72 hours of incubation period. Bacterial inoculation increased pH with concomitant reduction of Al, which can be translated into better rice growth. It was observed that Al had affected rice root development, especially at high concentration. It was observed that high Al concentration had severely affected the growth of the rice seedlings. Plant height and dry biomass significantly decreased with the increased Al concentration. In comparison, the bacterial inoculated plants were less affected by Al toxicity. High plant height and dry biomass were observed in the Burkholderia seminalis inoculated treatments (at 0 μM Al concentration). PSB associated with the plant roots produced organic acids that provided P and chelated the Al toxicity. Generally, higher root length, surface area and volume were found for the inoculated compared to those of the untreated rice plants. Inoculating rice seedlings with the PSB strains had increased the pH of the growth media from pH4 to 5.6 -7.0 which resulted in enhanced rice growth. The improved root volume and seedlings dry weight of the inoculated plants indicated the potential of these isolates to be used in biofertilizer formulation for rice cultivation on acid sulfate soils.

Keywords：*phosphate-solubilizing bacteria, acid sulphate soil, rice, aluminium toxicity*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Compositions and Properties of Microbial Residues Formed by Three Single Species Fungi and Mixed Strains in Cellulose-Containing Liquid Media

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Large part of plant C fraction can be assimilated into microbial biomass during the decomposition of plant residue before incorporation into soil organic materials in the form of microbial residues after cell death. The non-living microbial residues are bound up with SOM (soil organic matter) pool and they can be related to SOM turnover. The soil microorganisms can serve as a significant impetus of SOM formation and their residues in soil are an important parent material for humus formation. Cellulose, as a main component of plant residues, is also essential to the formation of humus. To ascertain how the humus is formed, the method of shake-flask in liquid culture is adopted. The suspensions of Trichoderma viride (Tv), Aspergillus niger (An), Penicillium (P) and mixed strains (Ms) are inoculated into the cellulose culture fluid, (NaNO3 2.0 g L-1, K2HPO4 1.0 g L-1, KCl 0.5 g L-1, MgSO4•7H2O 0.5 g L-1, FeSO4 0.01 g L-1, Sodium carboxymethyl cellulose 20 g L-1) the dynamic studies about microbial residues are conducted at 15, 30 and 70 d. The elemental analysis and FTIR are applied to assess the residues respectively formed by three single species fungi and mixed strains isolated from the Luvic Phaeozem in cellulose-containing culture fluid to study the following matters: (1) the conversion rate of cellulose and its C-turnover between microbial residues and metabolic product; (2) the comparative analysis on the humification degree happened in residue comparing with cellulose; (3) the dynamic analysis the different microbial effects on characterizations of microbial residues.

The results show that all the inoculums examined can disturb the organic C distributions between microbial residue and metabolic product, simultaneously enhance the C amount of residue gradually. The Ms (34.97%) performs an advantage over the other mono-fungi treatments in term of cellulose conversion. The cellulose conversion rate mentioned above is used to indicate the utilized and transformed efficiency of organic C in the cellulose culture fluid, whose value is indirectly related to the degradation capacities of tested strains.

Compared with the cellulose sample (C/N 88.13, H/C 2.18 and O/C 1.31), the C/N, H/C and O/C ratios from all the microbial treatments are reduced to some extents. Furthermore, in the end, the C/N (12.48), H/C (2.06) and O/C (1.26) ratios of residue formed by mixed culture is greater than the other mono-culture treatments. Thus it can be seen the formation of microbial residue is a process that the N-containing materials and aromatic structures are accumulated at the cost of consuming O-containing functional groups. In specific, there are more condensed aromatic structures and less O-containing functional groups existing in the residues treated by both Tv and An, in this process the humification process is promoted, whereas the oxidized degradation to cellulose is performed by both P and Ms.

The decreased in ratio of 2926/1639 could be interpreted as the transformation of cellulose to highly humified substrate under the forces of Tv and An. Ms and P in the cellulose fluid could only generate some intermediate products of HS and fail to polymerize their structure levels to humus. Although we confirm SOM is mainly from the remains of dead microbial cells, the faintly discernible peak at 1721cm-1 told us the transition of microbial residue into humus need rather a long period. This research was performed based on the financial support by National Basic Research Program of China (973 Program) (2011CB100503), National Natural Science Foundation of China (41171188).

Keywords：*microbial residues, single species fungi, mixed strains, cellulose liquid media, humification*

P3-286

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Organic Amendments Supply Nitrifiers and Enhance Nitrification in Soil

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Soil microbial community plays a major role in cycling of soil nutrients including nitrogen (N). Ammonification, nitrification, and denitrification are three main microbial processes involved in N transformation in soil amended with N fertilizers and organic amendments. Ammonification, mediated by ammonifiers is the conversion organic N to inorganic N, ammonium (NH_4^+); nitrification, carried out by nitrifiers is the conversion of NH_4^+ to nitrate (NO_3^-); denitrification is the conversion of NO_3^- to nitrogen or nitrous oxide (N_2O) gas. Both NH_4^+ and NO_3^- are plant available forms of N; N_2O is a major greenhouse gas. Though the role of microorganisms in N transformation in soils treated with N fertilizers is extensively studied, very little is known about the N transformation as affected by microbial community from organic amendments application.

Organic amendments are rich sources of carbon and nutrients for higher plants and microorganisms. The objectives of this study include: (i) to compare the influence of temperature on N mineralization in soils amended with 4 N sources; (ii) to compare the influence of N sources on N mineralization; and (iii) to examine the nitrifier communities as affected by organic amendment addition on N transformation. We used the results to predict the potential for NO_3^- production and leaching from soils treated with organic amendments and inorganic fertilizer. Transformation of N from a number of N sources (green waste compost, biosolids, chicken manure, and urea) was examined in 3 different Australian soils (with varying pH - 4.30, 7.09, and 9.15) at 3 temperatures (18, 24, and 37 ℃) by monitoring the ammonification (NH_4^+ concentration) and nitrification (NO_3^- concentration) rates. The most probable number (MPN) technique was used to monitor nitrifier community (i.e., ammonia oxidizing bacteria (AOB)) population and to examine their effect on N mineralization in the soils.

The results indicated that ammonification rate increased with an increase in temperature in all soil types. The effect of temperature on nitrification rate followed 24 > 37 > 18 ℃. Mineral N (bioavailable N, NH_4^+ plus NO_3^-) concentration was high in urea treatments than in organic N source treatments in all soil types. Nitrification rate was higher in neutral and alkaline soils than acidic soil. Acidic soil lacked nitrification activity resulting in low NO_3^- buildup in urea treatment, whereas a significant NO_3^- buildup was noticed in organic N sources treatments. The MPN data indicate that addition of organic N sources supplied AOB to soils thereby triggering nitrification in the soils (even at 37 ℃). We conclude that inorganic N source accumulate high NO_3^- in soils within a short period of application, thereby becoming a source of NO_3^- leaching; whereas organic N sources can serve as possible source of nitrifying bacteria (AOB), thereby increasing NO_3^- content in soils regardless of the soil properties and temperature. With increased NO_3^- concentration, substrate for denitrification, there is a potential for increased N_2O emission from organic amendments treated soils.

Keywords：*Nitrogen, Nitrification, Organic amendments, Ammonia oxidizing bacteria (AOB),, Nitrate (NO_3^-), nitrous oxide (N_2O)*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Vertical Divergence of Microfungal Communities through the Depth in Different Soil Formations in the Western Negev Desert, Israel

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Following the main fungal activities in organic matter decomposition which occur in the upper soil layers, most of the studies devoted to soil fungi focus on the soil surface. However, together with other microorganisms, fungi in deeper horizons also play an important role in biogeochemical processes, participating in soil formation and stabilization. Thus far, very little is known about the depth-dependent dynamics of microfungal communities in arid regions. To examine the distribution of microfungi along arid soil profiles, we conducted a study at the Nizzana research station located in the western Negev desert where two distinct soil units are distributed: sandy dunes and fine-grained sediments known as playas. Sandy dunes are covered by cyanobacterial and moss-dominated biological soil crusts (BSC). Most of the playas lack BSC, while the concave playa surfaces (~20-25%) receiving extra water are covered by 0.5 cm-thick cyanobacterial crusts.

Soil samples were collected in the summer 2012 from the sandy crusted profiles (covered by four types of cyanobacterial and one type of moss-dominated BSC) and from the non-crusted and crust-covered playa profiles (P-NC and P-CR, respectively), from the layers of 0-0.2, 0.2-1, 1-5, 5-10, 10-20, 20-30, 30-40, and 40-50 cm. In the sampled soil, pH, electrical conductivity (EC), and organic matter content were also determined. In the sandy sediments, pH gradually increased with depth (from 8.0-8.3 to 9.3-9.5), while electrical conductivity varied from 0.22 to 1.55 mS/cm with the highest and the lowest values at the surface and at the middle 5-20-cm layers, respectively. By contrast, in the playa profiles, pH gradually decreased with depth (from 9.0 to 8.2 and from 8.9 to 8.3 in P-NC and P-CR, respectively), while EC sharply increased in both profiles reaching more than 17 mS/cm at the 10-50-cm depth in P-NC. As for organic matter content, except for the sandy crusted surfaces, all other values were very low, less than 0.3%. Periodical measurements of available moisture content carried out during the 1990s and 2000s showed that following medium 20-mm rain events, water infiltration at P-NC and P-CR was limited to the upper 20 and 30 cm, respectively, whereas in sandy habitats it reached >30 cm.

In the course of the study, a total of 95 microfungal species belonging to 52 genera was isolated using the soil dilution plate method: 71 species (43 genera) and 72 species (39 genera) from the sandy crust and playa profiles, respectively. The mycobiota characteristics showed complicated and non-linear relationship with depth. A quantitative parameter – density of microfungal isolates, displayed the strongest negative depth dependence significantly correlating with organic matter content and pH in the sandy crust profiles (highly positively and negatively, respectively). The comparison between the fine-textured playa and the coarse-textured sandy soil confirmed that vertical distribution of microfungi is strongly associated with the substrate porosity responsible for water infiltration. This in turn affects the organic matter distribution and aeration and consequently the ability of fungi to penetrate and to survive in the deeper soil layers. The revealed depth-wise variations in composition and structure of the microfungal communities are in agreement with the Bass-Becking's (1934) often-cited statement, "Everything is everywhere, but the environment selects". High pressure of solar radiation as well as strongly limited aeration and increased salinity led to a dominance of slow-reproducing, dark-colored species with large, multi-celled conidia both in the topmost layers of all profiles and in the deep playa layers. At the same time, at the depth of less than 1 cm, species which produced high amounts of light-colored small one-celled conidia mostly prevailed. In that way, the above vertical variations resemble spatial differences in the composition of topsoil microfungal communities found on a regional scale between the sites located in the southern Negev desert and in the Mediterranean region of Israel, thus confirming the ability of soil microfungal communities to be a sensitive indicator of contrasting and changing environmental and edaphic conditions.

Keywords：*microfungal communities; soil profiles; biological soil crusts; playa; porosity; water infiltration*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Evaluation the Effect of Two Herbicide's Ingredients on Some Soil Microbiological Parameters

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Application of pesticide in the agriculture widespread in the plant protection; the herbicide usage is inseparable part of the plant production and plays a very important role in the regulation system of weeds. Beside the exemption from weeds we have to count another secondary effect of chemicals on soil life and on the so called "not purposed" soil organisms.

Nowadays more and more new herbicides put into issue, their selectivity is better, than the earlier chemicals, so they can be used in smaller concentration. In this paper the effect of two herbicides' ingredients was examined on some microbiological parameters of a chernozem soil. The active ingredients of herbicides are the acetochlor (Acenit A 880 EC) and isoxaflutole (Merlin 480 SC), applied in maize culture to the soil surface.

The effect of the herbicides was investigated on the sensitivity and quantity change of soil microorganism and biological parameters of soil in two different experiments. The first experiment was an in vitro investigation, where the different dosages of herbicides were measured on the sensitivity of 3 various fungi species originating from stock-breeding (Aspergillus niger, Fusarium oxysporum, Trichoderma sp.). The second one was a small plot experiment, where the simple, double and five time dosages of herbicides were examined on the number of total bacteria and microscopic fungi, on the quantitative changes of aerobic cellulose decomposing bacteria, on soil respiration, on quantity microbial biomass carbon (MBC) studied for four year.

The laboratory examinations were carried out in the soil chemical and soil microbiological laboratories of Department of Agrochemistry and Soil Science, Debrecen University.

Data analysis was performed using Microsoft Excel 2003 (mean values and standard deviation). Two factors variance analysis was used to get significant effect on measured parameters. The significant differences were accepted at the level 1%, but the evaluation was calculating by the LSD5% values as accepted in the agricultural research.

Pearson-type two-side correlation analyses also were performed (after the date were standardised), where relations were sought among the different doses of herbicides and the soil parameters examined.

In first experiment, 5 mm diameter micellium-containing little disks were set with the 3 different fungi species (Aspergillus niger, Fusarium oxysporum,.). It means four "micellium disks" colonies was set to every Petri-pot and they were incubated at 28 oC in thermostate. The diameter of fungi colonies was measured after 5 days, and the results were evaluated. The diameter of fungi colonies were reduced by the increasing dose of herbicides close negativ correlation was measured regarding the Aspergillus niger (Acenit r= -– 0,960; Merlin r= – 0,931), in case of Trichoderma sp(Acenit r= -– 0,923; Merlin r= – 0,814).

The small plot experiment was set up at the experimental site of the Department of Plant Protection, Faculty of Agriculture. The plots were set up in three repetitions, soil type was calcareous chernozem, herbicides' effects were investigated under maize culture.

It was a four year experiment, results of three different dosages of two herbicides are evaluated regarding to homogenous average soil samples.

While the increasing dose of herbicides decreased the number of total bacteria significantly, the number of microscopical fungi and cellulose decomposing bacteria incresed significantly. Close correlation was measured between the quantity accurence of microscopical fungi and cellulose decomposing bacteria, regarding to Acenit it was r=0,810, in case of Merlin it was r=0,834. Probably these two microscopic groups used the herbicides as carbon sources.

The CO2-production was increased by the five times dose of two herbicides significantly, while the MBC did not changed significantly, except the two-time dose of isoxaflutole, where the MBC decreased significantly.

In summary it can be stated that the various herbicide ingredients had different effect on soil microbiological properties, those chemicals may be recommended for use, which cause less inhibition on biological processes.

Keywords：*herbicide, soil biologycal parameters*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Molecular Characterization of Groundnut (arachis Hypogaea) Rhizosphere and Nodule Bacteria to Improve Crop Yield

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Enhancement of legume N2-fixation by co-inoculation of Rhizobia and some PGPR is a way to improve nitrogen availability in sustainable agriculture production systems. Groundnut is an important cash crop of Pothwar, and fixes about 10-30 kg N ha-1. Therefore, there is a need to characterize and identify the potential PGP strains from groundnut rhizosphere in order to explore its N2-fixation potential for increasing crop yield by co-inoculation with Rhizobium sp.The bacteria were isolated by adopting the dilution plate technique, using phosphate saline solution as buffer and Tryptic Soy Agar as general media for bacterial growth. For isolation of Rhizobium sp Yeast MannitolAgar was used. The purified strains were screened and characterized for nifH gene by using forward and reverse primersprimers i.e. PolFb(TGC GAY CCS AAR GCB GAC TC) and PolRb (ATS GCC ATC ATY TCR CCG GA), Indole Acetic Acid production and P-solubilization. Biochemical characterization of the strains was carried out by using Biolog, API ZYM and API 20E kits. More than 50 bacteria were isolated from groundnut rhizosphere soil and designated as G1, G2, G3,….etc. These bacteria solubilized tricalcium phosphate in the range of 30-300 µg ml-1. Similarly IAA produced by these isolates was in the range of 4-22 µg ml-1. Some tested isolates gave a PCR product with primers for nifH genes. DNA of the potential strains was amplified by PCR, using forward and reverse primers: 9F (5-GAGTTTGATCCTGGCTCAG-3) and 1510R (5-GGCTACCTTGTTACGA-3), and confirmed by gel electrophoresis. Comparative analysis of 16S rRNA gene sequence performed by universal primers, confirmed the diversity of rhizobacteria and the isolates belonged (>99% sequence similarity) to genus Rhizobium,Bacillus and Chryseobacterium etc. Four Rhizobium sp. (R. alkalisoli, R. massiliae, R. loessense and R. huautlense) were isolated from nodules and their nodulation test was performed to check the nodule formation on host plant. These Rhizobium sp. were also positive for housekeeping genes atpD, recA, glnII and rpoB. Phylogenetic tree based on neighbor joining method were constructed by retrieving their closest relatives through BLAST search using MEGA4 software. These potential PGPR will be further studied to be used as bio-innoculant for crop production.

Keywords：*Groundnut, PGPR, Rhizosphere, Rhizobium, Molecular, Biochemical*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Dynamics of Soil Amino Sugars during Maize Growing Season under Different Management

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Amino sugars, which are rapidly formed as by-products of microbial growth and decomposition, are one of the important indicators that link microbial community and soil organic matter turnover due to its differences in relative stability and microbial origin (Parsons, 1981). Among the four detectable amino sugars, N-acetyl muramic acid (MurN), a component of extra-cellular polysaccharides of the bacterial cell wall, is a bacterial indicator (Amelung, 2001). Due to the uncertainty of the origin of Galactosamine (GalN), its indication still remains unclear. Since Glucosamine (GluN) is a major compound of the chitin of fungal cell walls, it is widely used as a fungal indicator (Amelung, 2001). The dynamics of heterogeneous amino sugars can provide information regarding the microbial gross community shifts with environmental changes (Liang et al., 2008). Further, research reveals that the ratio of GluN to MurN would give more information on the response of different microorganism communities to the added substrates (Glaser and Gross, 2005).

In order to probe into the dynamics of soil amino sugars and the seasonal shift of microbial community structure in agricultural ecosystems, a field experiment was conducted in triplicate of micro-plots. A total of 50 kg N ha^{-1} as $(NH_4)_2SO_4$ was applied as a basal dressing, and two top dressings of 150 kg N ha^{-1} at jointing and filling stages were applied to a maize crop during one growing season. The distribution and seasonal dynamics of amino sugars were measured by gas chromatography (GC). Results showed that in the treatment of only applying fertilizer N without maize stalk (NT) the content of total amino sugars decreased about 204 μg g^{-1} soil (equal to 29%) from sowing to harvest stage in the depth of 0-10 cm, while GluN, GalN and MurN were decreased by 23%, 46% and 27%, respectively. In the treatment of fertilizer N applied with maize stalk (ST), the content of total soil amino sugars decreased by 42% ($P < 0.05$) from sowing to jointing stage, while it increased by 36% from jointing to harvest stage ($P < 0.05$). The ratio of GluN to MurN decreased from sowing to jointing stage, and then increased gradually from jointing to harvest stage. All the results implied that amino sugars could be decomposed as the N resource in the treatment of ST, while the decomposition of maize stalk stimulated the mineralization of amino sugars. At the early stage, the bacterial residues predominated for accumulation of organic matter, while fungal residues dominated in the latter stages.

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Keywords：*soil amino sugars, dynamics, seasonal , soil organic matter, maize, stalk*

P3-291

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Effects of 1-Octyl-3-Methylimidazolium Chloride ([omim]cl) Ionic Liquid on the Functional Diversity of Soil Microbial Communities and Enzymatic Activities

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Ionic liquids (ILs) refer to the salts composed with organic cation and inorganic anion. As low temperature molten salt, ionic liquids (ILs) have been considered to be green solvents and begun to see large-scale application in the chemical reaction, separation process, electrochemistry, etc. However, their toxicity has also started to draw attention in recent years. The Royal Chemical Society of Britain has pointed out: the biggest obstacle of ILs application is the information deficiency of basic data of physi-chemical properties and toxicological. In order to evaluate the impact of [omim]Cl application at different concentration levels under different exposure days (sampled at 7, 14, 21 and 28 d), two typical soil hydrolase (urease and acid phosphatase) activities and the functional diversity of soil microbial communities were directly measured through a lab simulation test.

(1)Functional diversity of soil microbial communities was examined by microbial metabolic diversity (BIOLOG) assays to evaluate the effects of [omim]Cl with different concentrations on soil microbial communities. The results showed that soil microbial metabolic diversity in the control was significantly higher than that in soil in which [omim]Cl was added. The effects of [omim]Cl on functional diversity of soil microbial communities were enhanced with the increase of [omim]Cl concentration. Compared to the control, the richness and diversity indexes of soils treated with [omim]Cl were significantly lowered. According to the principal component analysis (PCA) in the middle treatment stage (14d), the cumulative contribution rate of the first and second principal components were 41.94% and 23.54% respectively. The number of first advantage bacterium group decreased dramatically in the high concentration treatments.

(2)The activities of soil hydrolases (urease and acid phosphatase) served as the indicators to access the toxicity of [omim]Cl to soil microbial system. Urease activity was measured by indophenol-blue while acid phosphatase was assayed by PNPP reaction. The results showed that both of the urease and acid phosphatase activities in the low concentration treatments (1mg/kg) did not change significantly in all infected processing cycle, while high concentration treatment group (10,100 mg/kg) has a significant discrepancy in the determination result from 14d to 28d. In general, only a high concentration of [omim]Cl has an inhibitor effect on soil hydrolases activities.

In conclusion, the ionic liquids inhibited the activities of soil hydrolases and caused the decrease of microbial metabolic activity.Moreover, the results were concentration-and time-dependent according to the result of double factor analysis.

Keywords：*Ionic liquids, soil hydrolases, BIOLOG*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Soil Microbial Diversity and Community Structure as Affected by Endosulfan Residual

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Due to the extensive use in agriculture, endosulfan has persistent existed in soil, water, air, and food products. The US Environmental Protection Agency (EPA) concludes that endosulfan poses a hazard to both wildlife and humans, citing evidence of fish deaths downstream from treated areas and indications of neurodegenerative impacts in animals. According to the long half-lives in soils, sediments, air or biota and potential for environmental transport, endosulfan is designated as a persistent organic pollutant (POPs) under the Stockholm Convention in 2011 and will be withdrawn from the global market in 2013. To evaluate the soil toxicology effect of endosulfan at different concentration levels (0, 0.1, 1 and 10 mg endosulfan within per kg soil) on soil microorganisms, a number of indexes, such as soil respiration, microbial biomass carbon (MBC) and bacterial community structure diversity, were directly measured on the 7th, 14th, 21st and 28th days exposure. (1) Soil respiration was assayed by using the sealed air chamber. At the initial stage (7d), the endosulfan disturbed soil respiration extensively, with CO2 emission of treatment groups decreasing significantly. With the prolonged incubation(14d and 21d), the soil respiration in the endosulfan treatments of low and medium concentrations reduced compared to the controls. Nevertheless high concentration treatments were still less than control, while there was no significant difference between endosulfan treatments and controls at the last stage of incubation (28d). Overall, high concentrations of endosulfan inhibited soil respiration in the short term, but this inhibition can be removed with time.
(2) Microbial biomass carbon was determined by chloroform fumigation–extraction. In comparison with the control, the soil microbial biomass carbon in the endosulfan treatments was significantly higher during the period of incubation, but it decreased progressively with time. This result indicated that endosulfan played a role in stimulating the soil microbial biomass carbon.
(3) The technique of terminal restriction fragment length polymorphism (T-RFLP) was used to research the diversity of soil bacteria community structure under the influence of endosulfan contamination. The results showed that the microbial diversity fell because of endosulfan, and the more exposure time with a more significant impact. According to the principal component analysis (PCA), the cumulative contribution rate of the first and second principal components were 64.3% and 13.1% respectively. The number of first advantage bacterium group decreased dramatically in the high concentration treatments. This observation suggested that the soil bacteria community structure was repressed by endosulfan residual.
Soil respiration is an ideal indicator of soil microbial activity and mineralizable substrate. Soil is a complex ecological environment and microbial biomass carbon (MBC) is the active ingredients of soil organic material, which is associated with a variety of soil processes. Microbial communities are the main driver of earth biochemical cycle. In conclusion, the application of endosulfan has profound impact on soil ecosystem.

Keywords：*Endosulfan, Soil respiration , MBC, T-RFLP*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Bacterial Versus Fungal Contributions to Microbial Community Structure in Grasslands of Differing Management History

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Introduction/Methods –
The tallgrass prairie once dominated much of the mid-western United States. However, this highly productive system has been almost completely eradicated by intensive agricultural practices. In Illinois, for example, less than 0.1% of pre-settlement tallgrass prairie remains. The conversion from native tallgrass prairie to cropland leads to a rapid depletion of soil structure, SOM, and the soil microbial biota. Recently, there has been a renaissance in natural area restoration and stewardship of the tallgrass prairie in the Chicago region (Illinois, USA), especially in the efforts to restore former agricultural fields to tallgrass prairie. These restorations offer a valuable opportunity to assess the generality of changes in soil ecosystem-level processes in managed grassland systems. In this study, we examined the changes in the abundance of fungi relative to bacteria (F: B, by qPCR) and physical and chemical factors (texture; SOM; N, P fertility) in soils collected from prairie restorations of varying ages, as well as abandoned fields and undisturbed native prairie remnants. We used these data to ask whether shifts in microbial abundance and community structure occurred within aggrading soil systems, and how these shifts might be related to soil factors. More specifically, we predicted that the abundance of fungi relative to bacteria should increase following conversion from tillage agriculture to tallgrass prairie, and continue to increase with increases in SOM over the management period. If so, the detection of a substantial increase in microbial biomass and F: B could be used to indicate effective restoration progress, or reflect changes in other indicators of soil function.

Results/Discussion –
Our results demonstrate that F: B were lower in abandoned field than in restored sites. At the same time, the total microbial biomass was greater in abandoned fields than in restored sites and prairie remnants, owing to a greater abundance of bacteria in the soils of abandoned and unmanaged fields. Taken together, these findings demonstrate that restoration and management both modifies microbial biomass and guides the community towards greater abundance of fungi. These data support our prediction, and indicate that management on a regional scale promotes a shift in microbial abundance and community structure. This finding is important because it suggests that fungi play an increasingly significant role in soil biological processes of managed and restored grasslands. Further, the observed shifts in F: B were correlated with soil factors. Notably, an increase in F: B was associated with increases in SOM with management. The shift in F: B was not substantially correlated with soil aggregation, clay, or P. While these results support our predictions, they also indicate that changes in abiotic soil properties may be a prerequisite for increases in fungal biomass toward levels found in prairie remnants. Overall, these findings lay an important foundation for understanding tallgrass prairie restoration and management in that: deficits in the microbial community resulting from intensive agriculture may be reversible; restoration management may facilitate the shift to a fungal-based soil food web; and F: B ratios provide a valuable integrative measure of system development and maturity.

Keywords : *fungi, bacteria, microbial structure, soil organic matter (SOM), management, restoration, grassland, tallgrass prairie*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Phenotypic Composition of a Key Grass Species and Soil Processes in a Semiarid Grassland after a Rain Pulse Event

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Grazing by large herbivores (a form of land use change and land use intensification) can alter directly a number of soil physical and biogeochemical processes. Less acknowledged; however, is how grazing can affect soils indirectly through their effects on plant communities. For instance, by altering plant species composition differing in plant functional traits (e.g., litter chemistry), grazing could affect litter decomposition rates and eventually soil nutrient cycling. Some evidence on grazing indirect effects on soil exists in the literature for the plant species level, but less is known below the specific taxonomic class.

Here, we present results from a field experiment manipulating the phenotypic functional composition of Bouteloua gracilis (HBK) Lag. ex Steud, a bunchgrass and key species native to the semiarid North American shortgrass steppe, to look at phenotypic functional composition effects of on soil processes and soil microbial communities.

The field experiment was set up in summer 2003 at Central Mexico by creating synthetic plots with B. gracilis lines coming from two sites with contrasting grazing history; and which show consistent differences in leaf traits known to affect litter decomposition rates, soil nutrient cycling and soil microbial communities. These lines included a low leaf lignin content-low leaf dry mass phenotypes (LLC-LLDMC), and a high leaf lignin content-high leaf dry mass phenotypes (HLC-HLDMC) coming from a heavily and a lightly grazed areas respectively. With these two phenotypic lines and reproducing individual plants vegetatively, we built synthetic phenotypic plots differing in proportion of LLC-LLDMC and HLC-HLDMC individuals (called here phenotypic functional composition treatments). Three different phenotypic functional composition treatment plots (9 B. gracilis individual plants per plot, 6 replicated plots per treatment) were built: (1) a low lignin treatment (LC, all individuals LLC-LLDMC), (2) a high lignin treatment (HL, all individuals HLC-HLDMC), and (3) an intermediate lignin treatment (varying proportions of both phenotypes).

Additionally, we applied to the plots a small rain pulse events in spring 2006. This was done in order to reduce noise induced by plant activity on soil process (i.e., plant nutrient uptake). We followed up soil response in different times after the pulse application. We used an event size (10 mm) equivalent to the most frequent rain size in our study area from a long-term weather dataset.

We hypothesized that phenotypic functional composition would affect soil processes so that soil inorganic nitrogen (N) mineralisation and extractable inorganic N would respond inversely to the degree of lignin content proportion in a treatment (e.g., higher N in LC treatments). Similarly with respect to soil microbial communities, we expected soil microbes' catabolic activity (as measured by microplates substrate use) to be inversely related to proportion of lignin content in treatments. Our enquiry is relevant in terms of land management since the region of the shortgrass steppe in Central Mexico we focused on shows high rates of land use intensity and land use change driven by grazing. Grazing-driven land use has been shown to modify B. gracilis phenotypic composition at the local level as well.

Contrary to our expectations, soil inorganic N mineralisation rates, soil inorganic N content and soil microbial catabolic activity did not respond significantly to our phenotypic functional composition treatments. We attribute such lack of response to biophysical factors in semiarid ecosystems which constraint the degree of variation in leaf lignin content and dry leaf mass content of B. gracilis necessary to trigger a response in litter decomposition, N availability and soil microbial activity.

Nevertheless, the pulse experiment and our data on soil N, and soil catabolic activity along different times since pulse application allow us to suggest that N availability in this semiarid grassland might be related to soil microbial biomass turnover and activities of microbes with different soil moisture optima.

Overall, no evidence was found that grazing is a factor which affects soil N cycling indirectly by altering the phenotypic composition of the key species in the shortgrass steppe, at least within the time frame of our experiment.

Keywords：*plant functional diversity, plant functional composition, semiarid grasslands, soil nitrogen*

P3-295

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Effects of ZN, CU and Al Metals on Tetracycline Antibiotic Resistance in the Chicken Manure

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Tetracyclines (TCs) is one of the most widely-used antibiotics in the word, which are applied as human infection medicines, veterinary medicines and animal growth promoters. Because a small number of TCs are absorbed during metabolism, the majority of TC are excreted via feces and urine as the unchanged form. Frequent application of TC antibiotics has given cause for concern about increased antibiotic resistance of microorganisms in the terrestrial environment. Besides, heavy metals were widely used in feeding animals in order to improve the growth of them. There is less information on the effect of the antibiotics resistance in the presence of metals. In manure microbial ecosystems, TC and co-existence metal should affect the resistance of bacteria. In this research, we investigated the effects of TC and three metals, including Zn, Cu, and Al, on the microbial ecosystems isolated from chicken manure. The results showed that Zn has no significant effect on the resistance of bacteria isolated from chicken manure; the increasing concentrations of Cu and Al inhibited the growth of bacteria. Compared with TC resistance of bacteria in chicken manure, the bacteria in chicken manure was sensitive to the increasing concentrations of TC-Cu, but not the increasing concentrations of TC-Al. In the presence of Al, the activity of TC was reduced by the formation of TC-Al complexes. TC and co-existence Al promoted the growth of the bacteria. However, there is no obvious trend toward effects of the TC-Zn concentrations on the resistance of bacteria, and the bacteria were more sensitive to TC-Zn than TC-Cu or TC-Al. The interactions between co-metals and TC would affect the sensitivity of bacteria in chicken manure.

Keywords：*tetracycline, antibiotic, chicken manure, metal, resistance*

P3-296

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Evaluate Nematode Assemblage Analysis as Indicators of Long-Term Organic Amendments on Soil Quality: A Comparison between Upland and Paddy Field Soil

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Low fertility of red soil restricts the sustainable development of agricultural productivity in tropical and subtropical regions of China. Different fertilization managements may affect soil physicochemical and biological properties. Although soil nematode assemblage analyses have the great potential in indicating soil quality or health based on numerous earlier studies, fewer studies have addressed the comprehensive comparison of paddy and upland soil which are two dominant land-uses in this region. In this study, we collected soil from paddy and upland field under different fertilization practices in paddy and upland field with continuously maize and rice cropping, respectively. Five fertilization managements were established for paddy and upland field since 1981, including no fertilizer (CK), inorganic fertilizers (NPK), double application of inorganic fertilizers (2NPK), single organic manure (OM) and combination of both organic manure and inorganic fertilizers (NPK + OM). Besides investigating soil nematode assemblages, we also analyzed the relationship between nematode assemblage and other soil quality indexes to explore the indicative value of nematode assemblage. Our findings would help the improvement of agricultural management practices in subtropical red soil region. The main results are as follows: For both paddy and upland soil, the organic amendment significantly ($P<0.05$) increased the contents of total organic C, total N, microbial biomass C, microbial biomass N and mineral N and nematode abundance. Notably, the application of inorganic fertilizers deteriorated the situation of soil acidity. In contrast, soil pH value showed remarkable increases under organic amendments for both paddy and upland soil ($P<0.05$). Moreover, organic amendment can promote soil enzyme activities that participated in carbon, nitrogen and phosphorus cycle including invertase, xylanase, β-glucosidase, cellulose, urease, L-asparaginase, glutaminase, histidine deaminase and phosphatase, with the most remarkable effects were observed when the field received the single organic amendment for both paddy and upland soil, except one case of invertase in the upland soil. The capacity of soil microbial community to utilize various substrates was determined to evaluate the functional diversity. In paddy soil NPK, NPK+OM and CK were closely related, while in upland soil NPK+OM, OM and 2NPK performed closer. Similarly, the total abundance and the proportion of free-living nematodes (bacterivores, fungivores and omnivores/predators) increased with organic amendment in both paddy soil and upland soil. On the contrary, organic amendment decreased the proportion of herbivores, especially for the soils subjected to long-term organic amendments exclusively. Non-metric multidimensional scaling (nMDS) ordination showed that soil nematode assemblages of paddy soil and upland soil were clearly separated from each other. RDA analysis, however, failed to reveal any significant correlations between the specific nematode genus and soil microbiological and physicochemical indices. In conclusion, soil nematode assemblage demonstrated distinct responses to various fertilization managements. The analysis of nematode assemblage showed high potential values to indicate the effects of different fertilization managements. Surprisingly, we did not find strong relationships between nematode assemblage and other microbiological or physiochemical indices, which might be caused by the acclimatization of nematode assemblages to soil environment under long-term and constant fertilizations. Nevertheless, nematode assemblage analysis provides complementary information of the soil ecosystem state, leading to a more comprehensive understanding the structure and function of red soil ecosystem under different agricultural managements.

Keywords：*soil biota; soil function; fertilization; soil quality; nematode assemblage*

P3-297

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Modeling Carbon and Nitrogen Mineralisation from Diverse Crop Residues Measured from Incubation Studies

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The wide range of plant materials used in low-input tropical farming systems brings new challenges for modeling soil carbon and nitrogen dynamics. We report on four datasets sourced from incubation studies where modelled predictions of carbon and nitrogen dynamics from plant residues were compared to measurement. Residue quality, as indicated by C:N ratio (range: 9.1 to 148), lignin content (range: 0.6 to 25.5) and cellulose/hemi-cellulose as measured by Van Soest method (range: 3.4 to 75.2) profoundly affect decomposition patterns yet most models do not allow adjustment of plant residue inputs to allow for such effects. Using APSIM's SOILN (version 7.5, http://www.apsim.info/) soil organic matter model, the decomposition of fresh organic matter (FOM) representing added organic materials, results in the formation of two pools (BIOM - comprising the more labile organic matter and HUM - a more stable pool). To enable diverse residues to be simulated, the FOM pool has three compartments (FPOOLs), with each pool having a decomposition rate and the proportion of C allocated to FPOOLs variable.

The model has been successfully applied to representing the nitrogen mineralization from common crop residues (cereals and legumes), however when residues decompose slower than what their C:N suggests, the model setup must be modified to better match measured C and N release. In our study, these modifications included: (1) changing FPOOLs size based on measured data from default values as 0.2 : 0.7 : 0.1; (2) allowing the C:N ratios in each FPOOL vary, depending on N content which was determined by optimisation; (3) the proportion of the C decomposed from FOM pool that could be retained in the system based on biochemical quality of residues; (4) the proportion of the C decomposed from BIOM and HUM pools retained in the system based on soil characteristics; (5) re-formulation the fraction of retained biomass returned to biomass; (6) re-formulation the fraction of retained FOM transferred to biomass. With these modifications, the predictive ability of the model improved as indicated by modeling efficiency, a measure of goodness of fit between the simulated and observed data.

Keywords：*carbon, nitrogen, mineralisation, soil organic matter model, APSIM, SOILN*

P3-298

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Detection of Soil Microbial Activity by Infrared Thermography (irt)

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The determination of microbial activity is important for assessing soil fertility or indicating soil contamination. There exist several well established methods like calorimetry or respirometry. With these methods large samples campaigns are relatively elaborate and they do not allow a detection of spatial patterns of microbial activity.

In this contribution we present a new method to study microbial activity using infrared thermography (IRT). This method is based on the fact that microbial activity produces heat due to respiration. The main advantages of this method are: (i) spatial patterns of microbial activity can be determined, (ii) measurements are easy to conduct, (iii) both sample volume and sample number can be large, and (iv) measurements can potentially be conducted in situ without soil disturbance.

Two laboratory experiments were conducted. 8 samples of a Cambisol A horizon were treated with a glucose mixture while 8 were used as reference. Surface temperature distributions on the samples were measured using an IR camera. The microbial activity of glucose treated samples was also determined by CO2 and heat production measurements using respirometry and calorimetry, respectively. In the second experiment a glass container was filled with the same soil treated with glucose. Half of the soil in the container was additionally contaminated with copper.

Differences between surface temperatures between treated and untreated samples measured with the IR camera corresponded well with respirometer and calorimeter measurements. The predefined pattern of soil contamination in the second experiment could be well detected using the IR camera.

The new method is a useful tool to easily and rapidly determine microbial activity on large numbers of samples simultaneously. Furthermore, spatial distributions of soil contamination are detectable. If more precise information about microbial activity in soil samples is required, the classically used methods are favorable.

Keywords：*Infrared thermography; Spatial soil microbial activity; Detection of soil pollution; Calorimetry*

P3-299

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

No Correlation between Plant Diversity and AMF Diversity but Significant Variations of AMF Community Along Karst Vegetation Restoration

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Aims Arbuscular mycorrhizal fungi (AMF) are crucial in vegetation regeneration procedures since the AMF plays an important role in improving plant establishment and growth. However, the information on AMF diversity with plant diversity and their correlations are very limited during the process of vegetation restoration in degradation land. This study aim was to investigate the diversity and distribution of soil AMF in vegetation restoration ecosystems, and to explore relationships among soil AMF diversity, plant diversity and soil properties in Karst region of southwest China.

Material and Methods Four representative vegetation restoration stage ecosystems (tussock (T), shrub (S), secondary forest (SF), and primary forest (PF)) were selected as studied objects. The genetic diversity and structure of AMF community was determined using a pyrosequencing-based approach. Plant species Shannon-Wiener-Wieners diversity, species richness and species evenness were calculated based on field survey of the plant communities, and the contents of soil organic carbon (SOC), available phosphorus (AP), total nitrogen (TN) and soil pH were measured.

Results The plant species diversity and soil nutrient contents increased, but the soil AMF genetic diversity presented a concave dynamic trend with the vegetation restoration. The AMF species relative abundance from Glomerales order was dominant in the four ecosystem soils: 95.73%, 95.60%, 93.65% and 95.18% in the T, S, SF and PF, respectively; AMF species of the Diversisporales order were only found in PF and SF soils, and no AMF species from Archaeosporales and Paraglomerales order were detected in these four soils. The species composition, structure and diversity from four soil AMF communities were observed significantly different ($p < 0.05$). Redundancy analysis (RDA) showed that the soil AMF community was closely linked to the AP content and soil pH, which explained 66.4% variance of AMF community.

Conclusions Significant shifts of AMF community were concomitant with Karst vegetation restoration and plant species diversity and soil habitat nutrient positions codetermined soil AMF genetic diversity in these Karst ecosystems. Selections on AMF species for promoting plant species establishment and growth need to be considered in vegetation restoration of Karst degradation land.

Keywords：*Arbuscular mycorrhizal fungi Degradaton ecosystem-Ecological restoration-plant diversity-Pyrosequenc*

P3-300

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Winter Behaviors of Soil Microbial Biomass P and Alkaline Phosphatase as Affected by Tillage and Fertilization

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Soil microbial biomass P (SMB-P) and alkaline phosphatase (phosphomonoesterase) play important roles in the soil organic P transformation involved in P cycling. They should be affected by drastic variations in climatic conditions occurring during winter in cool and temperate regions of eastern Canada. Determining how agricultural management practices affect these parameters during winter could further our understanding of soil P cycle. This study assessed winter behaviors of soil microbial biomass phosphorus (SMB-P) and alkaline phosphatase as affected by tillage and P fertilization. In 1992, a long-term corn (Zea mays L.) and soybean (Glycine max L.) rotational experiment was established in the province of Quebec, Canada. Soil samples (0–10 and 10–20-cm) were collected in February 2010 and 2011 in plots under moldboard plow (MP) and no till (NT) management and fertilized with 0, 17.5, or 35 kg P ha-1 and 160 kg N ha-1. Soil samples were analyzed for different attributes including SMB-P, alkaline phosphatase, Mehlich-3 (PM3) and organic P (Po). Greater total snowfall, snow on the ground and lower air temperature were observed in 2011 compared with in 2010. Results show that SMB-P and alkaline phosphatase were greater in 2011 than 2010 indicating that these variations could be dependent on environmental factors. In the 0–10-cm soil depth, greater SMB-P in both years and greater alkaline phosphatase only in 2011 were observed in NT compared with MP. Tillage had no significant effect on these properties in the 10–20-cm soil depth. The P fertilization had no significant effect on SMB-P at the 0–10-cm soil depth and on alkaline phosphatase at both depths. However, significant effect was observed on SMB-P at the 10–20-cm soil depth. Under MP, SMB-P decreased in 2010 but increased in 2011 with the increasing P application while under NT, SMB-P increased with the increasing P application in 2010 and 2011. Under MP, SMB-P was negatively correlated to PM3 in 2010, but positively correlated to PM3 in 2011 indicating the impact of weather conditions on P cycle. Under NT, SMB-P was positively correlated to PM3, but negatively correlated to Po while the alkaline phosphatase was positively correlated to SMB-P and PM3 indicating that these two properties were predominant factors in the soil Po mineralization process under NT. We conclude that tillage and P fertilization could affect SMB-P and alkaline phosphatase involved in P cycle during winter, but they were largely influenced by environmental factors.

P3-301

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Biofortification of Iron in Chickpeas by Plant Growth Promoting Rhizobacteria

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Iron deficiency is a major nutritional disorder being responsible to affect millions of the people around the globe. Its malnutrition can be reduced through biofortification, a process to produce micronutrient enriched staple food. Plant growth promoting rhizobacteria (PGPR) have been reported to fortify iron content within plant tissues by enhancing its availability through siderophore production. In a pot study, five bacterial isolates were tested for improving plant growth and bioavailable iron contents in chickpeas where iron (Fe) was applied in the form of iron sulphate solution. Results showed that inoculation with PGPR significantly enhanced the plant height, number of pods, root length and Fe uptake compared to un-inoculated control plants. Application of PGPR showed 81% and 75% increase in grain and shoot iron content, respectively. These results suggested that PGPR can help plants to uptake extra Fe from soil if soil is supplemented with additional Fe. These findings advocate that microbial assisted biofortification in grain can alleviate micronutrient deficiency in resource limited countries.

Keywords：*Malnutrition, Iron biofrotification, PGPR, Chickpeas*

P3-302

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Studying the Population Variability of Microorganisms Adapted to the Conditions of Soil Degradation

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At present priority for the agriculture of the Republic of Uzbekistan is to obtain a volume growth of agricultural production by increasing crop yields. The solution to this very important task can be accomplished by reproduction and improvement of soil fertility, cropping differentiated taking into account soil - reclamation conditions and the introduction of new farming technologies developed and used in agricultural production in recent years (Kuziev, Sektimenko , 2009, Gafurova , 2012) . To improve the degraded, including saline soils need to be taken in-depth scientific and practical measures to preserve and improve the biological activity, the active introduction of biotechnology in soil science, improve the use of irrigated soils under saline conditions, focused and efficient reproduction of biological factors that increase the level of fertility of degraded soils.

In this regard, the creation of products - microbial complexes from local strains of our country, capable of retaining their basic properties in extreme environments is a promising and is of great theoretical and practical interest.

In the research center 'AgroEcoBiotechnology' at the National University named after Ulugbek technology for production of microbial composition 'Zamin -M ', which has a complex effect on the plants and soil. Based on these studies, it was found that the application of the microbial composition and Rhizosphere soil cotton formed specific salt-tolerant microorganisms consisting of heterotrophic Ammonifying, spore-forming bacteria, Actinomycetes and fungi. Molecular- biological screening mechanisms of salt tolerance associations of microorganisms belonging to the microbial composition 'Zamin -M' confirmed that the salt tolerance is the process of inheritance of genetic information and the adaptive mechanisms of microbes that allow them to respond more flexibly to changing environmental conditions.

P3-303

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Soil Enzymatic Activities and Microbial Functional Diversity under Different Agricultural Management Practices in Northern France

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The literature reports that in an agricultural system, management practices and land use can influence soil biological properties. Microbial activities often respond quickly to changes in soil management and are known to be indicators of soil quality and health.
This study implicated 15 plots of five different agricultural sites in North west of France in the region of Upper-Normandy. They have been selected according to contrasting agricultural practices as cultivated soils (conventional, integrated, and organic) and grassland. Grasslands soils were at least ten years old without soil disturbance. Plant cover of cultivated soils was wheat crop. Studied soils are all loamy soils.
Soils were characterized by both physicochemical and biological parameters. Granulometry, moisture, pH, organic C, total N, extractable P and CEC were assessed according normalized methods. Microbial functional diversity has been measured as potential metabolic activity of heterotrophic bacteria with BiologTM ecoplate well system (average well color development (AWCD) and Richness (R)). Finally, in situ enzymes activities were measured with pnp-substrates. Activities of cellulase, xylanase, β-glucosidase and N-acetyl-glucosaminidase have been assessed in order to evaluate the impact of agricultural practices on different steps of carbon cycle. Agronomic parameters, as yield, were measured the year of sampling.
Chemical analysis of soils showed differences only between grassland and crop soils ($p<0.05$). Agricultural practices did not impact the physicochemical parameters. Biological parameters discriminated grassland and crops, especially N-acetyl-glucosaminidase, β-glucosidase and xylanase ($p<0.001$). Cellulase and functional diversity (AWCD and R) were less significant ($p>0.05$). Organic and conventional practices induced modifications in functional diversity of soil communities that have consequence on enzymatic activities. Organic practices showed higher activity for xylanase (1.5 fold), and R (5 fold) and lowers for β-glucosidase (1.5 fold). Furthermore, grassland and cultivated soils differed on the ability of consumption of carbon substrates (BiologTM). Carbohydrates is the major carbon source used by grassland soil bacteria whereas bacteria of cultivated soil developed preferentially on amino acids. This kind of difference discriminate also integrated and others agricultural practices.
Under our agronomic, soil and climatic conditions, studied microbial descriptors discriminate two land use and several agricultural practices. Our results suggest that some agricultural practices provide a better conservation of soil biological properties, without effect on wheat yield. This work focus on biological functional properties on carbon cycle, it could be of interest to evaluate the effect of agricultural practices on other biogeochemical cycle and especially on nitrogen cycle.

Keywords：*Microbial functional diversity ; soil enzyme activities ; land use ; soil management ; soil quality*

P3-304

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Soil and Climate Effects on Cowpea Rhizobial Diversity in Pernambuco

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Biological nitrogen fixation by the legume-rhizobia symbiosis is one of the main sources of available nitrogen to crops, and incurs in minor risks to long-term sustainability of the food production systems. This sustainability is due to its independence from fossil fuels and to the low risk of groundwater contamination. Legume-rhizobia biological nitrogen fixation, though, is highly dependent on the bacteria component of the symbiosis, itself highly variable in efficiency and population, mostly due to its natural diversity. Rhizobial diversity is known to be affected by both climate and edaphic characteristics, which we aimed to evaluate under conditions prevailing in the semiarid region of Brazil. To this end, soil was sampled at all of the prevailing soil types of the eleven micro regions of Pernambuco State´s semiarid, with three to five different sampling points in each soil type for each micro region. At each sampling points, individual soil samples were obtained close to native forage legumes of the Desmanthus, Macroptillium and Stylosanthes genera, and if none of these occurred at a composite soil sample was obtained, for 1200 soil samples. These samples were used for standard soil fertility and particle size analysis, which together with climatic characteristics of their origin were used for cluster analysis. Cluster analysis formed eight clusters at the 50% similarity levels, of which two were most divergent, and from which soil samples were used for cowpea (Vigna unguiculata) inoculation on a Leonard jar experiment. Nodules from this experiment were used for rhizobial isolation under standard procedures, followed by again standard cultural characterization of the pure cultures. These characteristics were separately used for a cluster analysis for each original cluster, and evaluated through the standard diversity measures. The most divergent soil groups could be characterized as low and high fertility, with the former being acidic (average pH 5.03, standard deviation (SD) 0.69), and with low P contents (average 7,67 mg.kg-1. SD 5.20 mg.kg-1), while the latter was basic and with high P availability (average pH 7.7, SD 0.19, and average P content 33,33 mg.kg-1. SD 38,59 mg.kg-1). The much higher variability for P contents than for pH, while observed for both soil clusters, is even more marked for the high fertility one, probably due to a few samples with very high P contents, which might be due to a sampling artifact, but cannot be ruled as such with any degree of certainty. While soil fertility differed markedly among the soil clusters, the same did not happen to biodiversity, since Shannon´s (1.61 and 1.60 for low and high soil fertility), Pielou´s (0.90 and 0.88 for low and high soil fertility) and Simpson´s (0.02 and 0.04 for low and high soil fertility))indexes were almost the same for both soil groups. This lack of effect may indicate that soil fertility has a lesser effect on rhizobial biodiversity, but should not be taken to indicate there are no effects on it, since these indexes measure overall diversity, but can not indicate if the groupings themselves were affected by the environmental conditions, just the number of groups and individuals in each. Further work is being conducted to evaluate this aspect, as well as compare the symbiotic efficiency of the isolates.

Keywords：*tropical, biodiversity, rhizobia, biological nitrogen fixation*

P3-305

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Relationships between the Soil Chemical Properties and Microbiological Activity in a Long-Term Field Experiment in Hungary

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The most important element of sustainable agricultural production is to maintain the soil nutrient supply and fertility applying environmentally friendly technologies. So the primary aim of the crop production is to achieve higher yields besides the good quality crops.

The fulfilment of these expectations profoundly affects the natural, ecological factors, applied agrotechnical methods, endowments, genetic characteristics of plant to grow, as well as expectation the economy in production. Among the ecological factors, the soil physical, chemical and biological properties play a key role. Can not be imagined the sustainability of soil without deeper knowing of the relationships among these factors.

Due to the dynamic doses of fertilizers the nutrient stock had increased in the soil till the mid-1980s in Hungary, so a relatively good yield quality and a balanced crop safety was achieved. From the 1990s drastically reduced the amount of fertilizer used, the yield decreased dramatically as well. The fertilizer consumption is stagnating at a low level for years. Today the nutrient balance is negative since only the half of the nutrients is returned to the soil that is extracted by yields.

The results of Western European long-term experiment demonstrate that the fertilization have direct and indirect effect on soil as a life community, mainly influencing the quantity occurrence and activity of plants and soil microorganisms.

Mineral nutrients need to microorganisms, the direct effect of nutrient mainly depend on its chemical composition, solubility, the quantity and ratio to other nutrients. Microbiological studies were made in fertilization experiment and proved that a balanced nutrient supply (both of macro- and micronutrients) had a positive effect on the processes of soil matter and energy transformation, on biodynamic, and development of crops. The indirect effect of fertilization usually enforced through the change of properties in soil environment.

The Debrecen-Látókép long-term fertilization experiment can be found in the Eastern part of Hungary, on the “Hajdúság loess plateau”. The soil type of the experiment is calcareous chernozem (Chernozems in WRB). The fertilization experiment was set in 1983.

In the paper the effects of different fertilizer levels applied in maize mono- and bi-culture [control, small (N60 P45 K45), small-medium (N120 P90 K90), medium-large (N180 P135 K135) large (N240 P180 K180) doses] were evaluated non irrigated and irrigated conditions. On the bases of the research work made in a nearly 30-year old experiment the changes in the soil chemical and microbiological properties are shown.

Among the soil chemical properties the soil pH, in related with it the hydrolytic acidity, the available soil nitrate, phosphorus, potassium, organic carbon and nitrogen were measured. The quantity change of some microbiological groups referring to the dynamics of microorganisms in the soil also was investigated. The amount of microbial biomass carbon and nitrogen, carbon dioxide production, nitrate exploration, and activity of some soil enzymes (phosphatase, urease, catalase and saccharase) were determined.

In the results we evaluated the effect of agrotechnical factors and sought the correlations among the chemical and microbiological soil properties.

In the plots of long term fertilization experiment the soil pH decreased, the acidified soil environment affected not only the quantity change of microorganisms, but the occurrence of microbiological groups too. Close correlation was found between the plan nutrients and microbial population dynamics. Also close correlation was measured among the nutrient content of soil and the measured enzymes activity.

Keywords：*microbiological activity, long-term field experiment,fertilizer*

P3-306

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Regulatory Role of Microbes in Soil Microaggregate Formation and Carbon (c) Sequestration

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Soil is crucial for food production for the growing population and also plays a vital role in mitigating global climate change. Soil carbon is the largest source of sequestered carbon in the planet. Soil aggregate dynamics regulate carbon and nitrogen cycling within ecosystems. Soil microaggregates physically protect soil organic matter (SOM), influence microbial community structure, limit oxygen diffusion, regulate water flow. Microbial biomass, the living component of SOM is a sensitive indicator of changes in soil processes linking soil nutrient and energy dynamics, also mediating the transfer between soil organic carbon (SOC) fractions. Soil C sequestration is regulated by soil microbes within the physical and chemical constraints imposed by soil aggregate size, moisture and nutrient availability. Microbes promote aggregation via direct binding to soil particles and production of polysaccharides that act as binding agents. Research states that arable systems with lower mechanical disturbance store more soil C due to increase in microaggregate formation and fungal:bacterial ratio. To date knowledge of microbial communities and their activities within different micro-environments (i.e. aggregate size) is poor but essential for understanding the regulation of soil process rates at the cropping system scale. Although a few groups of microbes are postulated to play important role in SOM dynamics, however, there have been no mechanistic studies conducted to evaluate the role of these specialized microbial groups in soil C storage.

In this study, soil samples collected from grain producing agro-ecosystems under different management practices (fertilizer application, tillage, residue retention and organic matter load trial) and soil types will be used to isolate different microbial groups of bacteria, Arbuscular mycorrhizal fungi and saprophytic fungi. These microbial groups will be back inoculated in soil incubated with 13C substrate of different complexities. Soil samples will be harvested after 6 months and SOM will be separated into different aggregate size fractions. Evaluation of microbial community associated with organic fractions in microaggregates using Real time PCR coupled with Stable isotope probing (SIP) will provide direct evidence of whether microbes have a regulatory role in the formation of microaggregates and sequestration of C in different soil aggregate classes. Significance of this experiment will be a novel understanding of the role of various soil microbial groups in C storage in different soil aggregate sizes leading to identification of management practices and soil types which could enhance enhancing soil C storage in grain cropping systems.

Keywords：*Microaggregates, SOM, management practices, SIP, fungal:bacteria ratio*

P3-307

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Impact of Different Cultural Rotations (pastures- Crop) on Microbial Community in Agricultural French Context

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Optimization in designing of crop rotations could be considered as a key component in farming system because it will impact on different soil threats such as decline of soil organic carbon, soil compaction and habitat for soil biodiversity. The present work focuses on the influences of a several cultural rotations (pasture-crop) on microbial community. This work is part of the French national “Bioindicator program” which aims to validate biological tools for soil quality monitoring and to identify endpoints for soil ecological assessment.

The field experimental site is located in North-Western of France (49°36’41” N, 00°44’29” E) on a agricultural school.

Six treatments are studied : one cultivated field (long-term arable cropping; “GC”), two restored pastures (one pasture 2 years old established after 6 years of cropping period “SI” and the other after 4 years of cropping “SII”), one temporary pasture sampled under crop phase (2 years of wheat-maize rotation following 5 years of pasture, “SIII”) and another temporary pasture sampled under pasture phase (pasture is 5 years old following 2 years of wheat-maize rotations “SIV”), and at least one permanent grassland (>25 years of pasture, “PP”). PP and SIV offer the best conditions for microbial development : abundances and biomass are very high, in addition to bacterial biomass (ADN16S), fungal biomass (ADN18S, ergosterol) are widely present. In tendance, PP vs SIV presents mower abundance, related to the cow trampling impact. GC treatment strongly affects microbial community, due to annual ploughing and exportation of OM : activity (enzymatic activities measurement) and biomass (Total AND extraction) are very low. In case of restored pastures (SI, SII), a beneficial effect on microbial population is quickly observed : after 2 years of pasture, microbial biomass and activities significantly increase, even if the biomass remain relatively low. The crop treatment SIII shows an important microbial biomass, explained by the long period under pasture (5 years); this result demonstrates that the cultivated practices (e.g. ploughing) impact on microbial community but do not generates the total erosion of the community (PLFA profil). These microbial community results allow a better understanding of the influences of the number of cultural interventions and the length of the pasture phase, and thus contribute to advice farmers for the right balance within pasture-crop rotations.

Keywords：*microbial community, agricultural soil, enzymatic activities, fungal biomass, ADN16S, PLFA*

P3-308

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Soil Bacterial Community Structure Associated with Perennial Vegetation on Agricultural Land in South-Western Australia

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In south-western Australia where the soils are generally characterized by a high degree of weathering in addition to low fertility and low organic matter content, replacement of native vegetation with annual vegetation has been shown to increase the risk of land degradation. Since land degradation is a major constraint to sustainable agriculture, priority actions have been required to manage the soils effectively. For this purpose, trees and/or perennial vegetation have been introduced into farming systems to identify an acceptable balance between agricultural productions with environmental effects for sustainable agriculture systems. Deep rooted perennial vegetation is supposed to improve water use and return more organic matter to the soil through its highly developed root systems which may alter soil characteristics in physical and chemical ways. Several previous studies suggested that introducing perennial vegetation influences soil properties, such as salinity and soil carbon content. However the biological aspect of perennial vegetation establishment such as bacterial communities is limited.

Belowground bacterial communities play a critical role in maintaining various soil processes and functions such as soil structure formation, decomposition of organic matter and nutrient cycling. While soil bacteria are extremely diverse and numerous, there is increasing scientific evidence that only a minimum number of bacterial species are essential for ecosystem functioning while the majority are functionally redundant. Thus, understanding of microbial characteristics of soil, including the role of dominant bacterial taxa, provides a more accurate prediction of ecosystem responses to environment change in soil as well as deeper knowledge of global genetic resources.

Bacterial distribution, diversity and community composition vary widely and land use and management are assumed to have indirect but inherent effects on bacterial communities through alteration of soil physical and chemical characteristics.

The aim of this study was to identify and characterise the dominant bacterial communities in soil under perennial vegetation to determine the influence of soil properties and land use on both bacterial composition and diversity. This included investigation of bacterial communities with high throughput 16S rRNA based sequencing. The traditional soil biodiversity analysis methodologies that involve culture-based methods provide a biased subsample of only those organisms which grow on agar in the laboratory. In contrast, the advent of direct DNA extraction protocols and high throughput sequencing of the 16SrRNA gene provides

unprecedented insights into the bacterial diversity and community composition of soils without the need for culturing organisms and associated biases.

Soil samples were collected from a range of land use (agroforestry, cropping, and pasture) and vegetation type (annual and perennial) in south-western Australia. The sampling area included perennial pastures with different establishment age to investigate how the duration of perennial vegetation influences soil bacterial communities. Characterization of bacterial communities was based on direct targeting, amplification and sequencing of the V3 region of the bacterial 16S rRNA gene with the Ion Torrent Personal Genome Machine (PGM) platform.

Upon matching resulting sequences with the RDP_22 database, it was found that dominant OTUs detected were affiliated with the phyla Firmicutes, Actinobacteria, Proteobacteria, and Acidobacteria, in that order, with Firmicutes being the most dominant phylum (32%). The identification of Firmicutes as the most dominant phylum in this sample set was an unexpected result for two reasons. First, out of at least 52 identifiable major lineages of phyla in various habitats globally, Proteobacteria, Acidobacteria and Actinobacteria have been reported to be the most abundant, bacterial composition. Second, Firmicutes have previously been suggested to be best adapted to conditions that are typically high in nutrients and saline. However, these dominant taxa were observed to inhabit the low salinity sandy duplex soils area in south-western Australia. On the other hand, the results in the different age perennial grass pasture showed Firmicutes was likely to decrease with the establishment length of perennial vegetation associated with the change of soil properties. It appears that some bacterial communities such as Firmicutes may be largely responsible for observed shifts in bacterial community structures resulting from soil property change.

Keywords：*land use, bacterial communities, 16S rRNA, perennial vegetation*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Biodegradation of Phenanthrene in Saline Soils by New Consortium of Halophilic Bacteria

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Biodegradation of polycyclic aromatic hydrocarbons (PAHs) in contaminated saline soil is an attractive remediation technique and its success depends on the ability of PAH-degrading bacteria, bioavailability of contaminant and the optimal condition for PAH-degrading bacteria. In the first part, the effects of some factors on biodegradation of phenanthrene, a 3-ring model PAH, in saline conditions by halophilic consortium (the main dominant strains were Q-SH3,Q-SH12 and Q-SH14) and one halophilic bacterial strain (Q-SH1) isolated from sodic and saline crude oil contaminated soil, were investigated using the different salt concentrations, temperatures, pH and phenanthrene concentrations. The optimal biodegradation condition was 37°C, 10% salinity and pH 7-8 for both of halophilic consortium and Q-SH1 strain. After 10 days, approximately 87.66 and 83% of initial amount (40 mg/ l) of phenanthrene was degraded at optimal biodegradation condition by halophilic consortium and Q-SH1 strain respectively. The effect of phenanthrene concentration on biodegradation showed that with increasing concentration of phenanthrene the percent of phenanthrene degradation decreased.

Keywords：*Biodegradation, Halophilic bacteria, Phenanthrene, Saline soils*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

The Thallus Formed by Streptosporangium with Cellulose and its Alkali Extraction Components

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Cellulose is the most abundant organic compounds in nature, its processing method can be divided into chemical and biological methods, in which mainly on microbial degradation of biological methods became the research focus. As an important component of the soil microorganisms, actinomycetes are the main decomposers of lignocellulose, chitin and other high-molecular polymers, in which the Streptosporangium has a wide distribution in China's soil. Although there are many approaches to the formation and decomposition of humus, it is believed that humus is formed by soil microorganisms. This study examines the chemical structure and the distribution of the carbon component from alkali extraction which thallus formed by Streptosporangium sp. with cellulose, further explore whether the Streptosporangium sp. forms humus and whether its alkali extraction components are constituents of humus after degradation of cellulose or not. Sodium carboxymethyl cellulose as the sole carbon source, inoculated with Streptosporangium sp. inoculation amounts to 10%, at 28 ~ 30 ℃, 180 ~ 200 r/min in the liquid shaking bed shaking culture experiment, according to the different time to take out the culture. With a high-speed centrifuge (16000r/min, 15min) separation, sedimentation is "thallus", which are sieved through a 0.25mm mesh sieve before being air-dried at 50℃ to be used for chemical analyses, its chemical structure were measured by the elemental composition, differential thermal analysis and infrared spectroscopy, while the distribution of the carbon component was analyzed according to the method described by humus composition modification. The results showed that: (1) The production rate of thallus increased significantly with the extension of incubation time. The distribution of the carbon component from alkali extraction which thallus formed by Streptosporangium sp. with cellulose focused primarily on 'water-soluble 'and ' alkali soluble but acid-insoluble (the equivalent of humic acid)' fractions. Then carbon component of ' alkali soluble and acid soluble (the equivalent of fulvic acid)' was the least. Carbon components from (38 ~ 60d) in pure culture of cellulose, with the extension of incubation time, 'alkali-acid soluble' and 'residue(the equivalent of humin) ' increased gradually, they first formed 'alkali soluble and acid soluble components' and then transformed into 'alkali soluble but acid insoluble components' slowly; (2) After inoculation of Streptosporangium sp., the carbon content changes were from 390.5 ~ 531.0 g/kg, H/C in 1.958 ~ 2.041 (mol), O+ S/C in 0.461 ~ 0.970 (mol), Exothermal high/medium rate in 0.331 ~ 0.884, were irregular at the beginning of the culture stage (7 ~ 28d), in later stage of culture (38 ~ 60d), with the extension of incubation time, carbon content and exothermal high/medium rate increased, H/C and O+S/C gradually reduced, the condensation degree raised, the oxidation degree reduced and aromaticity improved;(3)Compared to carbon content, H/C ,O+S/C ,Exothermal high/medium rate of black soil-humic acid (HA) of 581.1g/kg,0.978(mol),0.437(mol),8.722, respectively. H/C, O+S/C values of Streptsporangium sp. (60d) were respectively 1.968(mol), 0.647(mol),which were higher than that of black soil HA, carbon content values(461.7g/kg), exothermal high/medium rate values(1.549) were lower and the molecular structure was relatively simpler than that of humic acid (HA) of black soil. According to the changes trend of the culture, we could extend the incubation time to observe whether thallus could reach the index of black soil or not, which will provide theoretical support for Streptosporangium sp. forms humus after resolving cellulose.

This research was performed based on the financial support by National Basic Research Program of China (973 Program) (2011CB100503), National Natural Science Foundation of China (41171188).

Keywords：*Streptosporangium sp.; cellulose; thallus structure characteristic; alkali extraction components*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Hybrid Rice Promotes Ammonia Oxizing Baceria Relative to Ammonia Oxidizing Archaea in Rhizosphere at Different Growing Stages

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Ammonia-oxidizing bacteria (AOB) and ammonia oxidizing archaea (AOA) are responsible for ammonia oxidation which is the first and rate-limiting step of nitrification and play an essential role in global nitrogen cycle. It is well documented that rice paddy soils are known to have activities of both AOB and AOA, but impact of rice cultivars on ecology of ammonia oxidizers (AOB & AOA) is poorly understood under field condition.

A field experiment was initiated to assess the structure and abundance of ammonia oxidizers in the rhizosphere of hybrid and conventional rice cultivars at three growing stages. Rhizosphere samples were collected at selected growth stages for each rice cultivar: 45 days after planting (tillering stage-S1, 81 days after planting (grain filling stage-S2) and 107 days after planting (ripening stage-S3). PCR-denaturing gradient gel electrophoresis (DGGE) and real-time PCR approaches were used to evaluate the structures and relative abundances of ammonia oxidizers (AOA and AOB) by targeting a functional gene fragment coding ammonia monooxygenase (amoA). Moreover, important band retrieved from DGGE gel were analyzed using sequencing and phylogenetic analysis.

Hybrid rice promoted 53%, 30% and 23% higher rhizosphere amoA (AOB) gene abundance relative to conventional cultivar at S1, S2, S3 stages, respectively. Though, rice cultivars showed no considerable effect on the amoA (AOA) gene abundance. Principal component analyses (PCA) of PCR-DGGE profile revealed profound shift of AOB communities structure between two cultivars across particular growing stages. However, rice cultivars did not significantly influence the structure of archaeal-amoA (AOA) in rhizosphere showing the higher stability of AOA communities. Diversity of AOA was limited to uncultured Crenarchaeote, whereas AOB analyses revealed several distinct operational taxonomic units markedly resemble to Nitrosospira sp. in the rhizosphere of hybrid cultivar compared to conventional cultivar. Hybrid rice can select for particular group of AOB in the rhizosphere relative to AOA throughout growth periods.

This study provides evidence that cultivation of hybrid rice may lead to substantial changes in particular group of AOB communities involved in N-cycling that can impact on ecosystem processes, including nitrification.

Keywords：*Hybrid rice, Rhizosphere, Ammonia oxidizing bacteria, Ammonia oxidizing archaea*

P3-312

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Microbial Reductive Dechlorination of Polychlorinated Dibenzo-P-Dioxins in Soils and Sediments from Areas Sprayed with Agent Orange

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Dioxin-pollution hotspots in Vietnam are former military air-bases and areas heavily sprayed with Agent Orange, a defoliant used during the Vietnam War. Agent Orange was a mixture 2,4-dichlorophenoxy acetic acid (2,4-D) and 2,4,5-tricholorophenoxyacetic acid (2,4,5-T) contaminated with dioxins. Spraying of the Agent Orange defoliant at the former Aso military airbase, its adjoining areas of Aluoi of Thua Thien Hue province and in Cua of Quang Tri province, Vietnam may have enriched for polychlorinated dibenzo-p-dioxin (PCDD) -dechlorinating bacteria in soils/sediments. Soil analysis revealed a high concentration of polychlorinated dibenzo-p-dioxins at these Agent Orange-sprayed areas, particularly at the former airbase, where 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) reached 900 pg/g. This study examined (i) the capacity of the anaerobic bacterial community of soils/sediments from Agent Orange sprayed areas to reductively dechlorinate 1,2,3,4-tetrachlorodibenzo-p-dioxin (1,2,3,4-TeCDD), 2,3-dichlorodibenzo-p-dioxin (2,3-DCDD) and 2,3,7,8-TeCDD; and (ii) phylogenetic analysis of enriched putative PCDD-dechlorinating bacterial community. Anaerobic microcosms were spiked with approximately 10 μM 1,2,3,4-TCDD or 2,3-DCDD for 19 soils/sediments collected from these sites. 1,2,3,4-TCDD dechlorinating activity was shown in all soils and sediments, with the exception of a sample collected from peatland at Camau, a supposedly non-polluted site. 2,3-DCDD dechlorinating activity occurred in 1 of 4 tested soils/sediments. High dechlorinating activity was shown at 4 sites, with almost all spiked 1,2,3,4-TCDD and 2,3-DCDD dechlorinated after four or six months of incubation at 27°C and accumulation of triCDD, diCDD, monoCDD and non-chlorinated dibenzo-p-dioxin daughter products. Two main echlorination pathways in the different soil/sediments were observed, with initial peri or lateral dechlorination. The enriched 2,3-DCDD dechlorinating community was also able to dechlorinate 2,3,7,8-TeCDD to 2,3,7-TrCDD after two-month incubation. A diverse Chloroflexi community was observed in the soil/sediment microcosms using Chloroflexi-specific 16S rRNA gene primers and DGGE analysis bacteria. A diverse Chloroflexi community and their increasing abundance were observed in the soil/sediment microcosms using Chloroflexi-specific 16S rRNA gene primers and DGGE analysis bacteria. The DGGE profile indicated enriched Chloroflexi putative PCDD-dechlorinating community quite different from well-known PCDD-dechlorinating Dehalococcoides ethenogenes strain 195 and strains enriched from sediment of Kymijoki river (Finland). The findings of this study indicate that PCDD dechlorinating bacterial community has become ubiquitous in PCDD polluted areas sprayed with Agent Orange. There is thus potential for using indigenous PCDD-dechlorinating bacterial community for detoxifying dioxin hotspots in Vietnam

Keywords：*polychlorinated dioxins, dehalogenase, Vietnam, Agent Orange*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Role of Microbial Inoculums on Jatropha Curcas L. Growth and Soil Carbon Stock

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In general plants serve as a source for the microbial community and in turn microbes provide nutrients for plant growth through decomposition and mineralization. Beneficial microbes, either living in symbiosis or free-living micro-organisms co-existing with plants, have been well documented to enhance plant growth. The present study investigated the influence of inoculation of three microbial strains viz. Azotobacter chroococcum, Acetobacter diazotrophicus and Aspergillus awamori on vegetative growth and mineral nutrient uptake in leaves of Jatropha curcas L. and nutrient content and enzyme activities in soil. The experimental results clearly showed that the microbial inoculations significantly enhanced the soil nutrients (N, P K and Na) as well as the plant growth and the plant nutrient content (C, N, P) at 99% confidence level. Inoculation with Aspergillus and Acetobacter showed an increase in acid and alkaline phosphatase. However, the inoculation did not significantly affect the soil pH and EC. Importantly, the inoculation of microbial strains Aspergillus awamori and Azotobacter chroococcum increased soil carbon stock (65.37 Mg ha-1 and 58.21 Mg ha-1) in JCL plantation site. This increment was more in JCL inoculated with Acetobacter diazotrophicus (56.47 Mg ha-1). Whereas, in the case of control (without inoculation), the total carbon stock was only 54.32 Mg ha-1. The microbial inoculation also enhanced ($p \leq 0.05$) the microbial biomass carbon (MBC) in soil which varied from 267.62 ± 18.73 µg g-1 to 894.24 ± 41.65 µg g-1. The results of this experiment show that the microbial inoculation is an important strategy for enhancing the soil carbon stock.

Keywords：*Microbes, Soil carbon sequestration, Microbial biomass carbon*

P3-314

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Effects of Artificially Putting Frogs into Paddy Fields on the Prevention of Pests and Diseases of Rice

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Frogs in paddy fields have become less and less due to applying large amounts of pesticides and killing for a long time, which causes more pests and diseases in paddy fields. A field experiment was carried out in the suburb of Shanghai to study the effects of artificially putting frogs into paddy fields on the prevention of pests and diseases. The experiments include two treatments. Treatment I: putting 150 frogs per 100 m2 in the fields under the organic farming system; Treatment II: putting no frogs in the fields with the organic farming system. Organic manure with 7500 kg/hm2 in amount was applied to the fields as base fertilizer before sowing in early June, 2013. Each treatment is in triplicate and each plot is 67 m2 in area. The results are as follows: (1) At the late stage of rice growth, the incidences of pests and diseases of the rice with Treatment I are significantly lower than those with Treatment II. The incidences of both rice sheath blight and chilo suppressalis with Treatment I are zero; those with Treatment II are 8.16% and 1.54% on average, respectively. The incidence of cnaphalocrocis medinalis of the rice with Treatment I and Treatment II is 2.18% and 2.47% on average, respectively. The numbers of rice planthopper with Treatment I and Treatment II are 4.25 per hill and 11 per hill, respectively. (2) The rice grain yield with Treatment I, 5157.73 kg/hm2 on average, is significantly higher than that with Treatment II, 3645.14 kg/hm2 on average. (3) During the entire period of rice growth, the activities of soil enzymes of the fields with the two treatments are significantly different. The activities of dehydrogenase, catalase, invertase and urease in the soils with Treatment I are significantly higher than those with Treatment II. The activity of phosphatase in the soils, however, is not significantly affected by the frog treatments. All the above fully suggest that artificially putting frogs into paddy fields could effectively prevent pests and diseases of rice, especially reduce the incidences of rice sheath blight and chilo suppressalis, which contributes to the increase of grain yield. Moreover, the activity of frogs in paddy fields could improve soil fertility, raise soil enzyme activities and benefit soil biodiversity.

Acknowledgements: This work was supported by the National Natural Science Foundation of China (No. 41130526).

Keywords：*Frog; paddy fields; Soil enzyme activity; pests and diseases; Soil biodiversity*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

The Status of Arbuscular Mycorrhiza Fungi at the Different Vegetation in Tailing Deposition Areas of Freeport Indonesia, Timika

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The status of Arbuscular Mycorrhiza Fungi (AMF) under different types of vegetation in the tailing deposition areas was studied in Timika-Papua, Indonesia. Soil and root samples were collected from 24 types of vegetation grown in tailing deposition areas using a systematic sampling technique. Spores of AMF in the soil was extracted using the wet sieving technique (Pacioni,1992), cleaning and staining roots (Phillip and Hyman, 1970) method and the percentage of root infection by AMF was calculated using the Giovannety and Mosse (1980) method. Bioassay glasshouse technique was also used to determine the percentage of root infection of soil from the field. Soil analysis was conducted for some soil characteristics i.e. soil pH, moisture content, soil texture and phosphorus.

The result showed that the spore number range from 4 to 20 spores/50 gram soil and the percentage of root infection range from 17% to 89%. The highest number of AMF spores and percentage of root infection were found under the vegetation of Astonia scholaris and Polialkia. The highest number of spore tends to followed by the highest percentage of root infected by AMF. In general, the number of spores and percentage of root infection were correlated with the distribution of vegetation and soil texture in the tailings areas. In the fine texture areas the number of spores and percentage of infection were higher than in the coarse soil texture. All of the samples of plants growth in the tailings areas were infected by AMF and most of the plants were formed above 50% root infection. Based on the spore identification, there were three genus of AMF found across the 24 vegetation grown in tailing deposition areas i.e. Glomus sp, Acaulospora sp and Gigaspora sp. These three genus are indicated to growth well in the tailing deposition areas and has a potency to be developed as an inoculum of bio fertilizer for the rehabilitation program in the tailing areas.

Keywords：*Tailing, Arbuscular Mycorrhiza Fungi, bio fertilizer, inoculum*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Soil Microbial Population and Distribution as Affected by Various Farming Systems in Batangas, Philippines

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Soil quality and farming systems influence the microbial population, distribution, and their activity in the soil. Soil physical and chemical properties are factors that interact with the different components of the farming systems which play a role in determining the number, type, and activity of soil microorganisms. This study evaluated the populations of microflora in soils under various farming systems i.e. within the context that basic information for the establishment of link between soil microbial populations/diversity and farming systems under specific soil types will be generated, future work on biological indicators of soil quality and farming systems sustainability could be directed.

Three farming systems namely: sugarcane-based farming system, corn-based farming system, and rice-based farming system were selected in Batangas Province, Philippines. Soil samples were collected from three soil layers: 0-10 cm, 10-20 cm, and 20-50 cm of seven soil types. Soil pH, organic matter (OM), total nitrogen (N), available phosphorus (P), exchangeable potassium (K), and cation exchange capacity (CEC) were determined. The populations of total bacteria, total fungi, N2 fixers, P solubilizers, mycorrhiza, and actinomycetes in these soils were also determined.

The three soils under sugarcane-based farming system have generally low to moderate pH, low OM and total N, low to high available P, and high exchangeable K and CEC. The soils under corn-based farming system have low pH, OM and total N, low to moderate available P, and high exchangeable K and CEC. The soils under rice-based farming system have low to moderate pH, low OM and total N, moderate available P, and high exchangeable K and CEC.

Bacterial populations in three soils under sugarcane-based farming system were significantly different in the three layers but not in two soils under corn-based farming system. Fungal populations were significantly different in two soils under sugarcane-based farming system and one soil under rice-based farming system. N2 fixers were significantly different in three layers of three soils under sugarcane-based farming system and two soils under rice-based farming system. Populations of P solubilizers were not different in the three soil layers while mycorrhiza populations were different in the three soil layers of all soils. Populations of actinomycetes were different in soil layers of one soil under sugarcane-based farming system and one soil under rice-based system. The abundance of the beneficial microorganisms in the three layers of soils under sugarcane-based, corn-based, and rice-based farming systems generally followed this order, N2 fixers >actinomycetes >P solubilizers >mycorrhiza.

This study on type and population distribution of soil microflora in the 0-10 cm, 10-20 cm, and 20-50 cm layer of seven soil types and three farming systems in Batangas Province, Philippines provided information that will serve as guide in developing crop production technology aimed at increasing resource-use effectiveness for sugarcane, corn, and rice on specific soil types. The current study suggested the need for data on soil productivity and additional farming systems per soil type to support the establishment of a link between soil types, farming systems, and soil microbial populations/diversity.

Keywords：*soil microbial population, farming systems, mbiological indicator*

P3-317

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Exploration of Oligotrophic Bacteria from Soils in Taiwan

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Soil, a heterogeneous habitat harbors considerable quantities of oligotrophic bacteria which can proliferate with limited nutrients. But owing to the selective isolation of rapidly growing bacteria by conventional cultivation method, the exploration of oligotrophs seems limited. This motivates us to perform a preliminary isolation and characterization of oligotrophic bacteria from soils in Taiwan. In the present studies different type of soils collected from a variety of regions were used for bacterial isolation. The novel self-developed soil extraction media or diluted nutrient agar were used to screen and isolate oligotrophs. In addition, the genotypic, physiological and biochemical characteristics of these isolates were studied. More than 100 isolates with different colony morphology were selected and purified. 16S rRNA gene sequence analyses assigned these oligotrophs to the phylum Actinobacteria, Bacteroidetes, Firmicutes, and Proteobacteria. These bacterial lineages comprised more than 30 bacterial genera. Differences in their abilities to grow on nutrient-rich (nutrient agar), nutrient-poor (water agar) or methanol-containing media were demonstrated. Nitrogen fixing or mineral phosphate solubilizing activities were detected in some of these isolates, which might serve as microbial fertilizers to promote plant growth. Besides, these oligotrophic bacteria showed a variety of promising activities in the transformation of carbohydrates, proteins or lipids. Higher enzyme activities regarding C, N, and P cycling were recorded. The divergence of their enzymatic patterns not only provided basis of their taxonomic classification, but reflected the unique biochemical behavior of each particular group of oligotrophs. The present work provided a preliminary study on the diversity of oligotrophs derived from soils in Taiwan. The nutrient requirement of these bacteria will be studied in more detail to clarify their oligotrophic behavior, and the multiple traits regarding plant growth promotion will be examined to explore the diverse oligotrophs used in agriculture.

Keywords：*oligotrophic bacteria, soil extraction agar, microbial fertilizer*

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Hydrolytic Characterization of Root Nodulating Bacteria

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In mutualistic symbioses among legume plants and root nodulating bacteria, plants provided carbon sources and niches for microorganisms. The clarification of the interactions between these heterotrophic bacteria and their host plants may serve as bases for successfully agricultural manipulations with bacterial inoculation. The root exudates which contain simple organic materials are commonly utilized by bacteria. But the studies on hydrolytic behavior of these bacteria toward more complicated organic matters such as plant constitutes are less. In the present work we have attempted to determine the abilities of root nodulating bacteria to produce hydrolytic enzyme toward a variety of substrates. Cellulose, hemicellulose, xylan and skimmed milk were served as a sole source of carbon or nitrogen in the selective media. Bacteria showing clear zone around colonies appeared directly or stained with appropriate dye were recorded as positive in the production of specifically hydrolytic enzyme. From our laboratory collections, isolates which affiliated with genera Burkholderia, Cupriavidus, Ensifer, Methylobacterium, and Rhizobium were tested. The cellulolytic activities were found in a higher proportion of these bacteria when compared with other hydrolytic enzymes. The less utilization of skimmed milk regarding the protease activity in these bacteria may owe to their abilities to fix nitrogen instead of mineralize organic nitrogen from protein. Among them, some of the isolates belonging to the genera Burkholderia and Methylobacterium show all the tested enzyme activities, and these strains have promising potential in the decomposition of organic materials derived from plants. By supplying these bacterial inoculants in the recycling of organic wastes it is possible to accelerate the composting process of plant residues. Besides, the root nodulating bacteria can also serve as microbial fertilizers or use in combination with organic fertilizers. These not only provide an alternative way to supply nutrients to plants but reduce the chemical fertilizer requirement, which toward a more sustainable agriculture.

Keywords：*root nodulating bacteria, hydrolytic enzyme, decomposition of organic matter, fertilizer*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Development of Pgpr Consortium for Potential Yield of Scented and Non-Scented Rice during Nascent Stage of Organic Farming on Indo-Gangetic Plains of India

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Low yield of cereal crops in general and rice in particular during initial stages of a developing organic farm in sub-tropical Indo-gangetic plains of northern India has been basic reason behind no interest of farmers for adopting organic farming of rice. Thus, to mitigate this problem, twenty one isolates of plant growth promoting rhizobacteria (PGPR), isolated from rice rhizosphere soils of Indo-Gangetic plains of eastern Uttar Pradesh, India, were identified by16S rRNA sequence analysis. After In-vitro testing for biochemical plant growth promoting properties, 3 strains of them viz. BHUPSB-01 (Pseudomonas aeruginosa), BHUPSB-03 (Burkholderia cepacia) and BHUPSB-04 (Pseudomonas putida) were selected as effective for preparation of their composite culture (CC) for field experimentations on scented and non-scented rice varieties.

A field, exhausted by raising mustard crop during winter and enriched with green manuring of Sesbania during summer season of 2005-06, was under taken to develop as an organic farm at Agriculture Research Farm, Banaras Hindu University, Varanasi. Initially, an experiment was conducted in the same field with three scented rice cultivars viz. HUBR-2-1, HUBR-2-1S and HUR-36 using different PGPR at application of 24 t FYM ha-1 during rainy season (July-October) of 2006. The scented var. HUBR-2-1 was found more promising. From the 2nd year, two experiments, one on scented var. HUBR-2-1 and other on non-scented var. Sarju-52 were simultaneously laid down during rainy season of 2007 and 2008.

The experiment on scented var. HUBR 2-1 was consisting with 8 treatments of absolute control (T1), 24 t FYM ha-1(T2), and PGPR inoculants (T3: Azotobacter chroococcum, T 4: Azospirillum brasilense, T5: Composit culture (CC), T 6: Aspergillus niger, T 7: Azotobacter + Azospirillum + CC + Aspergillus and T 8: Azotobacter + Azospirillum + CC+ Aspergillus + Azolla, each at application of 24 t FYM ha-1). This variety responded significantly to CC as well as all the other PGPR treatments at 24 t FYM ha-1 over absolute control and 24 t FYM ha-1 (T2). Application of CC (T5) increased plant growth and yield attributes drastically but negative impact was seen when applied with Aspergillus (T7). However, interesting finding of this investigation was compatibility of Azolla in T8, which resolved the antagonistic relationship between CC and Aspergillus and enhanced grain and straw yields maximum to 2.95 and 5.23 t ha-1 during 2007, and 3.67 and 5.60 t ha-1 during 2008, respectively.

The experiments on non-scented var. Sarju-52 with 8 treatments of PGPR (Azotobacter + Azospirillum + CC+ Aspergillus + Azolla) at 4 levels of FYM (0, 12, 24, 36 t ha-1) revealed significantly maximum grain and straw yields of 4.91 and 5.37 t ha-1 and 5.46 and 6.90 t ha-1 due to PGPR consortium at FYM 36 t ha-1 followed by treatment of same inoculants at FYM 24 t ha-1 over other treatments during 2007 and 2008, respectively.

After the initial three years of experimentation, significant increase in contents of organic carbon, available NPK, and dehydrogenase activity of the soil were noted with different treatments of PGPR and FYM, over the control treatments for both the varieties.

It was, therefore, conferred that high yield of scented or non-scented rice could be achieved from 2nd to 3rd years of organic farming, by seedlings inoculation with Azotobacter + Azospirillum + CC (Pseudomonas aeruginosa + Burkholderia cepacia + Pseudomonas putida) + Aspergillus + Azolla at application of 24 or 36 t FYM ha-1.

Keywords：Key words: Scented rice, non-scented rice, PGPR consortium, organic farming

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Isolation and Evaluation of Inoculation Effects of Beneficial Microbes on Growth of Corn and on Soil Nutrient Content in Ten Field Sites

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Nitrogen-fixing bacteria were isolated from the rhizopshere and roots of corn collected from various sites in the Philippines. From a total of more than 300 bacterial isolates, further screening was done for the ability to solubilize unavailable phosphorus and the production of plant growth promoting substances such as indole acetic acid (IAA), gibberellic acid (GA), and cytokinin like substances. Top performing isolates were identified by biochemical and molecular methods, through the Vitek 2 ID system and sequencing of the 16S rDNA. Individual isolates and different bacterial mixes effect on corn were evaluated through pot trials. Endomycorrhizal fungi were also isolated from various crops following the wet sieving and decanting method, identified using the INVAM guide and mass produced using trap plants in the screenhouse. From best performing isolates, a mixed microbial inoculant was formulated consisting of both beneficial bacteria and endomycorrhiza, and referred to as MykoPlus. Preliminary testing of the mixed inoculant, was done on various crops then used in corn field trials.

The field trials consisted of four treatments, namely: 1) Farmers' practice (FP), 2) FP + MykoPlus, 3) Recommended Rate of Chemical Fertilizer (RRC) (based from soil analysis), and 4) 70% RR+ MykoPlus. Results of two seasons cropping in ten field sites using the mixed inoculant showed that agronomic characters such as plant height and dry weights of corn plants at 60 days after plating (DAP) and at harvest did not show significant effect of inoculation. However, application of 70% RR + MykoPlus gave higher grain yield compared to RRC alone. Grain yield was increased by as much as 30% and 42% in plots applied with 70%RR+MykoPlus compared to RRC alone in 1st and 2nd season cropping, respectively in seven out of ten field sites. In plots treated with Farmers' practice + MykoPlus, grain yield obtained was increased by 54% in 5 out of 10 sites during the 1st season and 15% in 8 out of 10 sites during the 2nd season. These translates to savings in chemical fertilizer use by 30% of needed chemical N, P2O5 and K2O with comparable or higher grain yield due to beneficial microbe application that possibly hastened microbial activities leading to release of nutrients. Results of soil chemical and microbiological analysis supported the hypothesis with greater mycorrhizal spore counts in inoculated plots and with higher amounts of P and K per gram soil compared to the uninoculated control plots.

Keywords：*beneficial microbes, mycorrhiza,corn*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Spatial Ecology of Bacteria at the Microscale in Soil

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Despite an overwhelming number of bacterial cells and species in soils, bacterial diversity seems to have little effect on soil processes, such as respiration or nitrification, that can be affected by interactions between bacterial cells. The aim of this study is to understand how bacterial cells are distributed in soil to better understand the scaling between cell-to-cell interactions and what can be measured in a few milligrams, or more, of soil. Based on the analysis of 744 images of observed bacterial distributions in soil thin sections taken at different depths, we found that the inter-cell distance was, on average 12.46 μm and that these inter-cell distances were shorter near the soil surface (10.38 μm) than at depth (>18 μm), due to changes in cell densities. These images were also used to develop a spatial statistical model, based on Log Gaussian Cox Processes, to analyse the 2D distribution of cells and construct realistic 3D bacterial distributions. Our analyses suggest that despite the very high number of cells and species in soil, bacteria only interact with a few other individuals. For example, at bacterial densities commonly found in bulk soil (109 cells/g), the number of neighbours a single bacterium has within an interaction distance of ca. 20μm is relatively limited (120 cells on average). Making conservative assumptions about the distribution of species, we show that such neighbourhoods contain less than 100 species. This value did not change appreciably as a function of the overall diversity in soil, suggesting that the diversity of soil bacterial communities may be species-saturated. All in all, this work provides precise data on bacterial distributions, a novel way to model them at the micrometer scale as well as some new insights on the degree of interactions between individual bacterial cells in soils.

Keywords：*bacterial distribution / soil / spatial statistics / bacterial diversity / thin section*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Bio-Remediation of Salt Affected Soils through Halophilic Microbes

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The soil properties influence the ecosystem function and existence of microbial communities. Salt affected soils, contains excess salt, determine the limits of the ecosystem. In saline soils, considerable amounts of salts in rhizosphere affects crop yields. Both physical and chemical methods are not cost- effective for saline/sodic soil reclamation. The biotic approach 'plant-microbe interaction' to overcome salinity problems has recently received a considerable attention from many workers throughout the world. The halophilic microbes have potential for bio-remediation of salt dominant soils. The studies were conducted to test the efficacy of different types of microbes associated in salt affected coastal soils and their potential in bio-remediation.

Soil from the rhizosphere of the halophyte plant species were collected and bacteria were isolated having salt tolerance upto 10% NaCl in the nutrient agar media. Two promising halophilic bacterial strains which showed positive for plant growth promotion were selected and tested for salt removal efficiency. Halophilic bacteria (CSSRO2) was more efficient in reducing sodium concentration from 1,12,230 ppm in supernatant to 1,00,190 ppm at 24 hour and 92730 ppm at 24 hours and 92,730 ppm at 48 hours as compared to CSSRY2 in halophilic broth with 25% NaCl. The halophilic bacteria strains CSSRY1 and CSSRO2 were highly potential to remove the sodium ions from soil. CSSRY1 efficiently removed sodium at higher (6%, 8%, 10% NaCl) salt concentration in comparison of CSSRO2 and association of both organisms (CSSRY1 and CSSRO2). Once the sodium ion concentration reduces in rhizosphere of crop plant for short span plant under salt stress gets nutrients and water uptake. These halophilic bacteria were thus found to boost crop yields significantly when inoculated to seeds under salinity stress. The applications of halophilic bacteria include recovery of saline soil by directly supporting the growth of vegetation thus indirectly increasing crop yields in saline soil.

Keywords：*saline soil, rhizosphere bacteria, halophiles, remediation*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Controls on Microbial Activity in Chromium Contaminated Abandoned Agricultural Soils: A Case Study of Kasur, Pakistan

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Background and justification: Irrigation of fertile agricultural soils with industrial effluents has been gaining popularity in developing countries owing to water scarcity; however, there is extensive evidence of changes in soil biogeochemical indices after long-term application of industrial effluents. Tannery effluent and leather meal are rich source of chromium (Cr) as well as organic matter in soils. There is a need to assess how long-term application of these toxic tannery effluent affect soil microbial activity and nutrient dynamics. Methodology: A laboratory incubation study was conducted using chromium contaminated soils from Kasur (31.1170° N, 74.4502° E), a tannery laden industrial city in Pakistan, to evaluate impacts of Cr contamination on soil basil respiration (SBR), microbial biomass carbon (MBC), water extractable organic matter (WEOM), soil organic carbon and total soil nitrogen. Ten soil profiles were selected from an agricultural area of 8 hectares receiving tannery effluent for more than ten years. Surface soil sample (0-15 cm), in triplicate, were sampled from the selected soil profiles. Before incubation, soil samples were analyzed for pH, EC, particle size analysis and texture, total organic carbon (TOC), total nitrogen (TN) and total Cr contents using standard procedures and protocols. Soil were incubated in the dark at room temperature in microcosms at 60% water holding capacity for 60 days. Soil basil respiration was measured by trapping CO2 in 0.5M NaOH and titrating it against 0.5M HCl to phenolphthalein end point at regular intervals. At the end of the incubation period, soils were destructively analyzed for pH, EC, WEOM and MBC. Results and discussion: Soils from the contaminated abandoned area differed markedly in their physico-chemical characteristics. pH1:5 of the soils ranged from 8.17 at profile 9 to 8.80 at profile 9 whereas ECe showed more distinct variations and ranged from 3.07 to 12.50 d S/m at soil profiles 3 and 9 respectively. Analysis of soil particle size revealed that soils were light to heavy textured in nature with clay contents ranging from 190 to 500 g/kg soil. Soil profiles 1 and 10 had the lowest total organic carbon (12.1 g/kg soil); however, soil profile 9 had significantly higher ($p < 0.05$) TOC of 100.8 g/kg. Soil TN ranged from 0.7 to 8.5 g/kg. Soil TOC and TN were correlated significantly positively ($r = 0.984$; $p < 0.001$; $n = 10$). Soils varied significantly ($p < 0.001$) for their total Cr contents; Cr contents ranged from 0.17 g/kg for soil profile 10 to 20.68 g/kg for soil profile 9. Cumulative respiration was significantly ($p < 0.05$) higher in soil profile 9 compared to the other soil profiles and varied between 77.3 to 337.5 mg CO2-C/g soil over the period of 60 days. Soil microbial biomass carbon was noted to be the highest in the soil profile 9 (98.57 mg C/kg soil). Soil TOC seemed to be the important factor controlling SBR ($r = 0.897$; $p < 0.01$; $n = 10$) in heavily Cr contaminated soils. However, soil TOC was correlated positively but not significantly with MBC ($r = 0.519$; $p < 0.124$; $n = 10$). It was noticed that soil Cr contents were not affecting soil microbial activity negatively since there was significant positive relationship between SBR and soil Cr contents. In these tannery effluent irrigated soils, higher TOC could be the result of leather meal derived organic matter which tend to accumulate in the surface soils. Higher levels of SBR and MBC in these highly Cr contaminated soils may be result of TOC ameliorating the toxic effects of higher Cr, especially in heavy textured soils.

Keywords：*Chromium (Cr); Soil basil respiration; Soil microbial biomass carbon, Total organic carbon; , Total nitrogen; Water extractable organic matter*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Integrated Effect of Fly Ash and Chemical Fertilizers on Phosphate Solubilizing Bacteria Isolated from a Rhizospheric Soil of Forestry Species

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Fly ash used in conjunction with chemical fertilizers @ (0-24 per cent) as a soil ameliorant in rhizospheric soil of Acacia auriculiformis and Eucalyptus tereticornis was analysed for influence on phosphate solubilizing bacteria and focus was also laid on adjacently running soil microbial properties specifically organic carbon and dehydrogenase activity.The population of phosphate solubilizing bacteria in fly ash amended rhizospheric soil mixed with chemical fertilizers increased up to 18 %, with a similar trend observed for soil organic carbon for the two species attributed mainly to the synergistic effect of fly ash and fertilizers on the soil micro environment. Soil dehydrogenase activity was found to be highest in soil amended with 12 % fly ash with and without fertilizers for Eucalyptus.

These phosphate solubilizing soil bacteria could serve as efficient biofertilizer candidates for improving the P-nutrition of crop plants.

Phosphate solubilizing bacteria (PSB) isolated from rhizospheric soil of A.auriculiformis and E.tereticornis collected from 4-year-old plantations revealed that their population increased up to 18 per cent fly ash amendment in conjunction with chemical fertilizers. Among these five bacterial strains S1, S2, S3, S4 and S5 with phosphate solubilizing capacity ranging from 78.1-86.1% were selected for their efficiency in utilizing source of phosphorous and on basis of antibiotic profiling. All five were further subjected to lac Z marker based molecular tagging using E.coli 2842 bearing plasmid pMMB277 , with positive result for unidentified bacterial strain S2. The transformant S2:pMMB277 was further subjected to ecological studies in terms microbial biomass in fly ash amended soil and 10 % fly ash was worked out as an optimum concentration for best results. These phosphate solubilizing soil bacteria could serve as efficient biofertilizer candidates for improving the P-nutrition of crop plants and can be tested for their potential to augment soil microbial health.

Keywords：*Phosphorus, enzyme activities, microbial activities, rhizosphere, micro-environment.*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Microbial Population in the Rhizosphere Soil of Various Crop Plants as Affected by Salinity

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Salinity is a major concern for irrigated agriculture in arid and semi-arid regions of the world. Indiscriminate flood irrigation with poor drainage facilities and mono-cropping of high water consumptive crops (e.g. cotton) are the major factors accelerating secondary soil salinization in region of Uzbekistan in Central Asia. Environmental change will have direct and indirect effects on soil nutrient turnover processes, including N and C cycling which are closely connected with microbial activities. The objectives of the study were to evaluate the effects of irrigation-induced salinity on root associated microbial distribution under various crop plants grown in Uzbekistan. Sites used in this study represent continuously cultivated fields located in Syrdarya province of Uzbekistan. According to the WRB-FAO classification, the soils of selected fields were identified as calcisol (silt loam seirozem). The surface soil horizon was calcareous saline whereas the deeper soil horizons were only mildly alkaline. The average monthly minimum air temperature is 0°C in January, and the maximum one is 37°C in July. For determination of bacterial population associated with the root of cotton, wheat, maize, alfalfa, the soil cores (divided into 0-10, 10-20, and 20-30 cm depths) were randomly collected under the root system of plants grown in saline soil. The soil samples were collected in spring (April), summer (July), autumn (September) and winter (January). Soil cores were pooled and mixed to obtain a composite sample for each depth. Field-moist soils were then gently sieved through a 2-mm mesh, and a portion of the soil was incubated or analyzed to measure soil microbial populations within 72-h of sampling and processing. Plate dilution method was used for determination of ammonifying, nitrifying and nitrogen fixing microorganisms using specific agar mediums for each microbial communities. Ten gram of soil was shaken with 90 ml of sterile distilled water. From this suspension the serial dilution (1:10) was prepared and plated onto agar medium. After 3 days incubation, CFU of bacteria were counted and analyzed. Analysis of variance was performed using Excel version 11 for Windows 2007 (Microsoft Corp.), and standard error, LSD were calculated. The total number of root associated bacteria significantly varied in different samples of studied soils, and the range of variation comprised 105-108 CFU/g. The total number of microorganisms was higher at the 10-20 cm soil depth of soil than at the 0-10 cm and 20-30 cm depth regardless of plant type. Plant species had strong influence on rhizosphere bacterial population. We found that the highest density of plant associated bacteria was observed during spring and the lowest in winter. The year which characterised with hot summer and less precipitation affected to soil microbial population negatively. Marked effects were found for bacterial populations under alfalfa and wheat grown in saline arid soils. Alfalfa was able to support the highest number of ammonifying nitrogen fixing bacteria (37 Mln CFU/g soil-1) in all seasons, while fallow soil had the lowest. It is most probably related to greater release of exudates and availability of C substrates, due to alfalfa's extensive rooting system. It is know that nitrification process is very sensitive to environmental stress factors. Similar results we observed in our study, where the population of nitrifying bacteria in all samples were reduced. In conclusion, this experiment indicated that various agricultural crops affect on root associated bacteria population under saline and semi arid soil. Higher population of ammonifying and nitrogen fixing bacteria was found in soil under alfalfa and wheat. Thus to increase the soil fertility of saline arid soil, it is necessary to use legumes, which can increase microbial population that play an important role N cycle making mineral N bio-available in the soil.

Keywords：*salinity, soil, cotton, wheat, alfalfa, microbial population*

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[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Effects of Long-Term Swine Slurry Applications on Inoculum Potential of the Arbuscular Mycorrhizal Fungi in Soil under Conventional and No Tillage, South of Brazil

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The no tillage (NT) system contributes to preserve organic soil matter, besides from decreasing temperature and solar radiation and increasing water retention in the soil, therefore, soil microbial community are favored when comparing with conventional tillage (CT), that includes plowing and harrowing. The application of swine slurry (SS) as fertilizers into soil under NT can be also a environment-friendly option for recycling these residue nutrients from swine livestock. The arbuscular mycorrhizal fungi (AMF) plays an important role in plant nutrition and has potential as biomarkers to measure soil changes due to agricultural practices. Thus, this study aims to assess the effects of long-term successive SS applications on AMF inoculum potential in soil under NT.

Material and methods

Field experiment and soil sampling

Soil samples were collected from 0-10 cm depth, in a long-term field experiment, which was set up in 1996 at the experimental station of IAPAR in Palotina, Parana state (24°17'S, 53°50'W), Brazil. The climate is humid subtropical (Koppen´s Cfa) and the area has been cultivated for seven years with soybean/corn (Glycine max L./Zea mays L.) and wheat/forage pea (Triticum sativum Lam./Pisum sativum L.). The soil is a clayey Oxisol, which had in the superficial layer (0-20 cm) 600 g kg-1 of clay, 160 g kg-1 of silt, 240 g kg-1 of sand, pH 5.2 (CaCl2), 14.8 mg kg-1 of P (Mehlich) and 20.0 g kg-1 of organic carbon. The SS applied had 10.8% of total solids; pH 8.2; C=201; N=30; P=41 in g kg-1. The treatments evaluated were: tillage systems (NT and CT) and 0, 30, 60, 90 and 120 m3 ha-1 year-1 of SS. The experimental design was randomized blocks with four replicates.

AMF spore counting and external mycelium

The AMF spores were extracted from soil samples by wet sieving, centrifugation in water and flotation in sucrose (50%), and counted in stereoscopic microscope. The total external mycelium (TEM) of soil was extracted through wet sieving, with subsequent filtration in nitrocellulose membrane, staining with tripan blue and evaluated under optical microscope (Schubert et al., 1987).

Most Probable Number (MPN) of AMF infective propagules in greenhouse experiment

The AMF infective potential of soil was evaluated by the MPN method, in a bioassay conducted in the greenhouse, using corn as trap plant, in successive soil dilution, inoculated with soil samples from field treatments. After eight weeks, the plant roots were collected and AMF root colonization was evaluated in stereoscopic microscope to calculate the MPN of AMF infective propagules (Sieverding, 1991).

Results

The AMF sporulation was affected by the SS application, regardless of tillage systems. It was verified a decrease up to dose 60 m3 ha-1 year-1, where lesser spore densities were observed in both soil tillage systems and a little increase in subsequent doses. Higher

spore density was observed in CT, with an average of 16 spores per 50 mL of soil, while in NT system had 12 spores per 50 mL of soil. The impact of SS application was lesspronounced in soil under CT, there was a reduction of 38% in sporulation in CT in relation to the treatment without swine slurry, compared to 45% in soil under NT.

The application of SS in soil caused a reduction on the total external mycelium (TEM) production in both tillage systems. There was higher TEM length in NT, however, the negative effect of slurry application was greater in NT, with 25% decrease in comparison to the control treatment without swine slurry.

The AMF inoculum potential of soil was reduced by SS application in both tillage systems, with decrease of 71% in NT and 90% and in CT. MPN of infective propagules was higher in NT soil, regardless of swine slurry doses.

Conclusions

The long-term consecutive swine slurry applications reduces the inoculum potential of AMF in soil. Soil under NT system had higher production of TEM and AMF infective propagules than under CT that presented higher AMF sporulation.

Keywords：*soil sporulation, external mycelium, most probable number*

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Comparison of Three Macrophytes to Remediate Co-Contaminated Soils with Polycyclic Aromatic Hydrocarbons (pahs) and Trace Elements (tes), Implications for Green Urban Infrastructures

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Many studies report successful phytoremediation using macrophytes to treat wastewater in constructed wetlands. However, little is known about their phytoremediation capabilities in urban green spaces as swales or biofilters where they are submitted to dry and flood periods.

To access to the system behaviour under natural conditions, eight representative large-scale outdoor mesocosms were spiked with Cd, Pb, Zn, phenanthrene, pyrene and benzo[a]pyrene to reach 2, 100, 300, 10, 10, 10, mg.kg-1soil dry weight, respectively. Three macrophytes species were tested for remediation: Juncus effusus, Iris pseudacorus, Phalaris arundinacea and compared to a graminaceae mix. PAHs were extracted from soils by microwave assisted extractions and analysed by GC-MS. Microwave-acid digestion was used to extract metals from plants and soil, which were then analysed by ICP. TEs uptake varies considerably with plant species and the TE considered. Soil-plant transfer coefficients were calculated and allowed to identify the best accumulator. The transfer of TE to air parts is of best interest as shoots are cut at least once a year in urban green areas. The sequence of TEs availability to plant was determined. PAHs concentrations in soil were drastically reduced after six months and divided by 10 to 100 for low molecular weight PAHs and by 2 to 7 for benzo[a]pyrene depending on plant species. A special attention was paid to microbial community structure and activity in the soil compared to the rhizosphere to emphasize our understanding of the soil-root interface. Total, fungal and bacterial biomasses were investigated using Q-PCR, 16S rDNA and 18S rDNA. Fluorescein DiAcetate (FDA) and xylanase enzymatic activity allowed us to measure microbial activity.
The previous results obtained in the mesocosm experiment are faced to two swales along the road, planted with graminaceae and macrophytes. The first results show similar conclusion as those obtained with experimental mesocosms.

In both sites, macrophytes appeared to be of major interest compared to graminaceae for soil depollution. We suggest that introducing several macrophytes species in green urban infrastructures would be a best practice for soil remediation of TEs and PAHs at the same time.

Keywords：*Phytoremediation , Trace elements, Polycyclic Aromatic Hydrocarbon, Microbial biomass, Co-contamination, Rhizosphere*

P3-328

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Weathering of Illitic Soil in the Presence of Arbuscular Mycorrhizal Fungi Glomus Mosseae and Glomus Intraradices and Pseudomonas Fluorescens Bacteria with Corn Plant

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Potassium is one of the major essential elements for plant growth and is mainly supplied through the weathering of soil minerals having potassium. The role of these minerals which are mostly micaceous minerals is well known to provide needed potassium. Mycorhizzal symbiosis is one of the most important relations in soil. A great number of studies have been conducted regarding the positive role of this symbiosis in plant resistance to different stresses. But its effect on different nutrients uptake especially potassium and the changes in micaceous minerals is not well known. This study aimed to evaluate the effect of two types of mycorhizal fungi (Glomus mosseae and Glomus intraradices) and Pseudomonas fluorescens bacteria in corn symbiosis on the changes of a clay size micaceous mineral in an illitic soil. The research was conducted in a greenhouse trial in a completely randomized design with four replications. During 120 days of planting, the pots were irrigated by distilled water and potassium-free nutrient solution. At the end of the growing period, the plants were harvested and rhizosphere soils were collected from the root area and the clay fractions of the collected soils were analyzed by X-ray diffraction. The obtained results demonstrated that during the treat period, the chloritic minerals have transformed to smectite. These results most probably are the product of bacterial and mycorhizzal symbiosis effects on the type and amount of root exudates. The final results of such exudates are the pH decrease and transformation of chlorite to smectite and also it may play an important role in the change of illite to vermiculite or smectite in low amounts. Similar results were observed for fungal and bacterial treatments as well. Additionally, more stability of illitic minerals can be attributed to the resistance of the dioctahedral minerals to weathering. It can be concluded that in short time treating of illite dominated soils including some chlorite by bacterial and symbiotic mycorhizzal treatments demonstrates more sensitivity of chlorite to weathering rather than dioctahedral illite.

Keywords：*Micaceous minerals, mycorhizzal fungi, Pseudomonas fluorescens, Illite, rhizosphere*

P3-329

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Biological Activities in the Rhizosphere Soils of Medicinal Plants from Chatkal Biosphere Reserve of Uzbekistan

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The nature and diverse flora of Western Tien Shan is one of the most interesting places in Central Asia. Chatkal Biosphere Reserve is protected territory in Western Tien Shan within Uzbekistan that plays a significant part in the conservation of its unique biological diversity, because they provide important habitats for endemic and rare plant species. Vegetation cover of this region is represented with unique plant communities, and invaluable genetic pool of indigenous flora. The study of microbial populations and soil biological properties in such unique environments may thus provide valuable information on microbial distribution and activities, because those areas have not been affected with anthropogenic factors. The objectives of our study were to study rhizosphere microbial activity of Ziziphora capitata and Hypericum perforatum common endemic plant species found in biosphere reserve. In the laboratory, whole plants taken from biosphere reserve were gently removed from the soil, and the roots and shoots were separated from bulk soil. For the determination of rhizosphere bacterial colonisation, 1 g of soil strongly attached to the roots was removed and was shaken with 9 ml of sterile water. Subsequently the suspensions were serially diluted on solidified Nutrient agar (NA). The number of cfu's (colony forming units) was determined. The rhizosphere soil enzyme activities were analysed using standard soil test procedures. Our results showed that the soil enzyme activities such as invertase, phosphotase, catalase and urease are high, it is most probably related greater transformations of organic matter by microorganisms for their increasing energy and nutrients demand for survival than assimilation in response to high temperature and drought. The root associated bacteria of Hypericum perforatum and Ziziphora capitata showed high antagonistic activity against plant fungal pathogens. They have the potential to produce different biological active compounds such as cell wall degrading enzymes, IAA, siderophores, and utilize a wide range of carbohydrates as carbon as energy sources. They are temperature resistant and salt tolerant. We found that some strains showed multidrug resistance to various antibiotics. Their biochemical characterization and properties are also discussed.

Keywords：*Biosphere Reserve, microbial activity, soil enzymes, medicinal plant*

P3-330

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Suitability of Ergosterol as Soil Fungal Indicator Depending on Extraction and Sampling Date in Arable and Grassland Soils

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Although this bio indicator is often controversial (Zhao et al. 2006, Young et al. 2006), ergosterol is regularly used to estimate the content of fungal biomass in soils. Indeed, ergosterol is the most abundant sterol in the cell membranes of most filamentous fungi.While it is present in some microalgae , yeasts and some protozoans, but very little in plants and prokaryotic microorganisms . Quantifying its concentration in soil to estimate the fungal biomass is common even now (Trap et al 2011; Baldrian et al 2013.) Although molecular biology techniques are increasingly used (Gangneux et al 2012.). The method is faster, less expensive than the approaches of molecular biology and less trying than the historical technique of measuring the length of hyphae and / or quantification of chitin. Authors initially showed the direct relationship between the amount of ergosterol and fungal surface. In soils, it is also shown (Newell et al 1987) that the amount ergosterol depends on the species and age of the mycelium and nutrient sources. Indeed, many authors (Lumsden et al. 1990) have questioned the use of ergosterol as an indicator of fungal biomass in soils. In 2005, Zhao et al , studying mineralization in soil ergosterol and reliability of the concentration of ergosterol as an indicator of fungal biomass. Young et al in 2006, discuss these results in particular about the concentration range used, and the statistical treatment. Since this controversy, the analyze of ergosterol is still used routinely (Trap et al. 2011, Baldrian 2013), although the reasons for this choice are always explained .

We wish to shed light that the extraction method is of paramount importance to the related information. Many authors use the simple approach with methanol extraction (Gong et al. 2001), others use a stronger extraction method which also gives access to esterified ergosterol (Montgomery et al. 2000). Ergosterol is present in two forms, as free ergosterol and esterified ergosterol, which have different physiological functions. The relative abundances of free to esterified ergosterol are different among the various species. Ergosterol, a sterol component of fungal cell membranes, is assumed to be more strongly associated with living cytoplasm than other fungal cell wall component.

Thus, by performing the two extractions on the same sample, we can access information on the dynamics of fungal compartment in soils. The dataset is 600 samples for which both extractions (free and total ergosterol) were performed in the same protocol by the same laboratory for 6 years. Different soils were tested at different times in the year, mainly different types of grassland and crops. Finally, we will define on the most favorable periods to characterize fungal communities in temperate agricultural soils.

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Keywords : *fungalal biomass, soil, ergosterol, esterified ergosterol*

P3-331

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Diversity of Soil Invertebrates in Sugar Cane Area after Land Application of Sugar Factory Distillery Spent Wash

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The huge quantities of distillery-spent wash has been used for land application in Agriculture. However, the effects of using spent wash on soil ecosystem is limited. The objective of this study was to compare the biodiversity of soil invertebrates in various the utilization of spent wash liquor in the sugar cane areas. Soil invertebrates were collected in the four different managements: 1) control plot, 2) applied with spent wash liquor at 1 year plot, 3) applied with spent wash liquor at 2 year plot and 4) applied with spent wash liquor at 4 year plot. The soil invertebrate samples were collected by random sampling during November 2012 to October 2013. The result showed that a total of seven orders comprising 42 species in 31 families were collected in this study. The density of soil invertebrates were significantly higher than those in the control plots. The Shannon-Wiener's species diversity index indicated that the diversity was the highest in the applied with spent wash liquor at 2 year plot (2.26), followed by the applied with spent wash liquor at 4 year plot (2.06), applied with spent wash liquor at 1 year plot (2.04) and lastly the control plot (1.57).

Keywords：*soil invertebrates, spent wash liquor, sugar cane*

P3-332

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Isolation and Conservation of Fluorescent Pseudomonads Strains from Rhizosphere of Wheat

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Plant Growth Promoting Rhizobacteria (PGPR) meets those of inhomogeneous rhizobacteria groups which are patented to increase and promote plant growth. Pseudomonads bacteria are one of the most important PGPR bacteria which can increase yield, growth and health of the plant through direct and indirect mechanisms. In the present study, Fluorescent pseudomonads isolated from Savadkooh's soils have been investigated with respect to their biochemical tests and physiological characteristics.

In the first experiment, 30 soil samples were collected from the rooting zone of wheat(Triticum aestivum sp.) at the field in Savadkooh, Mazandaran province, Iran. The soil samples were serially diluted up to 6-7, plated on King's B agar medium and incubated at 28±2˚C for 48 h. Distinct colonies showing fluorescence under UV light were picked and streaked on KB agar medium to check the purity. In the second experiment, for the identification of Fluorescent pseudomonads, certain biochemical tests and physiological characteristics were conducted according to Bergey's Manual for determinative bacteriology.

The results showed that 17 pseudomonas strains were detected based on yellow, green and blue pigments by viewing under UV light. Population of bacteria were 2.71×10^5 - 6.43×10^7 cell per gram of rhizosphere soil. Based on results of biochemical tests and physiological characteristics we were detected three species, P. putida > P. fluorescens >> P. aeruginosa. Dominate species of Fluorescent pseudomonads in rhizosphere of wheat was found P. putida.

Keywords：*Rhizosphere, Fluorescent Pseudomonads, Wheat*

P3-333

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Seasonality of Arbuscular Mycorrhizal Fungi and Mineral Nutrition in Temperate Fruit Trees

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Arbuscular mycorrhizal fungus (AMF) is an ubiquitous association between fungi and agronomic plants and it has been well reported in fruit trees. However, their distribution and seasonality as well as the correlation with mineral nutrition need to be investigated. In the current research soil, roots and leaf samples were monthly taken for one year from 6 kinds of fruit trees located at Kyoto Prefectural University experimental farm, Seika-cho, Kyoto, Japan. The trees were apple (Malus domestica "Fuji"), peach (Prunus persica "Benishimizu"), kaki (Diospyros kaki "Hiratanenashi"), figs (Ficus carica "Masui Dalphine"), citrus (Citrus unshiu "Sastuma mandarin") and grape (Vitis vinifera "Fujiminori"). The mineral nutrients (N, P, K, Ca and Mg), AMF colonization and spores number were evaluated. The results indicated that the colonization and spores number reached to the top during the summer season, characterized by higher photosynthetic activity. The N and P concentration also had a peak in June and September in all fruit trees, but other elements the peaks could occur in August and September depending on the flowering and harvesting season. However, in citrus the variation were not so ranged as compared to other trees, where during the winter their leaves do not fall. The colonization and spores number were positively correlated to N and P concentration, but has no correlation with other elements. This data suggests that AMF activity could be strongly related to N and P nutrition in temperate fruit trees, however it could indirectly influence other elements too.

Keywords：*Arbuscular mycorrhizal fungus, Fruit trees, Mineral nutrition*

P3-334

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Spatial Variation of Soil Microbial Indicators in Different Soil Textural Classes Planted with Elaeis Guineensis (oil Palm)

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Microbial communities form an integral part of soil and their activity has been widely documented in various soil ecosystems inferring their contributive effect on the function and health of soils. Though considered of importance, their contributive roles in the oil palm soil ecosystem are poorly understood and furthermore investigated. Similar with many other intensive agriculture cropping systems, nutrient inputs are mainly derived from inorganic fertilizers though the utilisation of organic mulch derived from oil palm biomass waste are also commonly adopted where possible. The current cultivation techniques such as inorganic fertilizer applications, herbicide and pesticide applications are standard agricultural practices that would otherwise increase pressures on microbial diversity and activity and furthermore contribute to shifting the equilibrium in soil biological properties. With these shifts in soil biological attributes and their consequential effect on soils, protection in soil health is gaining importance. Hence a thorough understanding of the soil ecosystem process is critical in assessing the impact of agro-management practices and also for evaluation of soil remediation or rejuvenation practices.

In this study, we address the spatial variation of microbial indicators in different textural soils which are commonly cultivated with Elaeis guineensis or commonly known as oil palm and furthermore we attempt to ascertain their association with soil chemical properties. Our selection of soils for this study varied across different textural classes mainly in clay content, exemplifying the wide range of soils commonly cultivated with oil palms. Soil types comprised two soils classified as Typic Kandiudults with sandy clay loam and sandy clay texture respectively, a Fluvaquentic Endoaquepts with clay texture and lastly well decomposed peat or sapric soil (Typic Haplosaprists). With top-soils (0-15 cm), pH varied between 3.86 for the sapric soil up to 4.57 in sandy clay. Clay content varied the most ranging from 15% up to 50% and gradually increased at lower soil depths (45-50 cm), with the exception of the sapric soil. Apart from the sapric soil with significantly higher C/N ratio of 17.5-27 (across the soil profile), other soils exhibited consistent C/N ratio ranging from 7.6-9.3.

Microbial indicators measured include heterotrophic enumeration (for estimation of colony forming units or CFU), microbial biomass carbon (MB-C) and nitrogen (MB-N), ninhydrin-reactive N (MB-NN), and soil enzyme activity which included fluorescein diacetate hydrolysis (FDA) and soil dehydrogenase activity (DHA). Soil microbial catabolic capacity was determined using Biolog-Eco plates while microbial diversity analysed via 16S and 18S rRNA-PCR denaturing gradient gel electrophoresis (DGGE). Pearson Correlation Matrix and Principal Component Analysis (PCA) were used to assess trends between soil biological and chemical parameters.

DHA and FDA enzymatic activities were significantly and positively correlated to clay content, total C, organic C and total N and likewise with most of the other microbial indicator parameters though negatively correlated with pH which was more prominent with the sapric soil. MB-C, MB-N and MB-NN were good indicators which produced positive correlation ($p<0.05$) with most of the soil chemical components. Average well colour development (AWCD) for substrate guilds was also compared. Carbohydrates, polymers, carboxylic/acetic acids and amines/amides were overall negatively correlated though only significantly towards selected chemical parameters (carbohydrates: pH and organic C; polymers: total/organic C and total N; carboxylic/acetic acids: pH (R+); amines/amides: pH (R+), total C, organic C, total N). Amino acids were mainly positively correlated to clay content, total and organic C, and total N. The Shannon-Weaver Diversity Index (SWDI) based on substrate utilisation and their proportion to total AWCD differed very little between the mineral soils but clearly distinct compared to the sapric soil. SWDI also differed distinctly with soil depth with lower substrate utilisation at lower soil depths (30-45 cm) compared to the top soils (0-15 cm). UPGMA analysis with 16S rRNA PCR-DGGE analysis (top-soils) revealed highly divergent patterns and furthermore clustered separately with a similarity matrix ranging from 19-80% while 18S profiles varied between 76-88%. Similarity of profiles at lower depths became more varied with 16S and 18S patterns producing similarity index ranging from 36-87% and 4-32%, respectively.

The results indicate the divergent microbial activity and diversity in different soil types cultivated with oil palm and will form the basis for the establishment of a framework for evaluating soil health cultivated with this crop.

Keywords：*Elaeis guineensis, Soil microbial indicators, 16S rRNA gene, 18S rRNA gene, DGGE, Soil texture*

P3-335

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Bioaugmentation-Assisted Phytoextraction of Co, Pb and Zn By a Phosphate-Solubilizing Bacterium Isolated from Metal-Contaminated Mines

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A total of 20 bacterial strains with the potential ability to solubilize inorganic phosphates were isolated from heavy metal contaminated soils collected from abandoned mines of Boryeong area in South Korea. The bacterial strain with the highest degree of metal resistance was shown to have close proximity with Klebsiella oxytoca JCM1665, according to 16S rRNA sequence analysis, and selected for the study. The strain was found to be capable of solubilizing inorganic phosphate both in the absence and in the presence of metals (Co, Pb and Zn). Bacterial-assisted growth promotion and metal uptake in sunflower (Helianthus annuus) was evaluated in a pot experiment. In comparison with non-inoculated seedlings, the inoculation led to increase the growth of H. annuus by 49, 22 and 39% respectively in Co, Pb and Zn contaminated soils. Moreover, enhanced accumulation of Co, Pb and Zn in the shoot and root systems was observed in inoculated plants, where metal translocation from root to the above-ground tissues was also found to be enhanced by the strain. Metal mobilization potential of the strain was assessed in a batch experiment and the results showed that inoculation could increase the concentrations of water soluble Co, Pb and Zn by 51, 24 and 76% respectively, than those of non-inoculated soils. Plant growth promotion and metal mobilizing potential of the strain suggest that the strain could effectively be employed in enhancing phytoextraction of Co, Pb and Zn from contaminated soils.

Keywords：*Inoculation, Klebsiella oxytoca JCM1665, phytoextraction, sunflower*

P3-336

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Long-Term Monitoring of Chemical Properties from Upland Soils in Chungnam Province

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The monitoring of fertility changes in upland is very important for agricultural sustainability. Field monitoring was performed to evaluate the soil chemical properties of 150 upland soil samples in Chungnam province every 4 years from 2001 to 2013. Soil chemical properties such as pH, electrical conductivity, amount of organic matter, available phosphate, and exchangeable potassium, calcium, magnesium and sodium were analyzed. The amount of exchangeable calcium, and soil pH were significantly increased as cultivation year increases. In 2013, the frequency distribution for values of pH, organic matter, available phosphate and exchangeable potassium, calcium and magnesium that were within the optimum range was 26.0%, 31.3%, 14.7%, 11.3%, 11.4% and 23.4% respectively. Especially, available phosphate and exchangeable calcium were excess level with portions of 65.3%, and 59.3%, respectively. These results indicated that a balanced management of soil chemical properties can reduce the amount of fertilizer applied for sustainable agriculture in upland fields.

Keywords：*Chemical property, Upland soil, Soil fertility, Available phosphate, Exchangeable calcium*

P3-337

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Indolacetic Acid Production and Phosphate Solubilization Ability of Several Microorganisms Isolated from Panax Ginseng Rhizosphere

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Recently, there are worries of the side-effects due to the use of agrochemicals. A novel biotechnology of using of beneficial microorganisms to improve plant health and productivity has therefore been extensively concerned. In the current study, more than 120 bacterial and fungal strains belonging to 27 species were isolated from the rhizosphere of Panax ginseng, and then tested in vitro for phosphate solubilization and indole acetic acid (IAA) production. Pikovskaya's media was used to estimate the rhizomicrobial isolates to solubilize the tricalcium phosphate (Ca3 (PO4)2). Pseudomonas fluorescence and Azotobacter chroococcum demonstrated the highest phosphate solubility of (885.4 µg mL-1) and (863.4 µg mL-1), respectively. The phosphate solubilization activity of rhizofungi isolates was 82 %; however, rhizobacteria isolates showed phosphate solubilization percentage only 57.1 %. The overall rizobacteria isolates showed IAA productivity in percentage of 47.62 %, while (64.7 %) of the rhizosphere fungal isolates were able to produce IAA. Mucor sp. showed strong IAA productivity of 42.3 µg mL-1 on Czapek's-tryptophane medium, and the highest fungal species to solubilize the inorganic phosphate of (237.5 µg mL-1). Rhizobacteria were more powerful than rhizofungi in both activities of phosphate solubilization and IAA production. The study explores high P-solubilizing potential and IAA producer of Azotobacter chroococcum, P. fluorescens, and Mucor sp, which can be exploited for the solubilization of unavailable phosphates present in the soil and produce IAA, so improve soil fertility and plant growth.

Keywords：. *Rhizofungi* . *Phosphate solubilization* . *IAA*

P3-338

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Plant Growth Promotion by Rhizobacteria Isolated from Pinus Koraiensis on Chinese Cabbage (brassica Rapa)

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The development of satisfactory alternatives for supplying the nutrients needed by crops could decrease the problems associated with conventional NPK chemical fertilizers. In this study, the effects of bacterial and fungal effective microorganisms (EM) on the growth of Chinese cabbage (Brassica rapa) were evaluated. This investigation was carried out in comparision with conventional NPK chemical fertilizer and one type of commercially sold microbial fertilizer. Sterile water and molasse were used as controls. Azotobacter chroococcum effect also was studied either alone or in combination with the effective microorganisms on the growth parameters. In contrast the bacterial EM, the fungal EM alone without A. chroococcum had a more stimulating effect than fungal EM combined with A. chroococcum. Results showed that seedling inoculation significantly enhanced B. rapa growth. Shoot dry and fresh weight, and leaf length and width significantly were increased by both bacterial and fungal inoculation. The results indicated that the NPK chemical fertilizer deteriorates the microflora inhabiting the soil, while the effective microorganisms either fungal or bacterial ones increased the microbial density significantly. This study implies that both of fungal and bacterial EM are effective for the improvement of the Chineese cabbage growth and enhance the microorganisms in soil. The results showed antagonism occured between A. chroococcum and each of Penicillium sp and Trichoderma sp in both agar and planta assays. The data were statistically analyzed by ANOVA and Dunnett test.

Keywords：*Effective microorganisms, Chinese cabbage, Azotobacter chroococcum, antagonism*

P3-339

[C2.3-2] Life in Soils-Distribution and Function of Soil Microorganisms in a Changing Environment

Isolation and Detection of Genes Responsible for Pyoverdines Biosynthesis in Pseudomonas Putida Knuk9

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Pyoverdines (PVDs) are organic compounds produced by the fluorescent Pseudomonads. Among the isolated rhizosphere pseudomonads strains, P. putida KNUK9 showed the highest production (62.81%) siderophores units. DNA isolation, ligation, PCR amplification, and transformation using E. coli DH5α cells were carried out on the strong pyoverdine producer strains. Fifteen different genes responsible in the pyoverdine biosynthesis were investigated; we could detect seven genes known to play the fundamental roles in the pyoverdine metabolism in Pseudomonads. According to data and analysis we can deduce that the Pseudomonas strain of P. putida KNUK9 contains the essential genes required for pyoverdine biosynthesis.

Keywords：*Pseudomonas putida, Pyoverdines genes, Detection.*

P3-340

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Study of Genesis, Morphology and Clay Mineralogy in Kakan Area, Kohgiluyeh-Va-Buyer-Ahmad Province, Iran

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The goal of this research was the study of genesis, morphology and clay mineralogy of the soils of Kakan region, Kohgilouye-va-Boyerahmad Province as affected by a relatively wet climate. Clay minerals have key role on most physical, chemical and biological properties of the soils. Therefore the information regarding the genesis and transformation of clay minerals could be an important approach for enhanced understanding of the soil genesis. Soil sampling was carried out for the separation of the physiographic units. The soils were classified after routine soil analyses at family level. For clay mineralogy, the soils treated for removing organic matter, carbonates, gypsum, soluble salts and Fe-oxides. The method was followed by the separation of sand, silt and clays using kittrick and Hope technique. Dried clays were then treated by MgCl2, KCl, ethylene glycol and heating (550 °C). The soils were classified as Mollisols, Inceptisols and Alfisols using Soil Taxonomy. Clay mineral investigation revealed that smectite is the most abundant clay mineral observed in the soils studied. Neoformation from soil solution, transformation from mica and palygorskite are the main suggested pathways for the occurrence of this mineral. Chlorite was the second abundant clay mineral in the studied soils. Inheritance seems to be the main mechanism for the occurrence of this mineral. Rare amount of illite was observed in the soils as this mineral is transformed to smectite. Vermiculite occurrence needs particular pedoenvironmental condition that is not occur the studied soils. Inheriated quartz and kaolinite were found in the low amounts. High degree of weathering and rainfall inhibit the stability of the palygorskit in the soils of Kakan region.

Keywords：*Mineralogy, Kakan- Iran, Smectite, Alfisols*

P3-341

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Characterization of Phosphorus Species in Allophanic and Non-Allophanic Andisols Using Density Separations, Chemical Fractionation, Solution ^{31}p NMR, And Xanes Spectroscopy

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Andisols with abundant active aluminums (Al) and irons (Fe) are characterized by a high phosphorus (P) retention capacity. Such property leads to a significant inhibition of plant growth in Andisols unless properly managed. Andisols are classified into two types in accordance with the difference in the clay mineral compositions. One type is referred to as allophanic Andisols, in which allophane and imogolite are present in the clay fraction. The other type is referred to as non-allophanic Andisols, in which Al- and Fe- humus complexes and 2:1 phyllosillicates are predominant. Based on the result of chemical extraction, it has been suggested that these clay minerals appear to contribute to P retention capacity of Andisols. However, there are no reports that characterize chemical species and hosting phases of P in allophanic and non-allophanic Andisols. Molecular spectroscopic techniques in combination with chemical extraction can provide detailed information on the sorption mechanisms of P in soils. In addition, separating the different soil minerals in accordance with their density can limit the number of P-bearing phases, facilitating characterization of P speciation. Humus and Al or Fe minerals, which contribute largely to a P retention capacity, can be separated by their density. The objective of this study was to characterize the species and sorption hosts of P in allophanic and non-allophanic Andisols using density separations in combination with sequential fractionation, X-ray absorption near-edge structure (XANES) and solution ^{31}P nuclear magnetic resonance (NMR) spectroscopy.

Allophanic Andisols collected from Tsukuba, Japan were fractionated by sodium polytungstate into five density levels including 1.6−1.8, 1.8−2.0, 2.0−2.25, 2.25−2.5, and >2.5 g cm^{-3}. Phosphorus in each density fraction was extracted sequentially by deionized water, 0.5 M $NaHCO_3$, 0.1 M NaOH and 1.0 M HCl. After the extracts were filtered, the concentration of inorganic P (P_i) in all fractions was determined colorimetrically with a molybdenum blue method. The concentration of total P (P_t) in each fraction was determined by the same method after the solution was treated using H_2SO_4-persulphate digestion. The concentration of organic P (P_o) was calculated as the difference between P_t and P_i of each fraction.

The total concentration of P in the allophanic Andisols was 6.2 g P kg^{-1}. The sequential fractionation of bulk soil showed that the largest pool was NaOH-P (89%), followed by $NaHCO_3$ (7%), and HCl (4%). The density fractions of 2.0−2.25, 2.25−2.5, and > 2.5 g cm^{-3} accounted for 88% of bulk soil weight, and the 2.0−2.25 g cm^{-3} fraction was largest (44%) among five fractions. A large proportion of P_i (76-92%) and P_o (72-99%) in each density fraction was extracted by NaOH, indicating that P in the allophanic Andisols was mainly associated with Al and Fe hydroxides. In contrast, P extracted by HCl and $NaHCO_3$ was comparably smaller than that of NaOH fraction in each density fraction. Water-extractable P in each density fraction and bulk soil was not detected. The results combined with the density separations and sequential extraction indicated that P_i and P_o in the 2.0−2.25 g cm^{-3} fraction accounted largely for the total P of bulk soil (P_i: 57%, P_o: 72%). For more detail investigation, XANES and ^{31}P-NMR techniques were employed to reveal chemical speciation and hosting phases of P in the soil.

Keywords：*phosphorus, Andisols, ^{31}P-NMR, density fractionation, XANES*

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[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Transformation Processes in Bentonites- Epsp and Mock-Up-Cz In-Situ Experiments

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The international DOPAS (Full-Scale Demonstration of Plug and Seals) project involves research into, and the development of, different types of plugs and sealing materials for use in the construction of radioactive waste repositories.

The project was initiated by the IGD-TP and is being subsidised from European RTD project resources. Fourteen organisations (POSIVA, ANDRA, DBE TEC, GRS, NAGRA, NDA, SÚRAO, SKB, CTU, NRG, GSL, BTECH, VTT, ÚJV) from a total of eight European countries are involved in the project, the planned duration of which is four years (09/2012 – 08/2016). Financial support is provided by Euroatom´s Seventh Framework Programme.

Several different types of plugs are proposed in the Czech Deep Geological Repository concept. Their purpose is to safely and securely seal and close individual parts of the repository during the operational stage of the facility, i.e. up to 150 years. The EPSP plug must be constructed so as to be able to resist the high pressure (up to 7MPa) created as a consequence of hydrostatic pressure and volume changes within the bentonite barriers of the repository.

The plug construction experiment (EPSP) is being conducted by a 3-member Czech consortium (SÚRAO, CTU, ÚJV) at the Josef Underground Research Centre in the Čelina – Mokrsko Au-bearing section of the facility (Czech Republic).

The first layer of the plug consists of a concrete segment made of cement with limited pH and the second layer of compressed bentonite pellets and sprayed bentonite. The pellets are of Ca/Mg Czech bentonite with the industrial designation B75 from the Rokle/Černý Vrch deposit. The plug is sealed with a second concrete layer.

The objective of this study is to identify the mineralogical changes and to describe the transformation processes induced within selected Czech bentonites suitable for use in deep geological repositories.

A detailed mineralogical study of transformation processes of smectites due to long-term heating and interaction with synthetic/natural granitic and saline water was carried out. The structural and physico-chemical changes within the clays under investigation were evaluated using X-ray diffraction, infrared spectroscopy, DTA/TG, scanning electron microscopy, cation exchange capacity (CEC) and swell index.

The transformation processes observed in the Czech bentonite (Rokle deposit) consisted of the following:

• illitization was identified in 10 samples (5 samples from a 3-month laboratory experiment at 200°C, 2 samples from a 1-year laboratory experiment at 50°C and 15% NaCleq. and 3 samples from the 3-year-9-month Mock-Up-CZ experiment (Kolaříková et al., 2010) at temperatures of 40 – 50°C). The presence of illite-smectite mixed layer structures and pure illite caused a significant decrease in cation exchange capacity values from 71.8 ± 14.4 mmol/100g (smectite) to 37.5 ± 7.5 mmol/100g (illite-smectite) and 28.0 ± 5.6 mmol/100g for illite (Mock-Up-CZ experiment, Vinšová et al., 2008). Short-term laboratory experiments revealed a decrease from 68.9 to 45.6 mmol/100g and the CEC value of samples from the Ishirini deposit was a mere 35.2 mmol/100g. Both

the specific surface area of micropores and swelling ability decreased rapidly with increasing temperature and/or salinity. However, the extent of transformation was not sufficient to significantly influence the physico-chemical properties of the bulk bentonite samples (Kolaříková et al., 2010).

• Beidellitization occurred in 7 samples (Mock-Up-CZ experiment) as well as in the short-term laboratory experiments. The formation of beidellite did not lead to a deterioration in swell index values, cation exchange capacity or specific surface area.

Mock-Up-CZ experiment revealed the presence of newly-formed gypsum – domains of up to 4mm with an illitic contact aureole. The amount of gypsum decreased with increasing distance from the granitic water source (Kolaříková et al., 2010).

The data obtained from the EPSP experiment will be used for the construction of mathematical models and for safety analysis purposes.

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Keywords：*bentonites, transformation of smectites,mechanisms of transformation*

P3-343

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Comparative Analyses of Soils Formed on Carbonate Rocks

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The present study focuses on the physical and chemical investigation of soils formed primarily on carbonate rocks. One part of the investigated soil profiles originated from the top of the Bükk Hills, the Bükk-Highlands' limestone plateau, which is located in the North-Eastern part of Hungary. The rest of the samples were taken from the Szárhalom Forest (located in West Hungary). The different location and climate of the sites forms a basis of the comparison of the soils with similar base rock. These soils are formed mainly on limestones, however they differ significantly in terms of certain characteristic properties.

The following physical parameters were evaluated from the samples: transition, structure, compactness, roots, skeletal percent, colour, physical assortment, concretion and soil defect. Laboratory analysis involved the measurement of acidity, particle distribution, carbonated lime content, humus content, ammonium lactate-acetic acid soluble phosphorus- and potassium content, potassium chloride soluble calcium- and magnesium content, ethylene-diamine-tetraacetic-acid (EDTA) and diethylene-triamine-pentaacetic-acid (DTPA) soluble copper-, iron-, manganese- and zinc content. X-ray diffraction, thermoanalytical measurements and ICP-OES were also carried out to determine the mineral composition of the soils and the content of heavy metals. Evaluation focused on the comprehensive analysis of the data with a special regard to possible relationships and correlations.

Research was supported financially by the „Silva naturalis project (TÁMOP-4.2.2.A-11/1/KONV-2012-0004)".

Keywords：*mineral composition, limestone, physical and chemical parameters, thermoanalysis, X-ray diffraction*

P3-344

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Mineralogical Investigation of Soils Formed on Carbonate Rocks in the Bukk-Highlands (hungary)

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The primary aim of our mineralogical investigation was to study the mineral composition and the soil-forming materials of the soils in the Bükk Hills' native forest. The investigated soils can be found at the top of the Bükk Hills, on the so-called Bükk-Highlands. This limestone plateau is composed primarily of limestones but also contains dolomites and shales. In the course of our investigations we have analysed four soil profiles. The formation of the acidic and humus rich upper layer of the soil profiles is influenced by the mineral composition and the weathering of the rocks. In order to study the composition of soil minerals thermoanalytical and X-ray diffraction measurements have been carried out. Different soil particle fractions have been analysed by polarizing microscopy. According to the thermal analyses the most abundant mineral in the soil samples was quartz, accompanied by clay minerals and oxides-hidroxides. The presence of calcite could only be evidenced in a few samples. The X-ray diffraction measurements have also confirmed these findings, because according to this we can say that quartz represents the most significant proportion in all of the soil profiles, and besides quartz clay minerals, feldspars, oxides-hidroxides also occur; respecting calcite we have got interesting results, as this mineral appears only in four layers and in very little concentrations in all of the soil profiles.
X-ray analyses have also revealed the presence of alumogoethit in each of the profiles, a mineral, indicating a previously warmer and humider subtropical climate. This warmer cilmate of the area has been periodically changing for over 65 million years with a colder and dryer climate, and these changes also affect the development of the soils.
The investigated soils of the Bükk-Highland contain significant amounts of silicates, so apparently they cannot be the product of the weathering of limestone solely. The major part of soil-forming material originates presumably from previous dust fallings or the agglomerate materials of erosion.
Research was supported financially by the „Silva naturalis project (TÁMOP-4.2.2.A-11/1/KONV-2012-0004)".

Keywords：*Bukk (Hungary), limestone plateau, mineral investigation, thermoanalysis, X-ray diffraction*

P3-345

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Mineralogical and Chemical Characterization of Arid Granitic Soils after Prolonged Exposure to Acid Mine Drainage

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The effects of acid mine drainage (AMD) on natural systems has received considerable attention in recent years. Contamination of ground and surface water sources by AMD is of great concern especially in a water-scarce country, such as South Africa. South Africa has a long mining history and many of the early mining exploits paid little attention to the impacts that AMD has on the natural environment. As a result many derelict mining sites continue to serve as a point source of pollution to the surrounding environment. Soils are often one of the first receptors of AMD and play an essential role in detoxifying the drainage thus forming a buffer zone between the point source and the water resource. The effects of AMD on arid soil systems have generally received less attention than leachate affected soils in more humid regions. In arid climates the soil mantle is usually immature and the buffering capacity of the soil against acidity and metal migration is often low. Limited secondary mineral formation in arid soils reduces the metal attenuating capacity and increases the potential for metal mobility. In addition, evaporation is a major hydrologic process in arid climates, and this serves to increase the acidity and metal concentrations in soil pore waters. Sporadic high rainfall events often result in these concentrated acidic brines being leached into underlying water resources, which are often the sole means of fresh water for communities living in arid regions.

The arid Okiep Copper District (OCD) situated in the Namaqualand region of the Northern Cape, South Africa is the oldest mining district in the country. Over 150 years of intensive Cu mining has resulted in acute soil contamination as a result crude Cu extraction processes and unabated leaching of AMD into the soil. Shallow soil excavations were used as Cu extraction ponds and have resulted in the soils being exposed to AMD for extended periods of time. These acidic conditions accelerate weathering of primary minerals and the formation of secondary phases. The soil material in the shallow extraction ponds provides a unique opportunity to determine the effects of long-term exposure of primary and secondary soil minerals to AMD in an arid environment. This study aims at characterizing the mineralogy and solution chemistry of soils that have had a prolonged exposure to concentrated AMD.

The OCD receives an average rainfall of 106 mm/y, with most of the rainfall occurring during the cool winter months. The summers are hot and dry. As a result the leachate in the ponds is slightly diluted in the winter months, but becomes highly concentrated in the summer months. The soils in contact with the AMD are derived from granite-gneiss of the Namaqualand metamorphic complex. The soils are generally shallow (<1m) and would classify as Leptic Cambisols (Eutric).

Samples were collected from the extraction pond at the end of the dry season thus the AMD formed a concentrated pool in the center of the pond. This allowed soil samples to be collected from the floor of the pond. Pristine soil samples were collected 400 m away from the pond in a similar landscape position. Clay separates of soils were analyzed by x-ray diffraction analysis (XRD). The AMD and saturated paste extracts of the soils were analyzed for cations, anions and dissolved Si.

Felsic primary minerals dominate the clay phase of the pristine soils and testify to the youth of the solum. Kaolinite was the exclusive secondary mineral identified in the pristine soils. The pond soils showed broad noisy diffraction peaks, typical of poorly crystalline phases. Only halloysite could be identified unambiguously through XRD analysis. Large green melanterite (FeSO4 .7H2O) crystals were also identified at the base of the pooled AMD.

The AMD has a pH of 1.5 and contains extremely high metal concentrations with Al and Fe contents of 25.2 g/L and 38.8 g/L, respectively. Manganese, Cu, Mg and Zn were all above 1 g/L. Pond soil samples also contained elevated dissolved metal contents (Al 43.7g/L; Cu 4.9g/L; Zn 2.3g/L; Mn 4.5g/L). Dissolved Si concentrations were elevated to amorphous Si saturation. These results suggest that amorphous secondary Si phases are forming in AMD affected soils. These secondary phases should play an important role in heavy metal sequestration.

Keywords：*Acid Mine Drainage, Heavy Metals, Precipitation, Geochemistry*

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[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Palygorskite in Soils of Arid Regions

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Palygorskite is widespread in soils of arid regions. According to Kostov (1971) it is a peculiar mineral to be considered as an intermediate between chain and layer silicates. Its presence in soils is associated with pedogenesis. The other specialists think that this mineral is an inherited component of soil-forming rocks. Gradusov (1976) has identified two sources for the mineral synthesis in epicontinental evaporation basins within the arid zone and as a product of changes in ultrabasalts and basalts resulting from hypergene processes. The geological situation, under which palygorskite, sepiolote and their paragenetic associations appears have been described in detail. The following types of mineralization have been associated with such processes as (1) chemogenic-evaporational, (2) camouflaged volcanogenic-sedimentary and (3) terrigenic detrital (Lobova, 1977). The presence of palygorskite in the soil-forming rock being associated with smectite, kaolinite, chlorite and mixed-layer formations with different stability to the weathering allows considering it as a component of terrigenic capture, repeated redeposition and distribution of old material that has been resulted from Pliocene-Oligocene transgressions of epicontinental sea and lake basins of evaporitic type at platforms of Africa, Middle Asia, Arabia and Australia (Milo, 1968; Gradusov, 1976).

The objective of the given study is an analysis of palygorskite behavior in soils of the arid zone under the influence of the present soil formation and irrigation. Objects of research are fractions less than 1mkm, extracted from soils of Libya, Iran and Jemen.

comprehensive analysis of palygorskite behavior in soils and weathering crusts within the arid subtropics of Libya permitted to show that this mineral is a basic component of the fraction less than 1mkm. It is associated with a small amount of kaolinite, chlorite and mixed-layer formations of mica and smectite pockets. In the course of weathering and soil formation the palygorskite content is decreasing and layered silicates become transformed. The content of fractions less than 1mkm in undifferentiated arid reddish-brown soils is identical to that observed in weathering crusts. But the palygorskite amount gets much lower in the topsoil. The same picture takes place in arid brown differentiated soils. In the A1 horizon of these soils kaolinite is dominated as resulted from destructing palygorskite, chlorite and mixed-layer formations. In solonetzic-saline brown arid differentiated soils there is a clearly expressed differentiation of the soil profile due to intensive destruction of palygorskite and layer silicates.

In soils of Central Iran characterized by different chemical composition and salinization degree palygorskite seemed more sensitive to changes in pH during the soil formation. The acid pH in upper horizons of solonchaks led to palygorskite destruction in these horizons. The increased content of soluble sodium salts has the same effect on palygorskite structure. It is evident that the major clay minerals and palygorskite in particular suffer from mechanical disintegration of particles that are intensively destructed as affected by peptization.

The increased content of palygorskite in the topsoil of irrigation-transformed gray-brown desert soils is explained by its input to soil with irrigation waters from wells. At the studied territory the ground water being enriched with palygorskite is at a depth of impermeable clayey subsoil of Tertiary deposits. The behavior of palygorskite and layered silicates has been studied in desert soils of Jemen. The fine-dispersed fractions consisted mainly of palygorskite accounted for more than 50%, much smaller amounts of hydromica of sericite-muscovite type (15-24%), magnesium-iron chlorides (4-9%), sepiolite, mixed-later formations of two types (not more than 2%) and fine-dispersed quartz. During pedogenesis the structure of all the components of the clay fraction was degraded and sericites were transformed into rectorite. Human intervention led to changes in the behavior of minerals of the carbonate group, layered silicates and most of all the mixed-layer formations.

It seems reasonable to conclude that palygorskite is widely spread in arid soils. Its associations with smectite, kaolinite, chlorite, mixed-layer formations make it possible to consider the presence of this mineral in soil-forming rocks as a result of terrigenic capture of the material from more old deposits. The recent pedogenesis serves as evidence of palygorskite destruction, but most intensively it is destructed under the influence of irrigation.

Keywords：*arid soils, palygorskite, irrigation, smectite, kaolinite*

P3-347

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Effects of Termites on Clay Composition and Properties of Ferralsol Materials in the Upper Katanga (d.r. Congo)

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The effects of Macrotermes falciger activity on clay composition, charge characteristics, and water-dispersible clay (WDC) content of Ferralsol materials were investigated by a physico-chemical, mineralogical, and micromorphological study of termite mounds and control soil profiles at various sites near Lubumbashi (Upper Katanga, D.R. Congo).

The water-dispersible clay (WDC) content is much higher (4-87 fold) in mound materials than in the control soils, which is also expressed by the presence and nature of clay coatings within the mounds. Electro-chemical analysis shows that compared to the control soil at each site, the termite mound materials have a lower (1.6-fold) point of zero charge (pHo), lower (5-fold) actual anion exchange capacity (AEC), much greater (3.2 to 4.6-fold) actual base cation exchange capacity (CECB), and greater (~2-fold) amount of permanent negative charge (σp). X-ray diffraction analysis shows that mound materials are enriched in 2:1 clays, especially mica and expandable 2:1 clay minerals, compared to the surrounding Ferralsols, dominated by 1:1 clay minerals (kaolinite). The differences in surface charge characteristics and the much greater degree of clay dispersibility in termite mound materials than in the surrounding soils are largely attributed to the enrichment in 2:1 clay minerals. The 2:1 clay minerals enrichment of the studied mounds is attributed to upward transport of mica and smectite as part of termite-gathered aggregates of soil or saprolite material.

Keywords：*Clay mineralogy, Electro-chemical properties, Water-dispersible clay,Termites, Ferralsols*

P3-348

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Chemical Speciation and Dissolution of Cd in Paddy Soils in Various Redox Gradients

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Cadmium (Cd) contamination in paddy soils is one of the most serious issues in countries with a large dietary consumption of rice. In order to reduce the health risk of Cd, a proper soil management practice is needed to minimize transfer of Cd from paddy soils to rice grain. Limiting Cd transfer from soils to rice grains is closely related to Cd speciation in paddy soils, and Cd sulfide (CdS) occurring under reductive soil conditions decreases Cd solubility. Lowering soil's redox potential under continuous submergence during the emerging period of rice ears may enhance CdS formations and thereby reduce Cd uptake by rice plants. However, this method is incompatible with the present agricultural practice that usually conducts the intermittent irrigation after the midseason drainage. To minimize Cd uptake by rice plants, an alternative water-management practice to control Cd solubility and speciation is needed. Understanding of CdS formations in relation to soil redox chemistry may contribute to establish a guideline of irrigation practice to minimize Cd transfer from soils to rice grains. The objective of this study was to find a relationship between chemical speciation and dissolution of Cd in paddy soils in relation to the soil redox status.

Two paddy soils (Aeric Epiaquents and Aquents Fluvaquents) with different redox properties were selected for this study. To mimic a contaminated soil, Cd was added as Cd chloride salt to achieve the Cd concentration of 150 mg kg^{-1}. The soils were incubated for 29 days in a waterlogged (reductive) condition. After the reductive incubation, an aliquot of soils (~80 mL) were added to a short column with a quartz sand layer, and incubated for 21 days in an air-dry (oxidative) condition. The soil pH and Eh values were continuously measured during the 50-day incubation period. The soils were periodically sampled and Cd was extracted by 0.1 M HCl solution. Chemical speciation of Cd in the soils during reduced and oxidized periods were determined using Cd K-edge X-ray absorption near-edge structure (XANES) spectroscopy.

The Aquents soil was reduced faster than the Aeric soil. The Eh value decreased to -200 mV in 12 days for was the Aquents soil and in 28 days for the Aeric soil. The HCl-extractable Cd in both soils tended to decrease with decreasing the soil Eh value. During the waterlogging incubation, the HCl-extractable Cd decreased from 2.8 mg Cd L^{-1} (day 1) to 2.4 mg Cd L^{-1} (day 29) in the Aeric soil, and from 2.4 mg Cd L^{-1} (day 1) to 1.8 mg Cd L^{-1} (day 29) in the Aquents soil. The XANES study revealed that the formation of CdS was greater in the Aquents soil (89%) than the Aeric soil (49%) at the last day of flooding period (day 29), which corresponded to the smaller HCl-Cd in the Aquents soil. On the other hand, during the air-dry incubation, the HCl-extractable Cd increased from 2.3 mg Cd L^{-1} (day 33) to 3.6 mg Cd L^{-1} (day 50) in the Aeric soil, and from 2.0 mg Cd L^{-1} (day 33) to 3.6 mg Cd L^{-1} (day 50) in the Aquents soil. The Cd XANES spectra on the day 50 soils found that CdS disappeared in the Aeric soil but was present in the Aquents soil with 28% of the total Cd. Our study suggests that Cd solubility during the initial oxidation period (~10 days) can be attenuated more in the readily reducible soil.

Keywords：*Cadmium, chemical speciation, paddy soils, XANES, redox gradient*

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[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Recycle of Crop Residues in Fields through Fermentation

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China is an agricultural country with large population, where huge amounts of pesticides and fertilizers are used to obtain higher food yields. The excessive application of pesticides and fertilizers has led to the degradation of soil environmental quality. On the other side, a large huge amount of biomass annually produced in agricultural fields in China has posed a serious environmental problem. Burning straw conducted by local farmers often causes the severe pollution of atmosphere and has been forbidden by the government. Recycle of crop residues as organic manure can not only solve the environmental problem, but also significantly reduce the use of pesticides and fertilizers. In this work, four crop residues including corn straw and soybean, tomato and water spinach stalks were used as experimental materials and fermented by three microbial inocula, Japanese EM, Chinese Yu-Fei-Bao (YFB) and Rapidly Decayed Bacterium (RDB). The results indicated that the four crop residues become totally black in color after 60 days of fermentation, among which, the stalks of water spinach were decayed fastest due to its high content of water and low C/N ratio. The contents of ammonium nitrogen and nitrate nitrogen in the fermented materials maintain high levels after 14 days of fermentation. Moreover, ammonium and nitrate contents in the fermented soybean stalks are much higher than that in the others, suggesting that leguminous residues are more potential to be used as recycled organic manure as it contains higher content of nitrogen due to nitrogen fixation by its rhizobium. At the beginning of the fermentation, the content of ammonium nitrogen in the fermented materials is 10-30 times the amount of nitrate nitrogen, but ammonium in it is then sharply decreased and transformed into nitrate afterwards. The results also indicated that the Japanese EM and Chinese RDB could more effectively ferment soybean stalks than the Chinese YFB; the latter, however, can more effectively ferment corn straw than the former, suggesting that the functions of the microbial inocula on different crop residues are different and selective.

Keywords：*Biomass; fermentation; microbial inocula; organic manure; ammonium*

P3-350

[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Solubility and Chemical Speciation of Arsenic and Lead in a Contaminated Soil Using Amendments Containing Zeolite, Iron and Magnesium Oxides

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In a large size of contaminated sites, immobilization of heavy metals in contaminated soils has been considered as a cost-effective technique compared with a conventional excavation method. Mechanisms of metal immobilization by amendments are based on the changes of chemical species to be less soluble phases such as inner-sphere complexes and (co)precipitates. Although the immobilization technique presents a more efficient solution than a excavation method, the number of conducted immobilization is only 1.2% of total soil remediation conducted up to March, 2012 in Japan. Little knowledge about the chemical state of contaminants after adding amendments is one of the reasons for limited acceptance of immobilization. Therefore, it is important to reveal how the original metal species are transformed into less soluble phases in the soil after the immobilization technology is applied. A long term observation on solubility and chemical speciation of metals is also important for evaluating the immobilization technique. The objective of this study was to investigate solubility of and immobilization mechanisms of toxic metals in the soil amended with three different types of immobilizing agents that have been commercially available in Japan using extraction and X-ray absorption fine structure spectroscopy (XAFS) techniques. We focused on whether the amendments immobilized both cationic and oxianionic species in the contaminated soil.

A soil incubation experiment was conducted using a soil contaminated with arsenic (As), lead (Pb) and selenium (Se). Three types of immobilizing amendments used were i) a mixture of iron oxide and calcium sulfate (IC), ii) zeolite, and iii) magnesium oxide (magnesia), and these amendments were admixed with the soils at 3 and 10% w/w. The soils were incubated at a 20% water content at 25 ^{o}C in the dark for up to 30 days (data with longer time series in Poster). A treatment without any amendments (control) was also prepared. Metal solubility in the soil incubated at the 1st (immediately after the addition of amendments) and 30th days was assessed by a water extraction method. Chemical speciation of As in the soils with the amendments (10%) and without amendments after 49 days of incubation was analyzed using As K-edge XAFS.

Water-extractable Pb concentrations in all amended soils at the 1st day decreased below Japanese environmental allowance level of Pb (< 0.01 mg L^{-1}). After 30 days of incubation, water-extractable Pb concentrations in 3% zeolite- and 3 and 10% magnesia-treatments exceeded the allowance level. The Pb concentration of 3% zeolite-amended soil was notably high (0.042 mg L^{-1}). The IC-amended soil decreased water-extractable As below the allowance level of As(< 0.01 mg L^{-1}) at the 30th day of incubation. For zeolite and magnesia, however, water-extractable As at the 30th day was greater than that at the 1st day of incubation. Water-extractable As concentration of 3% zeolite-amended soil at the 1st day was 0.040 mg L^{-1}. At the 30th day of incubation, water-extractable As concentrations in the zeolite- and magnesia-amended soils exceeded the allowance level, regardless of application rates. Water-extractable Se concentrations of the control soil at the 1st and 30th days were less than the allowance level of Se (< 0.01 mg L^{-1}). However, water-extractable Se concentrations of all amended soils at the 30th day exeeded the allowance level. The increase of water-extractable Se concentration by the amendments was in the order of magnesia > zeolite > IC, which corresponded to the ascending order of the pH value of their extracts. The IC was found to be the most effective in immobilization of soil As and Pb among the three tested amendments, whereas none of the amendment could immobilize Se below the allowance levels.

Keywords：*arsenic, lead, selenium, XAFS, iron oxide, zeolite, magnesium oxide*

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[C2.4-1] Mineralogy and Reactivity of Soil Microsites

Solubility of Silver Derived from Nanoparticles and Silver Nitrate in Oxidized and Reduced Soils

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Silver (Ag) nanoparticles (< 100 nm in diameter, AgNPs) have widely been used in industrial and commercial products because of their bactericidal properties. Silver nanoparticles are either deposited directly to land or gradually washed away in household wastewater. The AgNPs similar to Ag^+ are partition to sludge in a wastewater treatment plant, and the sewage sludge may be applied as a land amendment to agricultural fields and urban landscapes. As a consequence, the levels of Ag can increase in soils for a long term application of AgNP containing sludge. However, toxic mechanism and mobility of Ag in the environment remain little known. To understand toxic properties and fate of Ag in soils, the chemical speciation of Ag is the critical information. AgNP (Ag^o) in soils is dissolved via oxidation reaction, indicating that soil redox chemistry plays an important role on determining Ag solubility and speciation. In addition, AgNP is highly reactive because it has a large surface area-to-volume ratio and thereby interacts with soil colloids. The chemical properties of AgNPs in the soil seem to be different from Ag ions, although the details remain unknown. The objective of this study is to investigate the differences in solubility and chemical speciation of Ag derived from Ag compound ($AgNO_3$) and AgNP (Ag^o) under oxidized and reduced soil conditions by extraction and X-ray absorption spectroscopy techniques.

A soil incubation study was conducted using a soil, Udants Hapludants amended with $AgNO_3$ and AgNPs up to the levels of 1000 mg Ag kg^{-1} soil. The soil water content was adjusted to the levels of 43% (oxidized) or 59% (reduced). The redox potential (Eh) and the Ag concentration in the soil solution was periodically measured in the reduced soils. The soil Ag was extracted by the SPLP solution (US EPA, weak-acid solution). The Ag concentrations were determined by flame atomic absorption spectroscopy.

In the reduced soil with $AgNO_3$ additions, the SPLP-extractable Ag decreased from 2 to 0.5 mg L^{-1} in 15 days. The soil solution Ag concentrations of $AgNO_3$ amended soils were 0.057 mg L^{-1} at 15th day. In AgNPs treatments, SPLP-extractable Ag in the reduced soils ranged from 0.01 to 0.02 mg L^{-1} up to 7 days, and it fell below detection limits (< 0.01 mg L^{-1}) at 15th day. The Eh value of soils amended with $AgNO_3$ and AgNPs decreased more slowly than that of the soil without Ag compounds. The soil Eh value decreased to 420 mV in $AgNO_3$ and 30 mV in AgNPs treatments at 15th day. A smaller amount of Ag dissolution in the AgNPs amended soil may result from the reduced soil condition that transformed dissolved Ag to be more stable forms (i.e., Ag_2S). In the oxidized soils, contrarily, the SPLP-extractable Ag concentrations from the $AgNO_3$ amended soils were 2-5 times greater than that of the reduced soils. The SPLP-extractable Ag from the AgNPs amended soil ranged from 0.01 to 0.05 mg L^{-1} during 15 days since the incubation started. Our study found that the dissolved Ag derived from $AgNO_3$ and AgNPs was attenuated more in the reduced condition than in the oxidized condition. The SPLP-Ag concentration decreased with decreasing the soil Eh values and it was below detectable levels at the Eh value of < 200 mV. A strong correlation between SPLP-Ag and Eh values (r = 0.90) for AgNPs and $AgNO_3$ soils suggests that soil's redox potential may be the primary factor controlling Ag solubility and speciation in the soil.

Keywords: *silver, nanoparticles, chemical speciation, redox potential, X-ray absorption spectroscopy*

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[C2.4-1] Mineralogy and Reactivity of Soil Microsites

A Study on Impacts and Mechanism of Mechanical Activation (planetary Milling) of Yichang Phosphate Rock Samples

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Practically all phosphorus (P) fertilizers are originated from phosphate rocks which are naturally occurring sedimentary rocks composed largely of calcium phosphate minerals (apatite). Apatites are stable calcium P minerals, similar to the insoluble calcium phosphates naturally occurring in grassland soils. This paper presents the results of the impacts of mechanical activation (planetary milling process) on chemical, physical and optical properties of phosphate rocks collected from Yichang, China, which are medium to low grade P reserves. We found that planetary milling of Yichang phosphate rock can increase the contents of citric acid soluble P of this P rock. A fifteen minutes milling increased the proportion of citric acid soluble P to total P from 38.1 mg (P〈sub〉2〈/sub〉O〈sb〉5〈/sub〉) kg〈sup〉-1〈/sup〉 in non-activated samples to 134 mg
(P〈sub〉2〈/sub〉O〈sb〉5〈/sub〉) kg〈sup〉-1〈/sup〉. Increase milling time from 15 min to 30 min did not further increase citric acid soluble P level. These changes of citric acid soluble P with milling time can be attribute to the changes of physical and mineral characteristics of phosphate rocks, including decrease in particle sizes, increases in specific surface areas and surface roughness. Crystal lattice structure and lattice ions of phosphate rocks also changed with milling processes; however, how these changes impact the P availability of Yichang phosphate rocks and what is the optimal milling time to maximize the P availability are worth of further study.

Keywords：*Yichange phosphate rocks; mechanical activation; phosphorus availability; physical properties; optic*

P3-353

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Comprehensive Chemical Investigations in the Sopron Wine Region (hungary)

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In this study we present comprehensive chemical analyses carried out in one of the most significant and historical wine-producing regions of Hungary, the Sopron wine region. The total area of the region is 4300 hectares, out of which 1800 hectares are used for grape cultivation. Kékfrankos (Blue Frankish) accounts for 60% of all the plantings, nevertheless other varieties are also grown here (including Zweigelt, Merlot, Cabernet Franc, Portugieser and Sauvignon Blanc). Investigations included the analysis of soil, grape and wine.

As soil is the premanent home of grapevine, its quality is determining for the growth of the plants and of the grape berries. The investigated soil parameters were as follows: humus content, transition, soil structure, compactness, roots, skeletal percent, color, physical assortment, concretion, soil defects.

Laboratory investigations involved pH, carbonated lime content, humus content, ammonium lactate-acetic acid soluble phosphorus and potassium content, potassium chloride soluble calcium- and magnesium content, EDTA and DTPA soluble copper, iron, manganese and zinc content measurements. Thermoanalytical measurements have also been carried out to determine the mineral composition of the soils.

Regarding the composition of grape berries and wine, the concentrations of organic acids (tartaric-, acetic-, succinic-, malic-, lactic acid), methanol, ethanol, glycerine, glucose and fructose have been determined by high performance liquid chromatography (HPLC).

With the presentation of the results the possible relationships between individual parameters will be demonstrated, with a special regard to the composition of soil and grape berries.

Research was supported financially by the „Silva naturalis project (TÁMOP-4.2.2.A-11/1/KONV-2012-0004)".

Keywords：*wine, viticulture, Hungary, chemical and physical parameters, liquid chromatography*

P3-354

[C2.4-3] Minerals as Regulators of Carbon Flow Through Soils

Effect of Change in Throughfall on Soil Respiration under a Temperate Mature Forest, Northeastern China

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A 4-yr field experiment was carried out under a temperate mature Korean pine and broadleaf mixed forest (>200 years old) at the foot of Changbai mountains, northeastern China, to study the effects of changes in throughfall on soil respiration and heterotrophic respiration and soil properties such as microbial biomass carbon (C) and dissolved organic C. The changes in throughfall under such forest canopy included the reduction of 25%, 50% and 100% compared to the control by sheltering PVC sheets, and an addition of 25% by watering during growing seasons from 2009 to 2012. For experimental plots with plus 25% and minus 100% throughfall and the control, trenching was performed to study the changes in soil heterotrophic respiration and soil properties from 2011 to 2012. The rates of soil respiration and heterotrophic respiration in the control ranged from 28.6 to 220.6 and from 28.1 to 143.2 mg CO_2-C m^{-2} h^{-1} during the experimental period, and had a significant seasonal and annual variation. In all experimental plots with three throughfall reduction levels, the rates of soil respiration and heterotrophic respiration ranged from 16.4 to 196.9 and from 19.6 to 88.6 CO_2-C m^{-2} h^{-1} during the experimental period, and average cumulative soil respiration rates during growth seasons each year varied from 270.2 to 416.7 g CO_2-C m^{-2}, which was 7-41% smaller than the rates in the control (448.0 to 451.3 g CO_2-C m^{-2}). The reduction percentile varied with experimental years, with a most reduction in the minus 50% throughfall treatment. Average cumulative soil heterotrophic respiration in the minus 100% throughfall treatment during growth seasons was 248.1 g CO_2-C m^{-2} in 2012, causing a decrease of 26% compared to the control (333.5 g CO_2-C m^{-2}). The rates of soil respiration and heterotrophic respiration in the plus 25% throughfall treatment ranged from 41.5 to 343.4 and from 38.5 to 154.6 mg CO2-C m-2 h-1, respectively, and average cumulative soil respiration rates during growth seasons each year varied from 542.1 to 688.3 g CO_2-C m^{-2}, which was 21-54% larger than the rates in the control. Average cumulative soil heterotrophic respiration in the plus 25% throughfall treatment during growth seasons was 414.7 g CO_2-C m^{-2}in 2012, causing an increase of 25% compared to the control. Together with the changes in soil properties such as microbial biomass C and dissolved organic C, the mechanisms involving soil CO_2 fluxes after disturbances of throughfall were fully discussed. From the results obtained, it can be concluded that the changes in precipitation can to some extent affect the carbon release from soil respiration and heterotrophic respiration into the atmosphere under temperate forests.

Keywords：*Change in throughfall; DOC; Heterotrophic respiration; Microbial biomass; Soil respiration*

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[C2.4-3] Minerals as Regulators of Carbon Flow Through Soils

Influence of Simulated Precipitation on Dryland Soil Respiration in the Loess Plateau, China

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Precipitation event can stimulate soil respiration, the so-called “Birch Effect”, by increasing microbial activity due to increased soil water content. The extent of such effect due to changes in precipitation levels on dryland cropping systems is not well known. We conducted a precipitation simulation experiment in the field to measure the short-term response of precipitation levels (1-32 mm) on soil respiration from 0 to 72 h under winter wheat and fallow in the Loess Plateau of China. Soil respiration increased with increased precipitation levels. Soil respiration peaked in 4 h with 1 to 16 mm of precipitation, but the peak delayed by another 4 h with 32 mm. The pulse intensity of soil respiration rate (Rpi) increased exponentially with increased precipitation (P) (Rpi=1.07P0.09, R2=0.98, P<0.01). Cumulative soil respiration after 72 h (CO2-P) increased linearly with the precipitation level (CO2-P=0.11P+6.04, R2=0.86, P<0.05). The temperature sensitivity of soil respiration (Q10) was correlated binomially with the precipitation level (Q10=-0.0065P2+0.21P+1.18, R2=0.95, P<0.01). Such effects were lower during the wheat growing season than during the fallow period due to wheat root respiration. Higher precipitation levels can delay but increase soil respiration compared to lower precipitation levels, probably by influencing on soil microbial activity. Root respiration during the crop growing season, however, can influence the pattern and amount of soil respiration.

Keywords：*Birch effect, Precipitation event, Precipitation amount, Soil respiration, Carbon dioxide emissions*

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[C2.4-3] Minerals as Regulators of Carbon Flow Through Soils

Temperature and Rhizosphere Interaction Regulates the Dynamics of Inorganic and Organic Carbon in a Limed Acidic Soil

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Lime is a common amendment applied to overcome soil acidification in agricultural production systems. The impact of lime on the dynamics of soil inorganic and organic carbon at varied temperatures in the presence of growing plants remains largely unknown. We monitored the rhizosphere effects of soybean on lime dissolution in an acidic soil (Red Kandosol) in growth chamber experiments conducted at 20°C and 30°C. Treatments consisted of soil only (control), soil + lime, soil + soybean, and soil + lime + soybean. The CO2-C was continuously trapped and collected at 6, 13, 21, 27, 43 and 50 days after planting (DAP). The CO2-C was continuously trapped from the planted treatments starting at 36 DAP and collected at 43 and 50 DAP. Leaching was induced at 29 and 51 DAP, and the leachates were analyzed for dissolved organic carbon (DOC) and inorganic carbon (DIC). The CO2-C flux rates significantly increased ($P<0.01$) with the addition of lime in comparison with the control, across all four treatments at both temperatures. Between 36 and 43 DAP, the largest increase in CO2-C fluxes was observed in the soil + lime + soybean treatment at 30°C. However, between 45 and 50 DAP, the CO2-C fluxes in the soil + lime + soybean treatment were similar to the soil + soybean treatment for 20°C, suggesting that most of the lime had dissolved in the soil + lime + soybean treatment. In contrast, the CO2-C fluxes in the soil + lime + soybean treatment at 30°C remained elevated as compared with the CO2-C fluxes from the soil + soybean treatment. These comparative increased CO2-C fluxes could be an indication of the secondary role of liming at higher temperature. Both DIC and DOC concentrations in the leachates significantly ($P<0.01$) increased with the lime addition and in the presence of growing plants. At 29 DAP, the soil under soybean increased DIC and DOC concentrations in the limed treatments at 30°C, but not at 20°C, highlighting the role of soybean roots on lime dissolution at higher temperature. We conclude that direct temperature effects on plant root growth influence dynamics of inorganic and organic carbon in a limed acidic soil.

Keywords：*Liming; rhizosphere; temperature; carbon fluxes; dissolved inorganic carbon; organic carbon; acidic , soil*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

The Effect of Mycorrhiza Fungi (vam) on Phosphorus Absorption by Corn Plant at Northern Khouzestan, Iran

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In order to understanding of the VAM effects on functions and nutrition of the corn, an experiment was conducted in the research farm at Agricultural Research Center of Safi Abad Khouzestan. The experiment was in randomized complete blocks with four replications. Treatments were Mycorrhiza Fungi and phosphorous, each one at two levels includes (Treatment 1: Phosphorus according to soil test. Treatment 2: VAM+ Phosphorus according to soil test. Treatment 3: Phosphorus according to 65% of soil test. Treatment 4: VAM+ Phosphorus according to 65% of soil test. Treatment 5: Check treatment). The experiment was conducted to determine the amount of absorbed macro and micro nutritious elements in shoot at early growth stage in corn plant. The amounts of absorbed elements in shoot at any of the treatment levels were not different according to the statistical analysis results. The phosphorus content in plant was variable from 0.12 in treatment 5 to 0.18 % in treatment 1. The plant dry matter was variable from 28.60 in treatment 4 to 36.48 gram in treatment 1 and also the yield of fresh plant was variable from 260 in treatment 5 to 320 gram in treatment 2. The treatment caused plant root to be colonized by Mycorrhiza and using phosphorous fertilizer, compared to soil test (check treatment), was the greatest amount of uptake in corn plant.

Keywords：*Fungi, Vizicolar Mycorrhiza Arbuscular (VAM), Corn, Phosphorous*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Effect of Combined Biologic and Priming Seed Treatments on Growth Indices of Nigella Sativa L

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Priming and biologic treatments are effective methods in growth enhancement of medicinal plants. Thus present study was carried out in the greenhouse of Agriculture Faculty, University of Birjand with factorial CRD statistical design in 2011. Factors were 1- Bacteria treatments a: (Pseudomonas sp 168), b: (Pseudomonas sp 187), c: (compose of Pseudomonas sp 168 and Pseudomonas sp 187) and d: (without Bacteria treatment), 2- priming with KH2PO4 (50 mM concentration and without priming). Results showed that bacteria application had increase in shoot fresh weight, dry matter and plant height. Interaction between seed priming and biologic treatments was significantly effective on shoot dry matter. Compose of Pseudomonas sp 168 and Pseudomonas sp 187 caused higher amounts of dry matter when it combined with priming.

Keywords：*medicinal plants, seed treatments, growth indices. Biofertilizer*

P3-359

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Increasing Rate of Decomposition of Sugarcane Bagasse by Decomposer Fungi and Helping Bacteria Azotobacter for Preparation Multipurpose Biological Fertilizer

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In this research Trichoderma harzianum was used as inoculated in composting, the inoculants was termed compost activator. Mixing Trichoderma harzianum as bioactivator with substrates (sugarcane bagasse) reduced composting period from 180 days to 60 days, also effect of inoculation of this fungi on solubilization rock phosphate and increase amount of phosphorus was assessed.Inoculation of fungi increased contents of p in during of composting. Application of sulfur to treatments that inoculated with Trichoderma harzianum fungi, causes increases quantities of sulfate as well as total fungi populations and electrical conductivity but lower pH and total bacteria numbers.

Therefore, sugarcane bagasse mixed with phosphate solubilizing fungi will produce a phosphorus and sulfate rich compost (in case rock phosphate and sulfur are also used) in the shortest time worthy of distribution to serve not only as an organic fertilizer but also as an inoculants as well as can use as bioactivator and controlling agent for fungi diseases.

Keywords：*Trichoderma harzianum, Rate of decomposition and Compost enrichment.*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Utilization of Agricultural Wastes as a Raw Material for Organic Fertilizer Applied on Paddy Rice Planted in an Acid Sulphate Soil

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Acid sulphate soil is an acidic mineral soil resulting in infertility condition, this acidic soil is found in large distribution in South Sumatra, Indonesia with low rice production. The soil is low content of nutrient and organic matter causing farmers should supply fertilizer in large quantity to support plant growth. Due to increasing price of fertilizer, farmers are difficulty to purchace the conventional fertilizer. To overcome this problem, it can be introduced local resources such as agriculrural wastes to supply nutrient for plant growth. Thus, objective of this research is to analyze the nutrition content of agricultural wastes to prepare a solid organic fertilizer in supporting paddy rice growth planted in an acid sulphate soil from South Sumatra, Indonesia. The organic materials analysed were composted rice straw, cow bone powder, cattle slurry, cow blood powder, and ash rice straw, and additional anorganic materials used were natural rock phosphate and zeolite. The results showed that highest content of N, P and K elements derived from organic materials were found in cow blood powder with value of 6.51% N, 1.69% P and 0.125% K respectively followed by cow slurry and humic acid subtances of composted rice straw. Furthermore, zeolite contained K, Ca and Mg amounting to 1.28% K, 3.39 % Ca and 0.85% Mg, whereas rock phosphate has Ca content with value of 20.15% and Mg 2.68%. These materials both organic and anorganic subtances were used as a raw material for preparing organic fertilizer becoming 9 formulas of organic fertilizer and 4 formulas were corresponded to SNI-19-7030-2004 code Indonesian product. The composition of formulas numbered from 6 till 9 combined with mineral fertilizers consisted of 30% Humic Acid (HA) + 30% Conventional Fertilizer (CF = 4N:2P:1K) + 40% Natural Material (NM) (F6), 45% HA + 15% CF + 40% NM (F7), 45% HA + 20% CF + 40% NM, (F8), 45% HA + 30% CF + 25% NM (F9). The reference for N, P and K fertilizers applied were 110 kg N, 47 kg P2O5 and 26 kg K2O/ha respectively. Meanwhile to calculate Ca and Mg contents derived from cow bone to add the organic fertilizer formulation based on the rates of 9 kg MgO/ha and 7 kg CaO/ha. All number of these mineral contents mentioned are expected to achieve the rice production amounting to 7.810 kg/ha. These 4th formulas obtained were tested in pot experiments using acid sulphate soil planted paddy rice. The result showed that formula 9 of organic fertilizer with a dosage of 750 ton/ha provided the best growth of paddy rice and it has significant effect to increase rice production compare to other formulas with highest yield of 14.33 g grain/crop.

Keywords : *Keywords: acid sulphate soil, cow blood and bone powder, organic fertilizer, paddy rice, humic acid*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Research Progress on Usage of Agricultural Wastes in Soilless Growing Medium Production

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Growing medium lays the foundation for the new high-efficiency agriculture, and the access to raw materials with rich nutrients, large quantity and low price is of vital importance for the large scale production of growing medium. In this review, the characteristics of agricultural wastes, and their potential usage for growing medium production were analyzed. The current situation for research of growing medium formula with agricultural wastes such as crop straw, mushroom spent, livestock excrements, coconut fibre, etc was introduced. The problems that constrained the development of large scale production of growing medium with agricultural wastes were pointed out., and the solutions for the problems and development prospect were summarized.

Keywords：*growing medium, crop straw, mushroom spent, livestock excrement, coconut fibre*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Activity of Urease, Phosphatase and Dehydrogenase in Submerged Soil under Integrated Nutrient Management with Transplanted Rice

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Field experiment was conducted during rainy season of 2009 and 2010 to investigate the effect of integrated nutrient management practices involving the conjunctive use of vermicompost obtained from different organic residues and chemical fertilizers on the activity of urease, acid and alkaline Phosphatase and Dehydrogenase. The enzymes chosen for this study were selected based on their role in soil fertility. The treatments consisted of the application of 100% recommended dose of nitrogen through inorganic fertilizers, 100% recommended dose of nitrogen through vermicompost and a combination of vermicompost and chemical fertilizers. The experiment was laid out in a randomized block design with 12 treatments. The soil samples were assayed for the activity of urease, acid and alkaline Phosphatase and Dehydrogenase at 30, 60, 90 DAT and at harvest. The results indicated a consistent increase in the activity of these enzymes up to 60 days and later sharply declined to original levels at harvest. The treatments receiving the integrated use of vermicompost in combination with fertilizers resulted in significantly higher enzyme activities as compared to chemical fertilizers alone. Significantly highest activity of urease (9.69 mgNH_4^+ released/5 g soil/2 hr), acid phosphatase (164 µgPNP released/g soil/hr) and alkaline phosphatase (202 µgPNP released/g soil/hr) was recorded during flowering stage of the crop in the plots which received 75 % chemical fertilizers + vegetable market waste compost @ 2.5 t/ha. There was a 10 to 15 fold increase in the activity of urease, phosphatase and 20 to 25 fold increase in the activity of dehydrogenase in submerged rice soils as compared with the control with out rice crop and incubated under laboratory conditions. This indicates predominance of facultative anaerobic micro organisms as compared to the aerobic microbes under upland conditions. Further the rice roots are also able to secret certain enzymes which also act on the decomposing organic matter. The results indicated the significant influence of combined application of vermin compost and inorganic fertilizers in increasing the enzyme activity and intern resulting in realizing higher grain and straw yields during both the years of study.

Keywords：*rice, soil enzymes, INM etc.,*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Effects of Calcium on Copper Rhizotoxicity to and Accumulation in Grapevines in Solution Culture

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Intensive and long-term application of copper (Cu)-containing fungicides in vine-growing areas has led to the accumulation of Cu in some vineyard soils around the world, thus posing the problems of Cu toxicity to the organisms therein. Recently, a number of studies have found that some cations, such as calcium (Ca) and magnesium (Mg), may alleviate the rhizotoxicity of Cu to plants. In this study, a 15-day hydroponic experiment was conducted to determine the influence of Ca concentration on the growth inhibition effects of Cu to grapevine (Vitis vinifera L. var. Kyoho) roots. The accumulation and translocation of Ca and Cu in the plants were also observed. Results of the present study indicated that a Ca concentration of 10 mM was able to significantly alleviate rhizotoxicity caused by Cu, both from root elongation and biomass perspectives. An increase of Ca from 0.5 to 10 mM enhanced accumulation of Cu in roots at lower solution Cu levels (1 and 2.5 μM); however, the enhancement effect was not significant at Cu concentration ≥ 5 μM. On the other hand, an increase of Ca from 0.5 to 5 mM reduced Cu translocation; however, the Cu translocation was increased with increasing Ca concentration from 5 to 10 mM. The results suggested that a background Ca level as high as 10 mM could ameliorate Cu rhizotoxicity by accelerating Cu translocation from roots to leaves in grapevines.

Keywords：*calcium, copper, grapevine, rhizotoxicity*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Chemical Mechanism of Potassium Release from Soil as Influenced by Root Exudates

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The availability of potassium in calcareous cinnamon soil is low for plants. It is significantly different in ability to enhance the potassium content (plant-available K) in soils of root exudates from plants of different species or genotypes. However, the mechanism underlying the phenomenon that root exudates release potassium is not fully understood. The present study is undertaken to analyze the components of root exudates and the ability to release potassium from soil. Moreover, the chemical model in which organic acid is resolved into H-ions and organic ligands is set for exploring possible mechanism and factors involved in releasing potassium from soil by root exudates.

Plant sample was flue-cured tobacco (Nicotiana tabacum L.)NC89. Root exudates were collected by putting 10-leaves seedlings in water for 6h in light and concentrated on rotary evaporator. By using GC-MC analysis, there were 27 components in root exudates, in which 80% of these were organic acids.

After adding 3g root exudates inspissations or 3g pure water to 2g dry soil, the soil samples were cultured under constant temperature environment for 10 days. The measured available potassium in test group was 155.2 ㎎/㎏, which increase by 57.7% compared with control (pure water, 98.4 ㎎/㎏). It showed that root exudates can release potassium from soil significantly.

Based on the molecular structure of organic acids, we analyzed the mechanism by chemical simulation. Additives were inorganic acid, organic acids, organic acid salts, inorganic acid with organic acid salts and pure water (control). After culturing the soil samples under constant temperature environment for 25 days, we measured the rapidly and slowly available potassium. In results, the activation effect with various treatments was significantly different.

Acidifying soil with inorganic acid and complexing soil with different kinds of organic acid salts can both increase available potassium. Through adding organic acids, we found that available potassium increase significantly when soil samples were acidified and complexed at the same time instead of single method, suggesting that there exists synergetic effect between acidification and complexation. However, there is difference in action effect among various organic acids, which mainly depends on the acidity coefficient. There was no difference in adding order between acidification and complexation under the same adding concentration, while soil releases the most available potassium when complexing followed by acidifying with higher consistency.

In summary, the process of potassium releases from soil is a sustained process which constituted by the following parts: complexing by organic ligands firstly and then replacing potassium in mineral lattice through acidifying and dissolving by H ions.This conclusion explains why the effect to release potassium in different species or genotypes is disparate. Increasing the quantity of organic matter which can complex soil in root exudates can significantly improve the availability of potassium in soil.

Keywords：*potassium release, root exudates, chemical simulation*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Improving Nutrient Use Efficiency and Yield of Canola in Eastern Canada

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While canola is not a major field crop, there is a market demand for growing this crop and an urgent need to develop nutrient best management practices for expanding canola production in eastern Canada. A field experiment was conducted at 16 sites-years across eastern Canada to investigate nitrogen (N) uptake, yield and quality traits of canola crop to preplant and sidedress application of N fertilizer at various combinations with soil applied sulphur (S), and soil and foliar applied boron (B). Canola yields were highly dependent on weather, soil N and S fertility, and more responsive to split N application than preplant application. For every kg N ha-1 fertilizer, yields increased on average by 9.7 kg ha-1 for preplant application, but increased by 13.7 kg ha-1 with split application. Nitrogen concentrations in plant and seed components increased ($P < 0.01$) with increasing amounts of N application especially for plants received sidedressed N. Preplant S at 20 kg ha-1 as ammonium sulphate significantly increased yields over plots that received no S in majority of the 16 sites-years. There appeared to be a yield advantage when B was applied foliarly at the 20% flowering stage. Under drought conditions, plant straw at harvest contained much higher N concentrations (10-15 g kg-1) than plants that were grown under more or less normal conditions (3-5 g kg-1), indicating N remobilization under drought conditions was restricted. Our data suggests that with appropriate management, it is possible to improve yield and nutrient use efficiency of canola crop concurrently in eastern Canada.

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Effect of Nitrate Influx and Efflux on Nitrate Accumulation in Lettuce and Spinach

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Most plants absorb nitrate in excess of their demand, especially if the nitrate concentration of the plant growth medium is relatively high. On the other hand leafy vegetables play a crucial role in human dietary. Excessive application of nitrogen fertilizer can lead to accumulation of high levels of nitrate in the tissues and cause further consequence. Studies have reported large variations of nitrate accumulation among plant species, however the reasons for these differences are not well established. In order to investigate the effect nitrate influx and efflux on nitrate accumulation in leafy vegetables, two harvest times (29 and 46 days after transplanting) and two plants of lettuce and spinach in two concentration of zinc (7 and 50 $\mu g.\ell^{-1}$) were used in hydroponic greenhouse experiment with a completely randomized design with 3 replicates. Modified Hoagland and Arnon nutrient solution were used for the experiment, nitrate as nitrogen source (concentration of 20 $mmol.\ell^{-1}$) from calcium nitrate and potassium nitrate and zinc from zinc sulphate supplied. The results indicated that by increasing zinc concentration in solution, nitrate influx rate for lettuce decreased from 136×10^{-6} to 91×10^{-6} $\mu mol.cm^{-1}.s^{-1}$. Net nitrate uptake in the shoot was also reduced. The same trend was observed for the nitrate efflux rate as well, changing from 110×10^{-6} to 79×10^{-6} $\mu mol.\ cm^{-1}.\ s^{-1}$. However in spinach, cumulative nitrate influx increased from 0.17 to 0.99 mol. g^{-1} shoot dry weight, and cumulative nitrate efflux changed from 0.15 to 0.80 mol. g^{-1} shoot dry weigh. Since the increase of nitrate influx occurred with a greater slope as compared to its efflux, an increase in net uptake of nitrate was observed. Results also showed the concentration of organic nitrogen in the shoots of both plants increased as zinc concentration in the nutrient solution increased. It seems that accumulation of nitrate is determined by the equilibrium between infux and efflux of nitrate. However, nitrate accumulation may be governed by nitrate efflux. The results above suggested that infux flow is dominant factor in the accumulation of nitrate in lettuce and spinach and plays a major role in controlling the concentration of nitrate in these vegetables.

Keywords：*words: Influx, Efflux, Nitrate Accumulation, Lactuca sativa L., Spinacia oleracea L.*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Nutrient Availability in Rice Rhizosphere under Conventional and Drip Irrigation with Film Mulch Cultivation

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Rice planted under drip irrigation with film mulch has been proved a huge potential for high yield and water-saving, but the soil nutrient status of the cultivation is poorly known. This study focus on the availability of N, P, K, Zn, Mn in rhizosphere and bulk soil of rice planted in conventional flooding irrigation pattern and drip irrigation with film mulch pattern, respectively. Two cultivation methods (conventional flooding irrigation (FI) and drip irrigation with film mulch (DI)) and two sampling positions (bulk soil (BS), rhizosphere soil (RS)) were designed in the study. Rice genotype T-04 (Oryza sativa L T-04.) that adopted to DI was used in this study. Soil samples were taken at four growth periods (Tillering stage, Jointing stage, Full heading and Grain filling stage), respectively. Compared to the available nutrition concentration in FI, NH4+ and exchangeable Mn in DI were reduced, Olsen P was stable, but NO3-, available K, available Zn and easily reduced Mn were enhanced. On the other hand, the NH4+, available K and exchangeable Mn depleted in RS, in contrast, NO3- and Zn enriched in RS, available P and easily reduced Mn in RS were approximately equal to BS in most of growth stages. Our results indicated that irrigation methods shift from FI to DI was beneficial for soil nutrient availability and rice production.

Keywords：*Nutrient availability, rice, drip irrigation with film mulch, flooding irrigation, rhizosphere, bulk*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Potassium Management of Fen Soils with the Habitant Type 6510

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In the Dromling Nature Park there is a trade-off between the European Union ban on deteriorating fauna flora habitat type (HT) 6510 (lowland hay meadows) and rewetting areas to preserve typical fen soils. This study was conducted to develop optimized land management strategies for HT 6510, which had an area of 586 hectares in the nature park Dromling. The results contribute to the preservation of HT 6510 in its conservation status and could be applied on 157.000 hectares of HT 6510 in Germany. An in situ experiment was established at two test fields, each comprised of different fertilization levels under differentiated hydrological conditions. Soil and plant biomass were analyzed for their content of macronutrients. The results showed that the sites' were well supplied with plant available soil nitrogen but both phosphorus and potassium (K) were HT 6510 limiting conservation factors. X-ray diffraction showed with increased soil depth, increased illite contents. This indicates a strong weathering of clay minerals due to continued potassium deficiency. The application of potash 60 improved the quality parameter of soil and plant biomass.

Keywords：*fen soils, potassium management, rewetting, conservation*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Techniques for Enhancing Fertilizer Use Efficiency in Sugarcane

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Sugarcane, being a long duration and huge biomass producing crop removes substantial amount of plant nutrients from the soil. Earlier reports revealed that a crop of 100 t ha^{-1} exhausts 208 kg N, 53 kg P and 280 kg K. High nutritional requirement, unscientific applications, nutrient leaching losses nutrient fixation in soil, depleted soils and spiraling fertilizer prices are the main constraints in sugarcane agriculture. Therefore, increasing use efficiency of applied fertilizers is foremost important in nutrient management. The techniques of fertigation, placement of fertilizer briquettes at root zone, sett treatment of Glucanoacetobacter diazotrophicus and soil application of phosphate solublizing bioinoculants (PSB) has been reported to increase nutrient availability and fertilizer use efficiency. It has also been reported 25% saving in recommended dose of fertilizers (RDF) due to placement of NPK briquettes and 25 to 50% reduction in recommended dose of N & P due to treatment of Glucanoacetobacter diazotrophicus and Phosphate solublising bioinoculant in sugarcane. Field experiments were conducted with the aim to develop an integrated package of different techniques for enhancing fertilizer use efficiency and minimizing use of chemical fertilizers in sugarcane. In first experiment the usefulness of specially formulated NPK-I (N:P2O5:K2O-13.6:23:24), NPK-II (N:P2O5:K2O – 28:13:12) and Urea Sulfur (USB) Briquettes (39% N) coupled with Glucanoacetobacter diazotrophicus bioinoculant were evaluated in sugarcane. The results revealed that fertilizer dose can be minimized by 50% through integration of FYM @ 20 t ha^{-1}, sett treatment of Glucanoacetobacter diazotrophicus @ 3 lit/ha 200 lit of water ha^{-1}, phosphate solublising culture @ 2.5 lit ha^{-1} mixing with FYM at planting and soil application of 50 % RDF in the vicinity of root zone through NPK-I briquettes at planting (NPK 10:50:50 % RDF), 45% RDN through USB briquettes at 45 days after planting and NPK-II briquettes at earthing up (NPK 45:50:50 % RDF). Under this package with 50% NPK, cane yield was increased by 5.35 % over 100% RDF applied through conventional fertilizers viz. urea, DAP and MOP. The increased cane yield even after 50% reduction in RDF is mainly contributed by enhanced plant population and cane height which was due to slow release of nutrients from fertilizer briquettes and their proper placement. Minimized leaching and volatization losses, synergistic effect of Nitrogen and Sulfur, atmospheric Nitrogen fixation by Glucanoacetobacter and increased Phosphate availability in soil due to PSB culture collectively fulfilled the nutritional requirement of crop. In another experiment package of fertigation technique, foliar application of Glucanoacetobacter diazotrophicus liquid bioinoculant and multinutrient liquid fertilizer containing macro (NPK-8:8:8) and micronutrients (Fe2.5%, Mn1.0%, Zn3%, Cu1.0%, Mo0.1% and B0.5%) was examined and the integrated package of 50 % RDF applied by fertigation technique in conjunction with foliar application of Glu:canoacetobacter diazotrophicus @ 3.0 lit ha^{-1} and foliar application of 1% multinutrient liquid fertilizers increased cane yield by 23.94% . The results showed 50% saving in recommended dose of chemical fertilizers due to increased fertilizer use efficiency under fertigation and supplements of nutrients by Glucanoacetobacter and foliar application of multinutrients. The techniques of fertilizer briquette placement at root zone, fertigation through drip and foliar application of multinutrients in conjunction with N – fixing and P solublizing microbial bioinoculants found efficient and economical package for maximum utilization of applied fertilizers and sugarcane production.

Keywords：*Nutrient use efficiency, Fertilizer briquettes, Fertigation, Glucanoacetobacter,*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Integration of Chemical and Biofertilizers Improved the Availability of Nitrogen and Phosphorus in Soil but Did Not Influence the Growth of Young Natural Rubber Plants

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The highly weathered acid soils of South India subjected to continuous cultivation of natural rubber (Hevea brasiliensis) have medium to high organic matter status. This is largely attributed to luxuriant growth of leguminous cover crop planted along with rubber which cover the inter row area completely by the second year and lasts for four to five years till the canopy of the rubber closes. Large amount of organic residues and root exudates are incorporated to the rhizosphere from the cover crop in addition to the proven advantages of soil moisture conservation,nitrogen fixation, prevention of weed growth etc. Build- up of phosphorus was recorded in these soils due to the regular application of phosphorus fertilizer. However, imbalance in nutrient availability and declining soil fertility is observed in recent years. Our hypothesis was that integration of chemical fertilizers with nitrogen fixers, phosphorus solubilizers and plant growth promoting rhizobacteria (PGPR) will improve the availability and uptake of nutrients and thus improve the growth of plants,with the added advantage of reducing the use of chemical fertilizers and sustaining soil health.

Field experiment with young natural rubber plants was conducted at two locations ,for four years. The organic carbon status of the two locations were different. The first location had high and the second location had medium organic carbon content. The experiment was laid out in randomised block design with three replications and the treatments were graded levels of nitrogen and phosphorus in combination with bio- inoculants, bio-inoculants alone,chemical fertilizer alone(as per the general recommendation for natural rubber) and a no fertilizer control. Nitrogen and phosphorus treatments along with common dose of potassium and magnesium as per the general recommendation were applied in the forms of urea, rock phosphate,muriate of potash and magnesium sulphate respectively, once during September in the first year of planting and during June and September from second year onwards. The bio-inoculants were isolates of Azotobacter sp.,Phosphobacteria (Bacillus sp.),PGPR (Pseudomonas sp.)isolated from rubber rhizosphere by Rubber Research Institute of India and arbuscular mycorhizal fungus (AMF) from The Energy and Resources Institute,New Delhi. Twenty gram each of lignite based preparation of Azotobacter, Phosphobacteria and Pseudomonas having 10^8 cells g^{-1} and five gram of AMF having 200 propagules g^{-1} were applied at the time of planting during the first year and twice during the subsequent years with a gap of twenty one days between the chemical fertilizer application and the bio-inoculant application. Luxuriant growth of leguminous cover crop was maintained in the inter row areas of rubber in every treatment.

Growth of the rubber plants recorded at periodical interval did not show significant difference between the treatments indicating lack of response of rubber plants to applied nutrients. However,analysis of soil samples for nitrogen availability indicated the influence of treatments on nitrogen transformation in the soil and differential response was recorded between the locations. The inorganic nitrogen in the soil, especially the ammoniacal nitrogen was improved by biofertilizer treatments either alone or in combination with chemical fertilizers. The beneficial effect of phosphorus solubilizers on phosphorus transformation was indicated through the significant difference in the phosphorus fractions, especially Fe-P fraction. Differential response was recorded between

locations on the major phosphorus fractions. The positive effect was more pronounced in location one where the organic carbon status of the soil was high. The influence of fertilizer phosphorus was directly reflected on the Ca-P fraction. Nitrogen concentration in the leaves was high in treatments where nitrogen fertilizer was applied in combination with bio-inoculants, and also the application of bio-inoculants alone indicating the beneficial effect of bio-inoculants especially nitrogen fixers and PGPRs in improving the nitrogen availability and assimilation and maintaining a high leaf tissue nitrogen status. Yet this did not lead to any improvement in growth compared to the other treatments.

Better understanding of the nutrient dynamics, having continuous uptake ,even from the deeper layers of the soil and from the slowly available inorganic fractions and organic forms is required to explain the soil test crop response correlations in a perennial crop like natural rubber

Keywords：*Inorganic nitrogen,phosphorus fractions,Phosphorus solubilizers,Nitrogen fixers, Rubber (, Hevea brasiliensis)*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Burkholderia Kururiensis as an Important Root-Associating, Diazotrophic Bacterium for a Highly Productive Cross-Hybrid Rice Cultivated in Unfertilized Paddock

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Background: We investigated the characteristics of root bacteria from a line of cross-hybrid paddy (*Oryza longistaminata* × *O. sativa* subsp. *japonica* cv T65 to be backcrossed with *O. sativa*) in an experimental paddock at the Institute of Plant Science and Resources, Okayama University. This experimental paddock was left unfertilized for over 20 years and no aboveground products was applied to the field for ten years. Since this line of the hybrid rice maintained its productivity even in the unfertilized paddock, we hypothesized that symbioses between rice and some soil bacteria highly associated with roots of the hybrid rice are involved in the survival strategy of the rice together with functional free-living diazotrophs. Hence, we initiated this study to investigate the unique root-associating and/or soil bacteria apparent on denaturant gradient gel electrophoresis (DGGE).

Materials and Methods: Together with reference rice varieties Norin 18-Go and Taichu 65-Go (T65), the roots of the cross-hybrid paddy line were collected at the transplanting stage (1 week after paddy transplanting, in early July), booting stage (in mid-August), and harvest stage (in late September) during paddy rice cultivation in 2013. In parallel, the bacterial compositions of soils from the unfertilized and fertilized paddocks unaffected by the rice roots seemed to be significant to characterize the soil eubacterial community. To follow microbial succession in the soil and rhizosphere of three paddy varieties, including the cross-hybrid rice, we collected the paddock soils, rhizosphere soils, and living roots. DNA from the soil was extracted using Isoil®. In the recovery of DNA from the roots, rhizosphere soils on the surface of the root tissues were initially washed out and removed from the rice roots by spraying with clean water. The resulting root tissues were placed in a 10-ml Falcon tube that contained 1 ml TE buffer and the root tissues were crushed with a sterilized stainless steel spatula. Only the turbid liquids were recovered with a micropipette, transferred to a 1.5-ml Eppendorf tube, and the bacterial cell-like suspended matter in the liquid was collected by brief spinning. The precipitates at the bottom were then subjected to DNA extraction using Isoplant II® for DNA extraction kit for bacteria. The DNA samples thus obtained were further subjected to 16S rRNA gene-targeted PCR-DGGE analysis.

Results and Discussion: Throughout the cultivation period, the bacterial composition of the fertilized and non-fertilized soils showed a marked change in DGGE patterns despite the fact that the eubacterial composition from the roots of rice was markedly different, particularly in the boot stage. Common and unique root bacterial compositions of the cross-hybrid rice grown in the unfertilized paddock were identified by sequence determination of the DGGE bands followed by the homology search on the NCBI DNA database. One unique eubacterium found from the roots of the hybrid rice was *Burkholderia kururiensis*, an important rice root endophyte that provides fixed nitrogen to the host rice plants. This finding suggests one possible explanation as to why the cross-hybrid rice can maintain high productivity in the continuously unfertilized experimental paddock. Some important endophytic and/or epiphytic bacteria, functional as members of potent nitrogen-fixing consortium, acquire the nitrogen-fixing niche in the unfertilized paddock. Furthermore, *Oryza longistaminata* and *O. sativa* subsp. *japonica* cv T65 hybrid rice may attract these nitrogen-fixing bacteria, including *B. kururiensis*, with specified secondary metabolites among the rice varieties.

Keywords：*unfertilized paddock soil, cross-hybrid rice, symbiotic diazotroph, Burkholderia kururiensis*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Rock Phosphate Enriched Compost Vis-A-Vis Mineral Fertilization: Effect on Soil Chemical and Biological Properties

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Management and recycling of farm wastes into value added enriched organic fertilizers could serve as the potential source of nutrients essential for plant growth. The use of diverse organic sources is becoming popular these days and compost has become an important component in the integrated use of plant nutrients. However, traditional composts prepared from farm wastes have low nutrient content particularly P and this nutrient need to be enriched by some means. Addition of low-grade rock phosphate (RP) in the composting pit with diverse crop residues is one such alternative means. The aim of the present study was to see the performances of RP-enriched compost vis-a-vis mineral fertilizers and to evaluate the impact by assessing the changes in chemical and biological properties at the end of third cropping cycle under a wheat-green gram crop rotation. The present field experiment was continued for three years from 2009-2010 to 2012-2013 at the experimental research farm, Indian Agricultural Research Institute, New Delhi, India. Soil samples (0-15 cm depth) from each plot were collected at the end of 3rd cropping cycle after the harvest of wheat and green gram analyzed for chemical and biological parameters. Enriched compost prepared had higher chemical (total P, K, Ca, Mg and micronutrients) as well as biological properties (microbial biomass C, dehydrogenase and phosphatase activity) than ordinary compost. The present study demonstrated that total C content decreased, while total N content increased during composting process in ordinary as well as RP-enriched compost. Addition of low-grade RP to crop residues during composting helps to increase total P content from 0.85% (ordinary compost) to 2.39% (RP-enriched compost). As far as bioavailable P is concerned, RP-enriched products had less water soluble P than ordinary compost. However, a substantial improvement in citrate soluble P content in enriched compost was noticed compared to ordinary compost. Data emanated from the field study revealed that the soil organic carbon (SOC) was found to be significant in treatments receiving 50% NPK+enriched compost. While, available P was significantly higher in 50% NPK+enriched compost. It is evident that the available N, K and S improved significantly in all the fertilized plots receiving RP-enriched composts and mineral fertilizers either alone or in combination than that of unfertilized control plot. Sequential P fractionation results revealed that all the inorganic fractions were higher in treatment receiving integrated use of 50% NPK+enriched compost and lowest in the control plot. The Ca-P was found to be in higher quantity than other fractions of P. Significant increase in CaCl2-S, inorganic-S and organic-S in soil were maintained in treatments receiving enriched compost after both the crops. Soil microbial biomass carbon increased significantly in treatments receiving enriched compost applied either alone or in combination with 50% NPK compared to unfertilized control and 100% NPK. Similarly, soil microbial biomass N and microbial biomass P followed the same trends where 50% of NPK+enriched compost resulted in highest values while lowest amount was found in control. Significantly highest qCO2 in the treatment where 100% recommended doses of NPK was applied and the lowest amount was observed in the control plot. The enzyme dehydrogenase was found to have significant effect in treatment 50% of NPK+ enriched compost and lowest dehydrogenase activity was observed in control plot. The fluorescein diacetate activity was found to be significantly different between the treatments and the similar trend

was also observed in the enzyme urease and significantly higher in treatment 50% of NPK+ enriched compost than the other treatments. Alkaline phosphatase was found to be significantly higher in 50% of NPK+ enriched compost and the lowest in control. But acid phosphatase failed to show the significant effect among the fertilized plots but these treatments were significantly higher than control. The alkaline phosphatase was found to be higher than the acid phosphatase in all the treatments under study. The basal respiration was found to be insignificant between the fertilized plots but significantly lower basal respiration was found in control plot. The result clearly demonstrated that enriched compost could be an alternative option for sustainable management of agricultural wastes and a potential avenue for utilization of low-grade rock phosphate into a value added organic product for sustainable crop production and maintaining soil fertility.

Keywords：*Rock phosphate, enriched compost, fertilization, available nutrients, soil enzyme activities*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Influence of Diazotrophic Bacterial Inoculation in Combination with Nitrogen on Growth, Biomass Production, Yield and Nutrient Concentration of Rice

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One each of laboratory and pot experiment were conducted during 2011-2012 cropping season at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh to characterize eight diazotrophic bacterial isolate/strains and to find out the potentiality of the diazotrophs on growth, biomass production, grain yield and nutrient concentration of rice (var. BR 33). Six promising diazotrophic isolates viz. BSMRAU 1005, BSMRAU 2005, BSMRAU 3004, BSMRAU 6001, BSMRAU 7001 and BSMRAU 7002 and two strains viz. Klebsiella pneumonia and Azospirillum brasilense were used in the experiments. The laboratory experiment was conducted to assess biochemical properties of the isolates/strains. The pot experiment was conducted to observe the effect of diazotrophic bacterial inoculation in combination with nitrogen using solar sterilized soil on growth, biomass production, grain yield and nutrient concentration of rice. The experiment was conducted using Completely Randomized Design with sixteen replications. Data were collected from four replications at tiller initiation stage and from another four replications at panicle initiation stage. To collect data on various growth parameters, biomass, grain yield and nutrient concentration the crop was finally harvested at maturity from the remaining eight replications. Results revealed that all the diazotrophs showed nitrogenage activity, negative Gram reaction, positive KOH reaction and cellulose degradation activity and produced IAA. Rhizobium isolates viz. BSMRAU 1005, BSMRAU 2005 and BSMRAU 3004 with 50% recommended dose of nitrogen performed better in respect of growth parameters, biomass, grain yield and nutrient concentration of rice compared to other diazotrophic isolates/strains. Significantly higher number of tiller plant-1, leaf greenness (SPAD value), leaf area index, plant height, root length, root volume and dry matter yield were obtained with the inoculation of isolate BSMRAU 2005 along with 50% recommended dose of nitrogen followed by BSMRAU 1005 in the presence of 50% recommended dose of nitrogen at tillering stage. At panicle initiation stage BSMRAU 1005 along with 50% recommended dose of nitrogen performed better in all the parameters as found in tillering stage. The effect of this treatment was followed by 100% recommended dose of nitrogen. At maturity stage BSMRAU 1005 also performed better regarding growth, biomass production, grain yield and nutrient concentration than other diazotrophs. The highest number of tiller, plant height, root length, root volume, number of panicle hill-1, dry matter and grain yields hill-1 were obtained from the treatment receiving BSMRAU 1005 along with 50% recommended dose of nitrogen. Nutrients viz. N, P, K, S and Zn concentrations in rice leaf also increased with the inoculation of BSMRAU 1005. Isolate BSMRAU 1005 in presence of 50% recommended dose of nitrogen increased dry matter hill-1 by 25.71, 8.15 and 6.27 percent and grain yield hill-1 by 46.13, 20.60 and 2.51 percent over the treatments receiving 50%, 75% and 100% recommended dose of nitrogen, respectively. It may be concluded that inoculation of Rhizobium isolate BSMRAU 1005 along with 50% nitrogen enhanced plant height, biomass, root attributes namely root volume and length, grain yield and nutrient concentration of rice under pot culture condition.

Keywords：*diazotrophic bacteria, nitrogen, growth, biomass, yield, nutrient, rice*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Modelling of Nutrients Release from Water-Borne Polymer Coated Controlled Release Fertilizers

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A new model of nutrients release from water-borne polymer coated controlled release fertilizers (CRFs) has been developed considering the situation of swelling pellet. Experiments of urea release were performed with single granule and population granules, and the water permeability and effective diffusion coefficient were modeled and validated. The results demonstrated that the diffusion coefficient of the swelling coating showed steeply decreased in the first two days followed by remaining a stable value, the stable diffusion coefficient was defined as effective diffusion coefficient, and the effective diffusion coefficient was used to the modeling of nutrient release; the radius of fertilizer pellet was found to be linearly related with time, and it was theoretically deduced that the nutrient release was the function of radius of fertilizer pellet; the model achieved satisfied predication of urea release from single pellet, and the predicted error was less than 5.5%; however, the prediction indicated large deviation for population pellets because of high transfer resistance.

Keywords：*Controlled-release fertilizers, Water-borne, Swelling*

P3-375

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Long-Term Effects of Chemical Fertilizer and Recycled Manure on Soil Chemical and Biological Properties

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This study was conducted to examine the soil chemical and biological properties in responses to fertilization regimes and environmental factors on an Alfisol in northeastern China, based on a consecutive 18-year field trial. Fertilization regimes included control (CK), chemical fertilizer (NPK treatment), recycled manure (M treatment), incorporation of chemical fertilizer and recycled manure (NPKM treatment), and soil samples were collected once every year after crop harvest. The results showed that 19 years' continuous fertilization significantly affected all the soil chemical and biological properties ($P<0.001$), except for TOC (total organic carbon)/TN (total nitrogen). Application of recycled manure (M treatment) significantly increased soil TOC, TN and AN (alkaline hydrolysable nitrogen) compared with chemical fertilize alone (NPK treatment), while chemical fertilizer significantly enhanced IN (inorganic nitrogen), AP (available P) and AK (available K). The long-term chemical fertilizer significantly reduced soil pH, especially in cooperation with recycled manure. Recycled manure application increased MBC (microbial biomass C), MBN (microbial biomass N) and MBC/MBN greatly ($P<0.001$), while the effect of chemical fertilizer on biological index was absolutely low compared with soil receiving recycled manure. All the soil biological properties (MBC, MBN and MBC/MBN) were significantly and positively correlated with TOC, TN and AN. In addition, AN showed the strongest correlation with MBC and MBC/MBN, while MBN correlated highly with TOC. Considering AN was more sensitive to environmental factors than TOC and TN, we suggested that, as the most influential factor relating to the microbial community, AN should be used as a reliable indicator of the soil microbial properties.

Keywords：*fertilization; soil biological properties; alkaline hydrolysable nitrogen*

P3-376

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Impact of Tillage and Crop Residues Restitution on Phosphorus Distribution within Topsoil in Loamy Soils of Wallonia (belgium)

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World reserves of mineral phosphorus (P) are limited and non-renewable at human scale. The disappearance of phosphate rock of high quality is expected in the coming decades (Cordell et al., 2009). Recently Renneson et al. (2013) showed that the reserves of total phosphorus in soils of Wallonia (Ptot) were high (904 mg P/kg on average in the topsoil). However only a small part of Ptot is available for plant nutrition (9% of Ptot - 71.6 mg P/kg) due to a high soil P sorption capacity (Renneson et al., 2013). There is an imperative need to re-mobilize phosphorus already present in soil without further increasing P inputs. To achieve this, a better exploration and an improved use of soil resources in agroecosystems are required (Cassman, 1999). In that context, this research studied the influence of tillage and crop residues restitution on P distribution within topsoil.

The experiment has taken place since autumn 2008 in Gembloux (Wallonia) where soils are representative of the most widespread cultivated soils of Belgium (WRB: Luvisol). Field is divided into 16 plots distributed over 4 modalities: Tillage (ploughing within 25 cm depth) without residues restitution (T OUT); Tillage with residues incorporation (T IN); No-tillage without residues (NT OUT); and No-tillage with residues (NT IN). No P fertilizers were added since 2008. Samples were taken from all plots at 30 cm depth with a tubular auger twice a year (autumn and spring) since autumn 2011. Samples were divided into three parts: 0-10, 10-20 and 20-30 cm. They were sieved at 8mm for water-soluble extractions, then dried and sieved at 2mm for other analyses. Phosphorus, calcium and magnesium contents were obtained using water extraction (Pw, Caw and Mgw) and ammonium acetate-EDTA extraction (PNH4, CaNH4, MgNH4).

The results show that tillage treatments mainly influence the spatial distribution of Pw within soil profile. Under NT practices, a higher Pw content occurred at the soil surface and decreased with depth while it was quite homogenous under till soil. Caw and Mgw presented higher contents in soil surface regardless tillage treatments. Pw content was significantly higher under NT IN than NT OUT from spring 2013 proving an effect of crop residues restitution. Actually the crop residues left on field decomposed and constitute a source of P (Ulén, 1997). However no significant increase under T IN could be observed compared to T OUT. Results also revealed a negative correlation between PNH4 and CaNH4 as well as between Pw and Mgw. The latter information coincides with observations of Genot et al. (2012). They showed that the Mg content in Walloon soils was increasing and suspected risks of P immobilization. Further researches are planned about the effect of Mg fertilization on soil P dynamics.

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Keywords：*soil phosphorus availability, tillage, crop residues restitution*

P3-377

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Phosphorous Uptake via Am Fungi from Phytate in Organic Matter: Possible Involvement of Phytate Degrading Bacteria

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Phytate is one of major organic P compounds in soil. Phytate in plant residues and its decomposition may be one of important P flows in P cycling in soil-plant system. It is well known that arbuscular mycorrhizal (AM) fungi absorb inorganic phosphate from soil and supply it to plant. However, AM fungi lack extracellular phytase. It is not well documented how AM fungi contribute to P flows from phytate in organic matter to plant. Recently, AM fungi may enhance decomposition of organic matter in soil by stimulating saprotrophs and/ or transfer nitrogen from organic matter via hyphae (Hodge *et al*, 2001, Cheng *et al*., 2013).

Based upon that phytate degrading-bacteria are frequently isolated from soil, AM fungi may transfer inorganic P mineralized from phytate. This AM fungal hyphal mediation of P flow from phytate to plant was currently shown (Wang *et al*., 2013). However, it is not clear how phytate degrading bacteria are involved in this process. In this study, we investigated if plant can uptake P from phytate in organic matter via AM fungi by the aid of phytate-degrading bacteria in soil.

Experiment 1

Seedlings of Lotus (*Lotus japonicus* B-129 'Gifu') were cultivated in a sterilized loamy soil-sand mixture (ratio 1:1) with/or without inoculation of AM fungi (*Rhizophagus irregularis* or *Claroideoglomus etunicatum*). After 9 weeks, the young plant was transferred to plastic pot containing 300 g of sterilized loamy soil-sand mixture. A mesh bag (37-μm mesh) which contained soil as microorganism inoculum (surface soil of upland field or that from deciduous forest, both soils are non-allophanic Andosol, 4.0 g dry weight) with/or without phytate-rich organic matter (mixture of crushed soybean seeds and crushed buckwheat seeds, total 0.8 g) was set under the plant in each pot. After 6 weeks, plants were harvested, and dry weight and P concentration were determined.

Plant growth and P uptake were increased when the organic matter was added and *R. irregularis* and the upland field soil were used as inoculum. This suggested that organic P was degraded by soil organism and the released inorganic P were taken by plant via AM fungi. In terms of organic P mineralization and P transfer via AM fungi, there were differences between 2 soil inoculums and between 2 species of AM fungi.

Experiment 2

In Experiment 1, the organic matter used contained both inorganic P and organic P including phytate. So, in the present experiment, P sources other than phytate-P was excluded by using alginate beads containing phytate P. The alginate beads containing Ca-phytate, Fe-phytate or inorganic P (calcium phosphate) as sole P source or without P source were prepared. *Rhizophagus irregularis* and the upland field soil were used as inoculum of AM fungi and soil organism. Plants and other experimental setting were the same as in Experiment 1. P uptake was increased in Ca-phytate alginate beads treatment compared with no-P alginate beads treatment.

These results suggested that microorganisms in upland field soil degraded phytate in organic matter, and that plant took the released P via AM fungi.

Keywords：*arbuscular mycorrhizal fungi, AM fungi, phytate, phytate degrading bacteria*

P3-378

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Rhizosphere Nitrification Inhibition by Australian Native Vegetation

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Nitrification, an important process in the soil nitrogen (N) cycle is the transformation of relatively immobile ammonium (NH_4^+) to highly mobile nitrate (NO_3^-). Nitrate can be lost into groundwater through leaching and also into atmosphere as nitrous oxide (N_2O) or nitrogen (N_2) gas due to denitrification. Loss of plant available N as NO_3^- and N_2O (greenhouse gas) is a major environmental problem. Suppression of nitrification to retain N in the NH_4^+ form is a key approach in extending N residence time in the soil. Synthetic nitrification inhibitors such as nitrapyrin and dicyandiamide are used in agriculture to achieve this aim.

Rhizosphere, the zone of soil around plant roots plays a major role in nutrient(s) transformation, availability, and uptake by plants. The rhizosphere zone is distinguished from the non-rhizosphere soil zone (edaphosphere) by enhanced microbial activity and increased concentration of root exudates. Some plant root exudates released into rhizosphere are reported to have nitrification inhibitory activity. Although there have been increasing interests in the rhizosphere-induced nitrification inhibition, the role of Australian native plants on nitrification inhibition has not been identified and examined in detail.

The objectives of this study include: (1) to examine the rhizosphere effect of a range of Australian native vegetation on microbial respiration, nitrification potential (NP) and ammonia oxidizing bacteria (AOB) population in soil; (2) to examine the persistence of the nitrification inhibitory activity in the rhizosphere of Australian native plants; and (3) to study the rhizosphere effect of Australian native plants on microbial respiration, NP, and AOB population with increasing distance from plant root surface.

Rhizosphere and non-rhizosphere soils of 29 Australian native plants were examined for microbial activity by measuring microbial respiration, NP by using short term nitrification assay, and nitrifiers (AOB population) by following most probable number technique. Rhizosphere soils of all the species had higher microbial respiration than non-rhizosphere soils with a rhizosphere effect (rhizosphere/edaphospere ratio) of R/E ratio > 1.0. Rhizosphere soils of 13 species showed significantly low NP and AOB population (i.e., higher nitrification inhibition; R/E ratio < 0.5); 14 species showed moderate NP and AOB population in rhizosphere soils (R/E ratio – 0.5 to 0.8) and 2 species showed high NP and AOB population in rhizosphere soils (i.e., lower nitrification inhibition; R/E ratio = 0.9 to 1.0) when compared with non-rhizosphere soils. The results indicate that some Australian native plants inhibit nitrification in their rhizosphere zones.

Persistence of nitrification inhibition activity in the rhizosphere of these Australian native plants was examined by mixing rhizosphere soils with their respective non-rhizosphere soils at varied ratios and the mixture was examined for NP and AOB population. Measured NP and AOB population was compared with predicted NP and AOB population. Results showed that the measured values were lower than the predicted values indicating the inhibitory effect of rhizosphere soils on non-rhizosphere soils.

In a glasshouse experiment, soils were collected at various distances away from the plant root surface of 3 selected Australian native plants (Chrysocephalum semipapposum (CS), Enteropogon acicularis (EA), and Scaveola albida (SA)) to examine their rhizosphere effect on microbial respiration, NP, and AOB population. Respiration decreased approximately by 36.27%, 10.15%,

and 14.29% in non-rhizosphere soils of CS, EA, and SA plants, respectively, when compared with their respective rhizosphere soils. In contrast to respiration which decreased with increasing distance from plant root surface, NP of soils from CS, EA, and SA plants decreased approximately by 99.89%, 55.39%, and 99.90%, respectively, in rhizosphere soils when compared with their respective non-rhizosphere soils. The AOB population in non-rhizosphere soils of CS, EA, and SA plants were approximately 46, 6, and 90 times, respectively, higher than in rhizosphere soils. These results show that in these plants with increasing distance from plant root surface, microbial respiration decreased, whereas NP and AOB increased confirming the nitrification inhibitory activity in their rhizosphere zones.

Our study provides direct evidence for the existence of nitrification inhibition activity in Australian native plants, especially in Chrysocephalum semipapposum, Enteropogon acicularis, and Scaveola albida. We propose further research to identify and characterise the compounds responsible for nitrification inhibition in these plants and also to examine the extent of this nitrification inhibition on reducing N loss as NO_3^- leaching and N_2O emission.

Keywords：*Nitrification inhibition, Rhizosphere, Native plants, Ammonia oxidizing bacteria (AOB),, Microbial respiration*

P3-379

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Effects of Clay Type, Rate and Placement on Nutrient Availability and Crop Productivity in Sandy Terrain of Southern Central Coastal Vietnam

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For productive crops on deep sands, fertilizers are usually necessary to overcome nutrient deficiencies to maintain adequate nutrient availability. However, managing nutrient and water supply on sands is challenging because of the low inherent capacity of the soil and the high risk of excessive drainage and leaching. Due to the poor nutrient holding capacity, and rapid drainage of water, more fertilizers are applied than necessary leading to nutrients leaching with the risk of contamination of shallow groundwater. We set out to test the hypothesis that adding 3-6 % reactive clays to sands would increase water and nutrient storage and increase nutrient use efficiency for crop production.

Two field experiments were carried out in An Chan commune, Phu Yen province (2013), south-central coastal Vietnam to study the effects of clay amendments on the ability to improve sand properties under vegetable cropping. Two rates of local clay and of zeolite were added at 50 and 150 tonnes/ha, and 100 and 300 tonnes/ha respectively to supply 3 and 6 % extra clay in the 0-20 cm layer. Addition of local clay increased the clay content in sands (initial clay content of sand <1 %) to 6% and as a result, significant increase in water holding capacity (6 % wt/vol) and CEC (6.26 cmolc/kg) were observed when 300 tonnes/ha local clay was added. In addition, yield of onion and green mustard increased by 40 to 60%.

Banding of 5 cm thick layer of local clay (equivalent to 600 tonnes/ha) at 20-25 cm (below the root depth) reduced nutrient leaching of added inorganic fertilizers by 12.7% N, 25.7% P and 35.8% K where as, banding of 5cm thick layer with zeolite reduced nutrient leaching by 10.8, 15.0 and 52.3 % of N, P and K respectively.

These results confirm that application of clay materials to sands improved nutrient retention and prevented them from leaching. Hence, addition of clay materials seemed like an option to improve nutrient use efficiency in the coastal sandy terrain of South Central Vietnam.

Keywords：*clay amendment, sandy soil, nutrient leaching*

P3-380

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Synchronizing Crop Demand and Soil Supply Ensures High Nitrogen Use Efficiency

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Introduction

A challenge for Chinese agriculture is to limit the over use of nitrogen (N) without reducing grain yield. Increasing crop yield and nitrogen use efficiency (NUE) involves not only controlling the total amount of chemical N fertilizer applied, but also synchronizing crop N demand and soil N supply.

Methods

A three-year field experiment with three N levels, unfertilized, optimized N management and conventional N practice was performed in maize. N uptake, temporal and spatial root distributions, and soil mineral N (Nmin) were thoroughly studied. In another experiment, six maize varieties widely cultivated in the last 60 years in China were employed; shoot and root dry weight (DW), grain yield, pre- and post-silking N accumulation, and total root length at silking and maturity of these varieties were analyzed and compared.

Results and discussion

Before silking, maize plants grow rapidly, especially after elongation stage. While the net increment in pre-silking DW accounted for about 50% of the total DW at maturity, the percentage of the pre-silking N accumulation to whole plant N content at maturity reached 60-85%. The results implied the importance of keeping the soil N supplying capacity during the pre-silking growth period. The optimized N treatment had an overlap of soil N supplying capacity and whole plant N accumulation, and obtained the highest grain yield, indicating that soil N supply met plant demand for N over the whole growth period.

Vegetative growth of maize ceases after silking. Growth center changes from leaves and roots to grains. Differing from the DW gain in maize grain, which was mainly contributed by post-silking photosynthesis, the amount of post-silking N uptake could not match the demand of grain development, and remobilization and cycling of N taken up pre-silking from vegetative tissues is needed for delivery of N to grains. Considering the rapid decrease in total root length and increase in N mineralization in the rhizosphere after silking, post-silking N topdressing is not beneficial for increasing grain yield and NUE.

Conclusion

A critical soil Nmin for guiding fertilizer application and maximizing maize grain yield is necessary in order to improve the N management in crop production.

Acknowledgements

We thank the National Natural Science Foundation of China (No: 31272232) and the Innovative Group Grant of National Natural Science Foundation of China (No. 31121062) for financial support.

Keywords：*N use efficiency; crop N demand; soil N supplying capacity; maize; root growth*

P3-381

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Adaptive Strategy of Three Typical Plant Species Over Majella Massif (central Italy): Differences in Microbial Community and Nutrient Uptake

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The rhizosphere represents a highly dynamic and complex interface for chemical, physical and biological interactions between plant and soil (Berg and Smalla, 2008). We report the adaptive strategy induced by the rhizosphere of three plants colonizing the high-elevated base-rich soils of Majella Massif (central Italy): Silene acaulis (L.), Dryas octopetala (L.), Helianthemum nummularium (L.) Mill. subsp. grandiflorum (Scop.). The aims of the research were to investigate the effects of these species, distinguishing between rhizospheric and bulk soil, on: (i) the main chemical characteristics (ii) the microbial community structure, abundance and activity, and (iii) the nutrient absorption strategy.

The soil, an Oxyaquic Eutrocryept, loamy-skeletal, mixed, frigid (Soil Survey Staff, 2010), was sampled under each species in summer 2011 and, once the samples were brought to the lab, rhizosphere and bulk soil were isolated according to the method of Corti et al. (2005). In the same area, bare soil was sampled as control.

Rhizosphere, bulk and control soil were analysed for pH, and the content of available water (AWC), total organic carbon (TOC), total nitrogen (TN), NH4-N, NO3-N, organic nitrogen (Norg), available and organic P (Pav, Porg), water extractable organic carbon and nitrogen (WEOC, WEN), microbial carbon (Cmic), basal respiration (evolved CO2-C), exchangeable Ca, Mg, K, Na, and different forms of Fe. The abundance and structure of soil microbial community was assessed by the analysis of phospholipids fatty acids (PLFA), which allowed us to estimate different types of microorganisms such as bacteria, fungi and arbuscolar mycorrhizal fungi (AMF). To appraise how the plants affected rhizosphere and bulk soil properties, we applied the Principal Component Analysis (PCA).

The PCA identified two axes, which explained 37.70 and 14.17% of the variation, respectively. The axis 1 appeared to be positively driven mostly by microbial community (in particular bacteria) and, to a lesser extent, TOC, TN, Norg, NO3-N and Porg and negatively driven by Pav, exchangeable K and Na, WEOC and NH4-N. The axis 2 was associated with positive relationships to pH and WEN.

The PCA biplot showed that Helianthemum was the species with the greatest differences between rhizosphere and bulk soil, followed by Dryas and Silene, where the two soil fractions had similar properties. The fact that the scores of the Helianthemum bulk and Dryas rhizosphere were positioned on the right side of the PCA-axis 1 indicated a strong positive relationship with the soil properties driving axis 1; conversely, Helianthemum rhizosphere was the most negatively associated with axis 1.

Dryas octopetala is an actinorhizal N-fixer species and, through the production of more N-enriched litter (Eskelinen et al., 2009), enhanced the activity of the microbial community and, in particular, the bacterial-based energy channel (Wardle et al., 2004). The ability of actinorhizal species to form nitrogen-fixing nodules confers a selective advantage to the plants living in poor soils. Indeed, they are often pioneer species that colonize young or little developed soils where N is scarce like moraines, volcanic flows or sand

dunes (Schwintzer and Tjepkema, 1990). Furthermore, Dryas promoted in the rhizosphere the accumulation of organic form of P, C and N. This was attributed to the fact that in the rhizosphere, with respect to fungi there were more bacteria, which are mostly involved in the degradation of simple substrates (Van der Wal et al., 2007). This fact, through a priming effect, should favour the degradation of stabilized organic matter with consequent release of nutrients available for the plant uptake and for the microbial community itself. Conversely to Dryas, Helianthemum-dominated site showed a higher amount of Pav, K, and NH4-N in the rhizosphere than in the bulk. This may be attributed to the higher organic C content in the rhizosphere, with a consequent increase of moisture content, mineralization, mineral weathering and exchange sites.

In conclusion, Dryas octopetala is a pioneer species able to ensure a N pool in harsh environments through the production and release of N-rich litters and the supported microbial community, whereas Helianthemum nummularis implements its adaptive strategy through rhizospheric processes. The typical domed shape of Silene acaulis could have mitigated the rhizosphere effects as this species may benefit more from the nutrients coming from the materials trapped inside the cushion than from those of the soil, so to invest few energy in the roots.

Keywords：*rhizosphere, PLFA, mountain soil, Silene acaulis, Dryas octopetala, Helianthemum nummularium*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Response of Coffee Plantations to the Phosphate Fertilization

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Phosphorus (P) is an essential nutrient to the growth and reproduction of plants, which do not reach their maximum potential of production without adequate supply of P. In tropical soils, the dynamics of P is extremely complex and generally limits the normal development of crops, therefore, in order to improve productivity high doses of P are annually applied. However, it is not clear yet how doses and sources of P should be applied for proper nutrition of coffee. Adult coffee plants have not been considered as plants high demanding of P, and the recommended doses normally range between 10 to 80 kg/ha of P2O5. In recent years, some investigations pointed out responses of coffee crop to P2O5 doses of about 300-400 kg/ha, specially in irrigated areas of central Brazil. Another challenge for improving coffee fertilization focuses the best P source, since it is a perennial plant and could be fertilized with P sources of low solubility. This study aimed to evaluate different rates and sources of P2O5 on coffee yield, P contents in indexes leaves and labile P content in the soil. The experiment was performed between October 2009 to April 2011, in an orchard of Coffea arabica L. cv. Paraiso two years old cultivated in an Oxisol soil with a plant population of 5555 plants/ha. The experimental design was randomized blocks with three replications, in a factorial arrangement (4x2)+1. We tested four sources of P2O5 including natural reactive phosphate (NRP), simple superphosphate (SS), triple superphosphate (TS), potassium monophosphate (PM) at the doses of 80 and 320 kg of P2O5 per hectare, plus an additional control treatment without P. The plots consisted of two coffee rows of 5 m, being the two central plants of each line adopted as useful area. The productivity was evaluated in the 2010 and 2011 harvests. Samples of soil from 0-20 and 20-40 cm in depth were collected and analyzed according to the Mehlinch-1 and cation/anion exchange resin methods. To diagnosis the P status in the plants, indexes leaves were collected and analyzed. The data were submitted to variance analysis and the means compared by the Tukey test at 5% of probability. The productivity in both harvest seasons did not respond significantly to the increase of the P2O5 dose from 80 to 320 kg/ha, nevertheless the production of the control treatment, that have not received P, was significantly lower. These results indicate that the dose of 80 kg/ha of P2O5, which is recommended for coffee plantations when the soil chemical analysis reveal 5 mg/dm ^{3} of P is enough for cultivation systems like this. In our study, high P doses, even applied annually, did not provide productivity of about 4200 kg/ha, like reported in some trials. However, the average productivity of 2400 kg/ha obtained is suitable for plantations well undertaken, in this level of soil fertility and cultivation system. Doses and sources of P did not influence the leaf content of P in the middle of the rainy season (January), but at the end of the rainy season, after the fruit loading (April) the leaves of plants receiving P2O5 fertilization presented higher contents than that of the control treatment. Despite of that, there were no differences among the plants receiving 80 and 320 kg/ha P2O5. At that time, the leaf content of P of the plants subjected to NPP was also significantly lower, showing the fast response of the plants to P soluble sources. The sources PM, TS and SS promoted coffee yields statistically similar, but these yields were statistically higher than the observed when RNP was used. Such results evidence the importance of fertilization with P sources containing soluble phosphorus to achieve the nutritional requirements of the coffee plants and get desired yields. Higher P levels in soil were obtained by applying greater doses of P2O5 and the average values extracted by the cation/anion exchange resin were higher than those obtained by the Mehlich 1 extractor. The P extracted from the soil fertilized with NRP was statistically higher for both used extractors. Like the expected, the cation/anion exchange resin extracted more P from the soil than Mehlich 1 extractor, and this fact can be justified to the extractor detrition in clay soils.

Keywords：*macronutrients, fertlilization, productivity*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Effect of the Application of Compost, Compost-Derived Humic Substances and Vermicompost on Zn Extractability and Growth of Walnut Trees (juglans Regia) in An Alkaline Soil

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Alternatively to the use of manure and compost, the use of liquid humic extracts is increasing in orchards of the central and northern Chile as a tool for stimulating root growth, since they can be easily incorporated into the root zone through drip irrigation systems, saving labor and time. Humic extracts are basically a mixture of humic and fulvic acids of different origin. These compounds have the ability of modifying the retention and mobility of metals, thus changing their availability for plants. The main objective of this study was to evaluate and compare the effect of the application of different liquid and solid organic amendments (OA) on Zn extractability (DTPA-Zn) and growth parameters of walnut trees grown in an Aridisol of natural low available Zn content (pHH2O = 7.5, organic matter = 0.5%, DTPA-Zn = 0.30 mg/kg). Walnut plants were grown in 10-L pots during five months. The treatments were a combination of one (solid OA: vineyard compost [CO], vermicompost [VE] from waste water residues) or two C rates (liquid OA: compost-derived liquid humus [LH] and fulvic acids [FA]) and two Zn rates (12 and 24 kg Zn/ha as ZnSO4) ordered using a randomized complete block design with five replicates. Solid OA were applied at planting (97 g C/tree) while humic substances were applied weekly (16 weeks, 97 and 194 g C/tree). All treatments received the application of NPK fertilizers, and negative controls (-Zn, -C) were also considered. Plant growth parameters, namely number of shoots, shoot length, and number of leaves per shoot were monitored along the season and soil samples were taken after 5 months for analyzing: DTPA-Zn, pH, electrical conductivity (EC), organic matter, water soluble C (Cws), and Olsen-P.

The Zn extractability was highly affected by the Zn and C rates ($p<0.05$). Controls without Zn addition (-Zn) indicated that liquid amendments tended to increase the extractability of native Zn. At the lowest Zn rate, the humic substances were more efficient than CO in increasing the DTPA-Zn in comparison to the respective control without C addition (12 kg Zn/ha, -C). In this case, VE and FA were the most efficient increasing DTPA-Zn, showing 4.2 and 2.9 fold increments over the control, respectively, and Zn extractability was positively correlated ($r= 0.300$, $p= 0.047$) with the Cws. When the Zn rate was increased, the presence of CO, FA and LH decreased the DTPA-Zn in comparison to the respective control (24 kg Zn/ha, -C) indicating strong soil-OM-Zn interactions. At the highest Zn rate only the VE-treated soil showed a Zn extractability higher than that of the respective control ($p<0.05$), mainly because of its acidic pH. Zinc extractability was not related to soil P availability. The greatest number of sprouts and leaves were obtained with the application of 24 kg Zn/ha without C addition, and with 12 kg Zn/ha + FA at the lowest C rate. Liquid humus and CO allowed to obtain similar plant parameters. Reduction of plant growth was noted when FA were applied at the highest C rate, because of the increased EC of the soil. Growth and nutritional status of plants are being analyzed during a second season.

Acknowledgments: FONDECYT Project N°11110509, Chile, granted to Dr. Mauricio Molina.

Keywords：*Liquid humus, fulvic acids, compost, Zn availability*

P3-384

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Phosphorus Acquisition by Maize and Cotton in Low Phosphorus Soil

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Phosphorus (P) has been termed as the bottle neck of world hunger and it is indeed frequently limited plant nutrient in the tropical and sub tropical soils. Its availability in soil depends on soil characteristics and content of mineralisable P fractions. The immobile properties of P can be exploited by mobilizing native plant available P to available form so that we can recycle the native P and minimize or omit P fertilization from outside sources. Plant species as well as genotypes with in the species may differ in their ability to grow in soils low in phosphorus availability (Lynch and Brown 2001). To increase agricultural eco benefits and product management, screening and identification of P efficient crops and genotypes with in a crop species is and to know how the various P compounds can be utilized by plants. Plants that are efficient in absorption and utilisation of native phosphorus minimize external application of P fertilizers.

With this background, a study was undertaken to evaluate the differential ability of maize and cotton to access and utilize P from different P pools in a P deficient soil. Green house experiment with maize and cotton as the test crops and with four levels of phosphorus (0,3.75, 7.50 and 15 mg P kg-1 soil) was carried out in a P deficient soil (7.2 kg ha-1). Solution of carrier free 32 P orthophosphate (Carrier-free 32P was obtained as ortho phosphoric acid in dilute hydrochloric acid medium from the Board of Radiation and Isotope Technology, Mumbai, India) was added and the soil was labeled at 3200 kBq pot -1. After the addition of phosphorus as SSP as per the treatments, the soil was homogenized. Plants were harvested 60 DAS. Rhizosphere (soil adhering to the roots) and bulk soil were collected for analysis . The harvested plants were separated in to shoot and root, oven dried, dried and grinded.

The inorganic P fractions (saloid - P, Fe-P, Al-P and Ca-P) were measured as per the procedure given by Chang and Jackson (1957). Phosphorus content in the plant was measured in acid extract (Piper, 1966). Phosphorus -32 was determined by using Liquid Scintillation Counter (Make: Perkin – Elmer; Model : Tricarb 210). All radioactive measurements were counted for radioactive decay. Using the analytical data, specific radioactivity in the plant and Iostopically Exchangeable Phosphorus (IEP) were calculated.

Increased available P content was noticed in rhizosphere soil and the increase was higher in the case of maize. Sparingly soluble P forms such as Ca - P, Al -P and -P are not equally available to plants, and plant species differ in their ability to utilize these different P sources. Significant differences noticed with regard to P fractions in rhizosphere soil in both the crops indicated that rhizosphere chemistry might have contributed to the solubilisation of the sparingly soluble source. In control and 3.75 mg P kg-1 decrease in Fe-P and Ca-P was noticed in maize which indicated that maize was able to utilize Fe-P and Ca-P but not Al-Pwhen compared to cotton. At all levels of P application, maize recorded significantly lesser values of Fe-P and Ca-P and higher values of saloid – P suggesting the superiority of maize to access sparingly soluble P from soils compared to cotton .

At all levels of P application, maize (51 Bq µg P-1 recorded significantly lower specific radioactivity than cotton (139 Bq µg P-1). Lower specific radioactivity recorded in maize indicates that maize is using otherwise unavailable P sources. The calculated mean values of IEP for maize were significantly larger (50.82 Bq µg-1 P) for maize than for cotton (20.01 Bq µg-1 P). Different values of IEP for maize and cotton indicate that chemically different pools of soil P were utilized and maize assessing a larger pool than cotton.

Ability to utilize sparingly soluble P fractions, lower specific radioactivity and higher IEP recorded by maize shows that maize is efficient than cotton with regard to P acquisition in low P soil.

Keywords : *Phosphorus, maize, cotton, iostopically exchangeable phosphorus*

P3-385

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Isolation of Putative Endophytic Bacteria from Selenium-Supplemented Wheat Plants and Their Potential Use for Biofortification and Biocontrol of a Soil Borne Pathogen

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Selenium (Se) is being studied as an essential micronutrient because of antioxidant capacity and beneficial effects on human health. Se dietary deficiency increases the incidence of important human diseases such as cancer and HIV. Soils from southern Chile is based on ash-derived volcanic soils (Andisols). Andisols provide suboptimal levels of Se for growing crops due that this metalloid can form stable complexes with clays and/or can be strongly adsorbed, resulting in low Se bioavailability to plants and food chain. Hence, our research group has focused its efforts on the study of Se biofortification in crops and pastures by native rhizobacteria. However, rhizobacteria are influenced by diverse biotic and abiotic factors and may not be as advantageous as endophytes, particularly because endophytes may be the biocontrol agents against pathogens. On the other hand, Chilean Andisols have high incidence of soil-borne pathogen Gaeumannomyces graminis var. tritici (Ggt) causing take-all (white heads), which is considered the most severe wheat disease in southern Chile. In this study we isolated endophytic bacteria from selenium-supplemented (Se+) and control wheat (Se-) grown under field conditions. Selected strains according to Se tolerance and plant-growth-promoting traits (auxin and siderophore production, phytate mineralization and tricalcium phosphate solubilization) were assayed for Ggt mycelia inhibition in vitro conditions.

According to Neighbor-joining tree of 16S rRNA gene sequences from GenBank database, our isolates showed genetic similarities respect to endophytic strains previously reported. Similarly, rhizospheric bacteria previously isolated from the same Andisol. Strains isolated from Se+ showed elevated tolerance to elevated selenium concentration (60 to 180 mM) than strains from Se- (10 to 100 mM). In addition, divergence in PGP traits in Se- and Se+ treatments was found, i.e. strains isolated from Se-supplemented plant showed a major indoleacetic acid production in comparison with control, suggesting that strains evolved survival mechanisms against stress conditions. Strains identified as Acinetobacter sp. (strain E6.2), Bacillus sp. (strain E8.1), Bacillus sp. and Klebsiella sp. (strain E5 and E1) diminish the Ggt mycelia growth in vitro (100, 50 and 30%, respectively).

We could suggest these strains for Se biofortification due to: i) elevated Se tolerance, ii) promoting crop growth traits, and iii) protection against Gaeummanomyces graminis. To the best of our knowledge, this is the first report on endophytic bacteria being used for two purposes: biofortification strategies and crop protection.

This study was supported by CONICYT Postdoctoral scholarship 3130542 and FONDECYT (CONICYT) 1100625 by the Chilean Government.

Keywords：*selenium, biofortification, endophytic bacteria*

P3-386

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Nitrate Leaching in Potato Rotation Field under the Influence of Manure Application in New Brunswick, Canada

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Potato is the predominant cash crop in the province of New Brunswick in Canada. Potato production system is characterized by elevated fertilizer application rates, which under maritime climate and sandy to loamy soils in this region may result in substantial nitrate leaching. However, nitrate leaching in potato production system in this region has not been well studied. In particular, there is no study reporting on a full cycle of potato production system, including the rotation crops. On the other hand, manure application has been used as a Beneficial Management Practices to reduce the use of commercial fertilizer. However, the effect of manure application on nitrate leaching is unknown.

In this study, a total of 12 plots were established in a field in the Potato Research Centre (PRC), located in Fredericton, New Brunswick. Each plot is rectangular in shape and is 20 m by 80 m in size with the short edge along the slope direction (~3% slope gradient) and the long edge along the contour direction. All plots were under potato-barley-clover-potato rotation from 2009 to 2012 and were managed the same except that in 2011, three treatments of manure application (full-rate manure, half-rate manure and no-manure) were randomly allocated to the 12 plots with 4 plots each treatment. An underground piping system was established to collect leaching water. The piping system includes two sets of drainage tiles, installed at approximately 1 m underground along the upper-slope and lower-slope edges of the plots, respectively. The upper-slope drainage tiles were designed to intercept water flowing into the plots from upper-slope areas and as such, the lower-slope drainage tiles only collect water from the plot areas. The upper-slope drainage tiles were connected to a pipe draining directly to a creek flowing by the field edge. The lower-slope drainage tiles were connected via separate pipes to outlets in a drainage hut. A tipping bucket flow meter was installed at the outlet. The flow meter has a datalogger to record the counts of tipping (1 L per tipping), which was used to trigger an autosampler for water sample collection. For every 500 counts of tipping (500L), a sample of 125 ml was dispatched into a 500 ml-sample bottle. The water samples were analyzed for nitrate concentration in the Soil Hydrology Lab in PRC.

The flow monitoring results showed that water flows from the drainage pipe outlets were episodic, characterized by high peaks of flow rates. For all years, differences between treatments were small, smaller than the differences between plots under the same treatments. Within a given year, high peaks were corresponding to the snowmelt events and the flow was relatively quiet during the growing season. The event Flow Weighted Mean Concentration (FWMC) for NO3 varied smoothly with time. The most obvious impact was fertilizer application. The treatment did not show impact on event NO3 FWMC. As a function of both event flow volume and event NO3 FWMC, event NO3 export showed peaks in early spring. These peaks were clearly driven by the high flow volume peaks during the snowmelt season. In 2009 and 2010, there were peaks of event NO3 export in the growing season, although the flow volume during the season was not high. These peaks of event NO3 export were likely a result of fertilizer applications. In all three years, there appeared to be small peaks of event NO3 export after harvesting towards the year end. Overall, our study suggests that manure application in rotation year of forage crop in a potato production system has no significant impact on nitrate leaching. Different crops, with their associated fertilizer application, drive the pattern of event NO3 FWMC. The risk of shallow groundwater contamination by NO3 is high in the potato production year due to its high requirement for fertilizer inputs. Future study is needed to develop practices to reduce this risk.

Keywords：*potato production system, nitrate leaching, Atlantic canada*

P3-387

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Challenges and Opportunities in Application of Nanotechnology in Enhancing Nutrient Use Efficiency- An Overview

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Nano-scale materials and devices are found in a growing number of applications offering numerous opportunities as well as challenges. The allure of materials and particles having dimensions below 100 nm is their unique properties that arise from high surface area to volume ratio and/or quantum mechanical effects (EPA Report, 2007). Manufactured nanoparticles (NPs) have a wide range of application due to the unique properties compared with their bulk counter parts. Several reports are available for the production of highly productive nano fertilizers to boost agricultural production. Nano-fertilizers can supply essential nutrients for plant growth, have higher use efficiency and can be delivered in a timely manner to a rhizospheric target or by foliar spray. There is an urgent need of improving nutrient fertilizer use efficiency by crop plants for instance of zinc, which is very low. Millions of farmers are applying bulk ZnSO4 and its efficiency is about 3% only. Nano materials can be used in producing more soluble and diffusible sources of Zn fertilizers. Higher specific surface area and reactivity of ZnO NPs compared to bulky ZnO may improve Zn solubility, diffusion in soil and hence better Zn availability to plants (Milani et al., 2010). Efficient use of nutrient fertilizers assumed critical importance because their raw materials are finite and insufficient availability is foreseen. Lin and Xing (2008) examined cell internalization and upward translocation of ZnO NPs by ryegrass in a hydroponic culture system. Individual ZnO NPs were observed present in apoplast and protoplast of the root epidermis and stele. Maria et al. (2010) showed that ZnO NPs can enter the root tissue of ryegrass further suggest that new nutrient delivery systems, which exploit the nanoscale porous parts of plants, can be developed.

Recently, Prasad et al, (2012) showed that addition of nanoscale ZnO NPs (25nm) at 1000ppm concentration promoted peanut seed germination, early flowering and higher leaf chlorophyll content, whereas pod yields per plant was 34% higher compared to chelated ZnSO4. The impact of nano-fertilizer products on physiological, biochemical, nutritional and morphological changes in plants and the fate of nano products in soil and plant system have to be studied. During the last years, some works have been published about absorption and uptake of nanoparticles by plants, dealing with their putative adverse effects. At the same time reports underline positive or no adverse effects of NPs on higher plants are also emerging in larger numbers. In order to understand the possible benefits of applying nanotechnology to agriculture, the first step will be to analyze penetration and transport of nanoparticles in the plants. The fate of NPs in the agricultural environment will vary with soil and water components.

Challenges ahead lies in to synthesize nano structures of substances that decrease anti-nutrient substances (e.g. phytate, polyphenolics etc) that inhibit nutrient bioavailability. 'Dissolution of metal-based nanoparticles is a debatable mechanism for the nanotoxicity; researchers reported either positive or negative evidence for the mechanism. Toxicity of nanoparticles depends on their property, test organism species, and surrounding solution conditions. If a test organism is very susceptible to a metal ion, the toxicity of metal-based nanoparticles could be overwhelmed by the dissolved metal ions. Therefore, more research is needed to clarify the contribution of dissolution to the toxicity of metal-based nanoparticles.'

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Keywords：*Agriculture, Nanofertilizers, Nutrient, Plants, Use Efficiency, Zinc*

P3-388

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

P-Rich By-Products as Sources of Plant Available P - Comparison of Different Test Methods

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Phosphorus (P) is an essential plant nutrient that is provided by soil reserves and fertilizers. As a finite natural resource, estimations of depletion of primary P stocks have peaked P fertilizer prices, decreasing its use. Besides animal manure also other significant, but poorly utilized P-rich by-products such as sewage sludges must be increasingly utilized. To use the by-products environmentally and economically, plant available P fraction needs to be known. Currently availability of P in these by-products is estimated with wide variety of different extractants. Whether they can reliably estimate plant availability of P is a matter of debate.

In this study we evaluated plant available P fraction both in different types of manures (dairy cow slurry, pig slurry and fox manure) and in sewage sludges [anaerobically digested, chemically precipitated sludge, lime stabilized sewage sludge and thermally treated sewage sludges after pyrolysis (300 °C) and hydrothermal carbonization (HTC)]. Reference P source was superphosphate.

Changes in the plant available P fraction in soil (P deficient sandy soil, 70 % water holding capacity) caused by the additions of different P sources was followed in an incubation experiment. Application level of P was 100 mg kg-1 (manures), 150 (sewage sludges) and an increasing levels (25, 50, 100, 150 and 300) as superphosphate. Soil samples were analyzed for plant available P content after 2 weeks and 4 months with following soil test P (STP) extractants: (1) acid ammonium acetate (pH 4.65, official extractant for evaluating plant available P content in soil in Finland), (2) Mehlich 3 and (3) 0.5 M NaHCO3 (pH 8.5, Olsen-P). Also, (4) DGT-method (Diffusive Gradient in Thin-films) was used to analyze plant available P content in soils. Modified (5) Hedley fractionation scheme (Sharpley and Moyer, 2000) was applied for both soils and P sources.

Furthermore, a pot experiment with barley (Hordeum vulgare, var. Elmeri) was conducted with the above mentioned P sources to evaluate the suitability of the STP methods (1-4) and Hedley fractionation scheme (5) for predicting P availability.

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Keywords：*STP, DGT, manure, sewage sludge, pyrolysis, HTC, phosphorus, plant available P, Hedley fractionation*

P3-389

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Crop Nitrogen Status Investigate Using a Digital Camera

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Nitrogen is one of the most important nutrient elements in plant growth and development. Digital camera was also widely used in agriculture monitoring.

A camera can record spectral information of visible bands. We investigate the study of using commercial digital camera to access the nitrogen status or growth conditions of rice (Oryza sativa L.) plant. In our study, a digital camera was used to take pictures of the canopies of 3 rice cultivars with 6 different nitrogen (N) application rates vertically, along with the plant sampling, photosynthetically active radiation (PAR), leaf area index (LAI) and SPAD measurement every 15 days or so from transplanting to earing stage. After that, canopy images were segmented by setting threshold values based on the magnitude and distribution of the green channel minus red channel (GMR) value of the image, and then correlations were established between image feature parameters and 3 plant indices (i.e., above-ground biomass, N content and LAI) before and after image segmentation. Results showed significant exponential relationships between the image parameters and the plant indices. Before the segmentation, the GMR values were closely related to the 3 plant indices, with correlation coefficient of 0.93**, 0.93** and 0.94**, respectively; while after the segmentation, the correlation coefficients between canopy cover (CC) and plant indices were 0.90**, 0.91** and 0.95**, respectively. We also analyzed the relationship between leaf nitrogen concentration (LNC) and the image feature parameters. Result showed good correlation coefficients between the LNC and image feature parameters with in one sample date (correlation coefficients up to 0.95**). But it become worse when combined all the sample data. These changes were attributed to the environment change, such as the illumination intensity, specular reflection, shadows and wind. All these factors can cause massive changing in the images. Therefore, we used several color constancy algorithms to restore the images from the changing illumination, it showed a better result but not good enough.

We conclude that GMR and CC will be valid indicators in the application of N diagnosis both for japonica and indica rice and it is not subject to the environment changes. Also, the method we used is simple and easy to apply. It only needs a unified threshold value set for a group of images and is also very quick in data processing (less than 1 second to segment a 15 mega pixels image on a desktop computer, 3.4 GHz CPU). Moreover, this method is applicable to extract canopies of most other green plants.

Keywords：*digital camera; visible spectrum; image processing technology; color constancy; nitrogen nutrition;*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Plant Uptake of Phosphorus Recycled from Human Waste Water and Sewage Sludge Ashes

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The growing human population and urbanization result in greater phosphorus (P) fluxes from agro-ecosystems to consumers and finally into waste water. Field application of sewage sludge is prohibited in Switzerland since 2006. Sewage sludge is currently mono-incinerated and deposited in landfills. Various technologies are available to recover the essential P resource from these waste streams, thus presenting options to recycle P to crop land. Technologies are available to precipitate struvite (MgNH4PO4.6H2O) either from human urine when collected separately or from the sewage water stream. Another option is to recycle P from sewage sludge incineration ashes by removing the undesired heavy metals. In either way the recycling of P back to crop land requires that the plant availability of P in the recycling product is known.

We studied P uptake by plants from struvite precipitated from synthetic human urine (MAP-syn) and P recovered from sewage sludge ashes (SSA) by a thermo-chemical process (SSA-tc). We used radioisotope labeling to determine the P in Lolium multiflorum taken up from the fertilizer under controlled conditions in the greenhouse over several growing cycles. Plant P uptake from MAP-syn was determined on a sandy slightly acidic soil with low P availability. The SSA-tc was tested on three soils with a gradient in pH (acidic, neutral and alkaline) and low P availability. Relative fertilizer efficiency is expressed as P uptake from the fertilizer relative to water soluble mineral P.

The results show that P contained in the MAP-syn is readily available to plants on a slightly acidic soil, with 93% relative efficiency. Phosphorus contained in SSA-tc was significantly less available than water soluble mineral P fertilizer. The relative efficiency was 50% in the slightly acidic soil and 20% in the alkaline soil.

The results showed that struvite represents a viable alternative P fertilizer. The significant lower relative efficiency of the SSA-tc fertilizer indicates that this fertilizer is not suited as P fertilizer in alkaline soils, unless specific biological P mobilization would be promoted.

We currently test biological P mobilization from SSA-tc in an alkaline soil by a P mobilizing cover crop, Lupinus albus, and by a plant growth promoting rhizobacteria (Pseudomonas sp. DSMZ 13134). All experiments are performed under controlled greenhouse conditions with radioisotope labeling. The results will be available in spring 2014.

Keywords：*alternative phosphorus fertilizers, cover crop, fertilizer use efficiency, isotopic technique, plant growth promoting rhizobacteria, phosphorus recycling, struvite, treated sewage sludge ash*

P3-391

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Contents of Total Iron and Different Iron Forms Distribution of Harran Plain, Southeast of Turkey

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Iron (Fe) is very important element for agricultural applications and the development of plants, which has different form in the soil. Fe is unavailable under high pH and under arid-semiarid climate that occurs soils. Profiles of arid and semi-arid zones soils of Harran Plain (Şanlıurfa city), southeastern Turkey, were investigated for different forms of iron (Fe): total Fe (FeT), Free Fe oxides(FeD), DTPA extractable Fe (FeDTPA), Amorphous Fe oxides (FeO) and Sodium pyrophosphate extractable Fe (FeP) contents in the studied area. The studied area had high pH, low organic matter, generally high salinity, high lime contents, and clayey soil. Iron forms analyses results showed that; FeT contents (1.17 – 47.71 g kg-1, mean 13.81 g kg-1) › FeD contents (0.18 – 17.85 g kg-1 mean 7.23 g kg-1) › FeO contents (0.01 – 0.31 g kg-1 mean 0.18 g kg-1) › FeDTPA contents (0.00 – 0.17 g kg-1 mean 0.04 g kg-1) › FeP contents (0.00 – 0.02 g kg-1 mean 0.01 g kg-1) .

Soil horizons had very different Fe values in the area studied. Although FeD, FeDTPA, FeO ve FeP had low quantity, FeT values were enough to growth plant. The main reason of the low value; high pH and lime, low organic matter, clay texture and because of all these reasons, iron are not easily dissolved in soil. Organic matter and content of the clay-silt fractions had a strong bearing on the distribution of forms of Fe. Based on a linear coefficient of correlation, the soil solution plus exchangeable Fe adsorbed onto inorganic sites and DTPA-extractable Fe increased with increase in soil organic carbon but decreased with increase in soil pH and calcium carbonate content. Total Fe increased with increase in cation exchange capacity (CEC) and clay and silt content. The results also revealed that there was equilibrium in different fractions of this element. Among the different Fe forms, Fe bound by organic sites, water-soluble plus exchangeable Fe, and Fe adsorbed onto oxides (amorphous surfaces) were positively correlated with the DTPA-extractable Fe. Though some forms are interrelated, none of the forms had any relationship with the total Fe.

Keywords：*Iron, Different forms, Soil properties*

P3-392

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

The Dynamics of Competitive P Uptake by Intercropped Wheat and Fababean

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Introduction

In China, intercropping has been practiced for over 2000 years, and is still popular in many regions. Due to 'complementary N use' and P mobilization by rhizosphere process, the wheat/fababean intercropping system is widely accepted by famers especially in southwestern and northwestern of China. The mechanisms underlying overyielding and phosphorus uptake of intercropping were documented in detail in previous studies. For example, the rhizosphere pH modification, carboxylates exudation, acid phosphatase secretion by legumes mobilized phosphorus to increase phosphorus uptake by neighboring cereals (Li et al., 2004; Li et al., 2007). However, we usually understood the competitive or facilitative interactions on the base of yield and nutrition uptake by single or limited samplings, which missed the true dynamics of interaction. Therefore, it is necessary to reveal the dynamics of competitive and facilitative phosphorus uptake and the rhizosphere process in intercropping.

Methods

Experimental design

The pot experiment was carried out in a glasshouse. Air temperatures ranged from18-28ºC during plant growth. Each pot contained 2 kg low phosphorus soil (Olsen-P, 11.0 mg kg-1). There were 4 treatments: SW-sole wheat (1 plant per pot), MW-monocropped wheat (3 plants per pot), SF-sole fababean (1 plant per pot), IW and IF-intercropping wheat and fababean (3 wheat plants and 1 fababean plant per pot). There were total 156 pots for 39 replicates of each treatment. Thirteen destructive harvests (3 replicates for each treatment) were taken every few days from 15 to 81 days after sowing (DAS) to obtain the shoot biomass and phosphorus content. At each harvest, we determined the rhizosphere pH, carboxylates exudation, and acid phosphatase.

Data analysis

The logistic equation $Yt+1=Yt\Delta t[1+(r[1-(Yt/Ymax)])]$ (r, the rate constant (d-1) for per capita biomass production; Ymax, a maximum to which Y tends asymptotically.) (Trinder et al., 2012) was used to separately fit the data of shoot biomass and phosphorus content by simultaneously adjusting r and Ymax to maximize R2 with the SOLVER in Microsoft Excel. The instantaneous rates were derived as the slopes of cumulative curves of biomass or phosphorus uptake derived from the logistic models rather than the measured data.

Results and discussion

a) Limited phosphorus significantly slow down the plant growth, the final biomass of wheat or fababean ranged from 1.45 g to 3.22 g and the instantaneous growth rates had not got their maximum rate until final harvest. Compared with monocropped wheat or sole fababean, the biomass of intercropped wheat and fababean was not significantly different, which means there was no

significant phosphorus competition. The main reason should be that the Olsen-P maintained around 6.8-11 mg kg-1 during the experiment.

b) We achieved the dynamics of biomass production and phosphorus content by plotting the data of wheat as horizontal axis but the data of fababean as the vertical. It is clear that the superiority of growth and phosphorus uptake was shifted from fababean to wheat, which means fababean had a much stronger competition to produce biomass and uptake phosphorus. In terms of biomass production, there was a trend that intercropped wheat received facilitation with neighboring fababean compared with monocropped wheat.

c) The dynamics of the growth and phosphorus uptake was influenced by the rhizosphere process. The acid phosphatase activity increased from 36 days after sowing when soil phosphorus level decreased. And two major kinds of organic acid like malate and citrate increased from 53 days after sowing as well as the species variation in pH confirmed previous studies.

Conclusions

The logistic model characterized the dynamics of growth and phosphorus uptake by intercropped wheat and fababean, but there was not significant competition and facilitation between them. And the dynamics of phosphorus uptake between intercropped wheat and fababean was related to rhizosphere process.

Acknowledgements

This research was supported by the National Natural Science Foundation of China (31201691) and Chinese Universities Scientific Fund (2012QJ160).

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Keywords：*wheat fababean intercroppping, phosphorus uptake, dynamics, interaction*

P3-393

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Morphological Responses of Grapevine Root to Copper Stress Given Different Calcium Nutritional Levels

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Intensive and long-term applications of copper-based fungicides to control vine downy mildew have resulted in the dramatic accumulation of copper (Cu) in viticulture soils. The elevation of Cu contents in soil would be associated with Cu toxicity and accumulation in grapevine plants. And there may be adverse impacts on the environmental health, viticulture and food safety. Copper toxicity to plant was suggested to be dependent on the common existed macro cations (e.g., Ca2+, Mg2+, K+, Na+, and H+) in soil solution. It has been found that the higher calcium (Ca) background concentrations in solution can alleviate metal phytoxicity and change metal accumulation and distribution in plant. Because Ca is an essential element, Ca availability in acid soil for plant growth is usually concerned. The issue about Cu toxicity to grapevine related to Ca nutrition regulation in Cu-accumulated soils is thus worthy to pay attention. Because compared with stem and leaf, root represents relatively sensitive to many soil-derived stress factors, root morphology is usually used as a growth response index to acutely environmental stresses. Especially, one can find the immediate and dynamic changes of ultra-morphology in root apex tissues which directly respond to the exogenous stresses. So far, there were few studies to concern the rhizo-toxicity of Cu to grapevine with ultra-morphological responses.

In this study, in order to assess the ultra-morphological responses of grapevine root to Cu as given different Ca background concentrations in solution, grapevine cuttings (Vitis vinifera L. var. Kyoho) in a hydroponic system were exposed to Cu-spiked solutions (0, 1, 5, 10, 25 μM) with two Ca backgrounds (0.5 and 5 mM) for 15 days. After the Cu exposure experiment, root length and volume of each cutting were determined with the image analysis software DIGIROOT V. 2.5. Elongation of total root length for each cutting was calculated by the change in total root length between before and after the experiment. The root samples were excided at a distance of 0.5-1.0 cm from the root apex and fixed in LR White resin. Then approximately 1 μm thick semi-thin sections were prepared on an ultra-microtome and stained with toluidine blue for histological examination by an optical microscope.

In the results, there was no new white root emerged with Cu concentrations exceeding 5 μM. While the cutting was exposed to 25 μM Cu, its roots were sparse, appeared dark, and exhibited malformed terminal swellings. The changes of morphological phenomena of root responding to increase of Cu concentrations were more pronounced by a Ca nutritional level of 5 mM than of 0.5 mM. Moreover, the 5 mM Ca nutritional level would enhance the reduction in relative root elongation but alleviate the reduction in relative root volume with increased Cu exposure. According to the results of the histological examination, it was found that at a Ca nutritional level of 0.5 mM, the epidermal cells showed disintegration and some cortical cells were deformed and plasmolyzed; but at a Ca nutritional level of 5 mM, the plasmolysis in the cortex was diminished and the epidermal cells appeared intact with obvious flattened and thick walls.

Keywords：*copper, calcium, rhizo-toxicity, plant anatomy, Vitis vinifera L.*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Isolation of Phytase-Producing Rhizobacteria from Extreme Environments

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Bacterial communities associated with roots (rhizobacteria) carry out functions that are essential to plant nutrition in terrestrial ecosystems. In comparison to ecosystems under normal conditions, microbial communities under extreme environments have often undergone selection for thousands of years. They may thus be specifically adapted to their plant host and the local soil conditions and thereby contribute to the adaptation of their plant hosts to the local environment. Rhizobacteria that inhabit such harsh regions produce enzymes adapted to those environments. The properties of these enzymes may be of high interest for several biotechnological applications. Phytate is one of the most abundant sources of organic phosphorus in Andisols and phytase-producing rhizobacteria have been proposed as potential biofertilizers to improve phosphorus uptake in plants. Although phytase-producing rhizobacteria are commonly isolated from the rhizosphere of pastures and cereal crops, little is known about the ecology and communities associated with rhizosphere of native plants established extreme Chilean environments. The goal of this study was to isolate and characterize phytase-producing rhizobacteria from Chilean extreme environments. We used various culture media supplemented with vitamins (B5, H, Bx, B3 B6 and B1) and different sources of phosphorus (phytate), carbon (glucose, galactose) and nitrogen to isolate a diverse collection of rhizobacteria. Isolation was obtained from different plants from extreme ecosystems (Atacama Desert, Natural hot spring and Patagonia) located all over Chile. Our results showed that the use of different culture media allowed the isolation of a wide variety of bacterial phenotypes, including those with motility, ability to form biofilms, pigmentation and production of endospores. In addition, two groups of phytase-producing rhizobacteria were isolated from natural hot spring environments and Atacama Desert. The strains were identified as member of thermophilic Geobacillus sp and Bacillus sp (natural hot spring) and Enterobacter sp. genera (Atacama Desert). The phytase produced by the after mentioned strains were identified as intracellular acid phytases. More precisely, the pytases produced by the thermophilic strains were most likely beta propeller phytases (BPP), since their activity was Ca-dependent and a phytase positive signal was obtained in a PCR reaction with the degenerated primers described by Tye et al., (2002). The phytase activity produced by Enterobacter sp. strains, however, was Ca independent. Thus, this phytase is either a histidine acid phytase or a cysteine phytase. This study showed that Chilean ecosystems contains a wide rhizobacterial diversity and highlight our limited knowledge of their ecology, interaction with plants, and their potential as plant growth promoting rhizobacteria based on the production of phytase.

Acknowledgement:FONCECYT project no. 3140620 and CONICYT-DAAD PCCI1 2011

Keywords：*Rhizobacteria, phytase, extreme enviroments*

P3-395

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Importance of Straw Residue Management for Silicon Supply to Rice Plants in Contrasting Southeast Asian Regions

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Background

Silicon (Si) is a beneficial element for rice plants. The plant accumulates up to 10% Si, which precipitates in plant tissue forming amorphous Si bodies, so-called `phytoliths`. A sufficient Si supply can enhance the strength and rigidity of rice plants, improve their resistance against pathogens and the efficiency of fertilizers, and prevent the uptake of toxic metals.

We conduct research within the LEGATO project on sustainable rice production in Vietnam and the Philippines (www.legato-project.net). Our aim is to develop recommendations on an adequate management of Si in contrasting regions. Generally, the Vietnamese regions are characterized by low, the Phillippine regions by high content of plant-available Si (Sipa) in soils. The supposed reason for the differences is that the release of Sipa by mineral weathering is larger in Philippine than in Vietnamese soils. Variations in Sipa status within regions might be due to management of rice straw (i.e., some farmers burn the straw, some export part of the straw or ash from fields). The straw comprises about 70% of total plant Si uptake.

Question/Hypothesis

How relevant are phytoliths in straw and ash for the Si supply to rice plants? Our hypothesis is that in soils with low contents of weatherable minerals (Vietnam), release of Si from phytoliths (in straw or ash) controls Sipa, while in soils with high contents of weatherable minerals (Philippines), phytolith input shows little effects on Sipa.

Approaches

We use different approaches:

• Laboratory experiments on effects of phytolith addition (with rice straw or ash from rice straw) and of silica-gel addition (=easily dissolvable amorphous Si grains) to topsoils (Ap horizons) on Si in soil solution, plant-Si-uptake, and plant growth.

• Field experiments on effects of phytolith addition (rice straw or ash) on plant-Si-uptake and plant growth (conducted in the Philippines).

• Laboratory analysis of release of soluble Si from Vietnamese and Philippine topsoil (Ap horizons from altogether 40 fields) in dependence on contents of amorphous Si (assessed with the 1% Na2CO3 method; it can be assumed that phytoliths comprise the largest part of the amorphous Si in paddy topsoils).

First results and implications of laboratory experiments

During a 29-day laboratory incubation using one topsoil (Ap horizon) from the Philippines (P) and two topsoils from Vietnam (V1 and V2), with initial Sipa concentrations of 141 mg kg-1 (P), 31 mg kg-1 (V1), and 51 mg kg-1 (V2) (estimated by Na-acetate extraction), Si concentrations in soil solutions were in average 19 mg L-1 (P), 4 mg L-1 (V1), and 3 mg L-1 (V2). Plant-Si-uptake was positively related to Si in soil solutions; after 29 days, Si concentrations in plants were in average 2.9% (P), 0.7% (V1) and 0.5% (V2); total Si uptake was 29 mg (P), 6 mg (V1), and 4 mg (V2). In all soils, addition of ash (~4 g Si kg-1 soil; or ~10-15 times of potential annual input in the field) significantly increased Si concentrations in soil solutions and plant-Si-uptake and effects were larger in the Vietnamese soils. For instance, total-Si-uptake was enhanced by 30% (P), 502% (V1), and 1020% (V2). Effects of silica-gel addition on Si concentrations in soil solutions and plants were comparable to those of ash addition. Silica-gel addition did not change total biomass production, but ash addition enhanced it in case of V1 and V2, suggesting that in the Philippines other nutrients than Si added with ash limited biomass production.

Our first results are in line with our hypothesis and imply that particularly in (sub-) tropical regions with stronger weathered soils (such as in Vietnam), phytolith inputs strongly affect Si supply to plants; straw residues should therefore be completely recycled.

Keywords：*silicon, rice, paddy soils, straw residue management, phytoliths*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

The Potential of New Zealand Native Plants to Mitigate Nitrogen Transport from Agricultural Land

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The success of agricultural production in New Zealand is dependent on maintaining the "100% pure New Zealand" brand and avoidance of real or perceived contamination risk. Of increasing concern is the management of soil nitrogen from fertilisers and animal wastes that may leach to waterways or contribute to greenhouse gas emissions. Coupled with this, there is growing recognition of the benefits associated with increased biodiversity in agricultural landscapes. Integrating New Zealand native vegetation into agricultural environments is potentially a cost effective and environmentally-friendly nutrient mitigation technique. Plants and their rhizospheres can assimilate nutrients and filter soil-water before it enters waterways. The presence of plant matter, roots and their exudates can change the soil microbial community and alter physico-chemical properties which in turn influences the amount of nitrogen leaving the soil as nitrate or nitrous oxide.

New Zealand native species could be planted in riparian zones or on paddock borders to intercept overland or lateral subsurface flow of nitrogen. Native plantings on farms could be used for disposal of excess animal effluent and mitigate the vertical leaching of nitrogen. Additionally native plants provide habitat linkages in agricultural landscapes and ecosystem services, such as increased crop pollination, pest and disease control. New Zealand native plants can also produce valuable essential oils and honey. Relatively little is known about the capability of New Zealand's native plants to mediate nitrogen fluxes. This research investigates the interactions of New Zealand native plants with soil nitrogen processes, specifically their potential for nitrogen uptake and mitigation of nitrate leaching or nitrous oxide production.

We examined the rhizosphere of New Zealand native plants in terms of root structure and soil physico-chemical properties across a range of soil types. The concentration and speciation of nitrogen in rhizopshere soil-pore water was measured in-situ using Rhizon suction samplers. We investigated the fate of nitrogen added to the rhizosphere of various native species. Plant growth and nitrogen uptake were determined in glasshouse pot-trials. The concentration and speciation of nitrogen in soil and nitrous oxide production from the plant rhizospheres were measured in the field. The field principal field study system is five year old mixed native planting adjacent to a dairy farm in Canterbury, New Zealand. Native species included in this study were typical riparian or colonising plants that are widely used in restoration efforts.

New Zealand native plants used in restoration differ in growth form and root morphology. Some are leafy monocot species with fibrous root systems, while others are trees with woody roots. Under background field conditions, two species Austroderia richardii (toetoe) and Plagianthus regius (ribbonwood) had significantly higher extractable nitrate in their rhizosphere soil than others. Variation in extractable ammonium and soil physico-chemical properties was also found. The growth response of native plants to added nitrogen was limited but a large amount of nitrogen was assimilated, particularly by the monocot species. That New Zealand native species had a relatively poor growth response to nitrogen is constant with these plants evolving in low-fertility soils. Several species reduced the amount of nitrogen leaching vertically through the rhizosphere, potentially through assimilation of mobile nitrate and reducing water flux via transpiration. Kunzea ericoides (kānuka), a native tree with antimicrobial properties, suppressed nitrous oxide emissions from soil amended with dairy shed effluent.

It is argued that this knowledge of the ameliorative capabilities of native plants could be used to make informed decisions in sustainable agricultural management including targeted planting strategies for different on farm situations.

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Urea Deep Placement for Paddy Rice: The Scientific Foundations

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Over the past five decades rice production in Asia has expanded to meet rapid population growth. The doubling of total food production is associated with a seven-fold increase in fertilizer use. IFA statistics for 2010/11 indicate that global fertilizer use on rice was approximately 25 Tg of N+P2O5 + K2O. Urea is the main nitrogen source and major rice growing countries such as China, India and Indonesia are amongst the largest producers of urea.

Rates of application vary widely but many farmers in high-yielding irrigated areas apply more than 200 kg N ha-1 by broadcasting the urea onto the surface of the puddled soil or floodwater. This traditional method of application results in average apparent fertilizer N recoveries of 30-35%, which, due in large part to various N loss mechanisms, are 15-25% lower than recorded for upland cereals. The low N recoveries by rice constitute a direct cost to farmers and a massive waste of the fossil fuel used to manufacture the urea. Losses of broadcast urea in surface runoff from paddies can have environmental impacts locally and in coastal waters. Nitrous oxide produced during soil N transformations add to the global impacts of greenhouse gas emissions from the urea manufacturing process. Volatilized ammonia has little environmental impact as it largely returns in rain, mostly elsewhere. This paper reviews our understanding of the fate and efficiency of urea which provides the scientific underpinning for recent successes in implementing urea deep placement, particularly in Bangladesh, a major rice-producing country.

Research begun more than 35 years ago provided the scientific base for approaches to improve urea fertilizer efficiency for rice. A series of multi-country fertilizer trials were coordinated by IRRI and IFDC; the results showed that to produce a rice yield increase of 1 t ha-1 33% to 56% less urea was necessary if applied as slow release (sulphur-coated) urea or deep point placement of urea supergranules compared with broadcast urea. This led to more detailed measurement in greenhouse and field experiments showing that the yield response of rice to different modes and methods of urea application was inversely related to the level of total ammoniacal N in the floodwater. Floodwater chemistry studies indicated that the pH of floodwater could reach as high as 10 due to urea hydrolysis and photosynthetic activities of algae that lowered dissolved carbon dioxide. Under these conditions with natural levels of air exchange, ammonia losses exceeding 50% of broadcast urea-N were measured under field and controlled conditions. Balance experiments using 15N showed that total losses of broadcast urea exceeded 50% in many cases but this was reduced to around 10% with deep placement. Attempts to directly measure all of the gases produced by denitrification have proven difficult. 15N balance data combined with direct ammonia volatilization loss measurements indicate that nitrification-denitrification is a significant loss mechanism only under some conditions if urea is surface applied. Deep placement hampers all loss mechanisms except leaching in highly sandy soils. An added benefit from deep placement is that the low floodwater N levels encourage nitrogen fixation by blue green algae in contrast to the green algae that proliferate when urea is surface broadcast.

Urea efficiency can be improved through the use of deep placement, slow release formulations, urease inhibitors or repeated split applications. Most of these approaches are either too expensive or have proven too knowledge-intensive for small-holder farmers. One exception is urea deep placement based on village-level production of urea briquettes designed for placement by hand or with simple applicators below the paddy soil surface. This approach, based on large discreet particles of urea, is necessary because urea is hygroscopic and attempts to develop devices that place commercial prilled or granular urea deep in a puddled soil have failed. In practice urea deep placement is an innovative, proven fertilizer application technology that can achieve 20 percent yield increases while reducing fertilizer use by about one-third and nitrogen losses by 40 percent. In Bangladesh, more than 4.65 million farmers have adopted urea deep placement on 1.5 million ha over three rice cropping seasons per year. The proven economic, productivity and environmental benefits show that the spread of this technology to other tropical rice producing countries should be given high priority.

Keywords：*fertilizer efficiency, placement, nitrogen losses*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Modeling of Phyto-Extraction on Pot Experiments

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Phyto-extraction is a technique whose efficiency is strongly influenced by a large set of environmental variables in the soil - plant - atmosphere continuum. In order to develop a predictive methodology, a software code was calibrated on data from pot experiments using Chrysopogon Zizanioides (Vetiver grass) in a soil contaminated by toxic metal cations (Cd2+,Ni2+, Pb2+, Zn2+). Variably-saturated ?ow was described using the standard Richards' equation, and solute transport using the advection-dispersion equation. Sink terms in the governing flow and transport equations accounted for root water and solute uptake, respectively. Plant growth and compartmentalization of the contaminants within the vegetation, were not considered. Sorption of metals by the solid phase was described using linear isotherms. The model was adjusted to hydraulic conditions consistent with the experimental data. Phyto-extraction was simulated using root passive and active solute uptake. Experimental extracted mass of metal in the dried mass of the plants was used to calibrate the model. Passive uptake simulations showed good agreement with the experimental data for Pb2+ and Zn2+ (R2 values were 0.8526 and 0.7435, respectively) but they significantly overestimated data for Ni2+ and Cd2+. For these metals it was necessary to use an active solute uptake model (yielding R2 values 0.9884 and 0.9360 for Cd2+ and Ni2+, respectively). This study showed that it was possible to achieve good calibration of the metal phyto-extraction process by Vetiver grass as observed by a series of controlled pot experiments. The adopted numerical approach appears very promising for application to more dynamic field conditions.

Keywords：*Modeling, soil - plant - atmosphere continuum, non-saturated soil, toxic metals, plant solute uptake*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Effects of Magnesium Contents on the Freundlich Adsorption Isotherm Constants and Phosphorus Availability in Agricultural Soils of Wallonia (Belgium)

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The reserves of total phosphorus (Ptot) in Walloon soils are high, 904 mgP/kg on average in the topsoil [1]. It resulted from continuous and excessive fertilization and manure applications [2]. However, only 9% of Ptot on average (71.6 mgP/kg) is available in Walloon topsoil due to high soil P sorption capacity [1]. Thus, a better understanding of P behavior in Walloon soils is needed to adapt practices of fertilization to the requirement of limiting and improving phosphorus (P) availability in soils of Wallonia. Recently, different studies have shown that during the last decade, magnesium (Mg) content in soils of Wallonia increased between 10 to 35% [3]. Hence, Mg contents could influence the availability of P in these same soils [4].

In that context we studied P available (PO4-P) in different agricultural soils of Wallonia (N=5) by batch equilibrium experiments in order to define: (1) the influence of Mg content on the Freundlich adsorption coefficients ; (2) the effects of Mg content on the magnitude of P adsorption.

A 3 g air dried sample was weighed into a 100 mL centrifuge tube with a cap and equilibrated with 60 mL of one of six P solutions having 0, 0.1, 1, 10, 75, 150 ppm P. The solution added to the soil was prepared by dissolving KH2PO4. Few drops NaNOH3 0.01M was added. Mg solutions prepared by dissolving MgSO4 were added to different centrifuge tubes to produce a range of Mg contents between 0 and 40%. To inhibit the microbial activity in each tube, three drops of chloroform were added. The tubes were shaken for 72h for equilibration purpose and subsequently were centrifuged and supernatant was collected for P determination. The P concentration in the extracts was determined by using the method of Murphy and Riley [5] with absorption measure using a spectrophotometer at a wavelength at 880 nm. The Mg content in the extracts was determined by using an ICP-AES.

In a first step, the Freundlich adsorption isotherms were defined in five Walloon soils by batch equilibrium experiment. These results show that the addition of Mg influences the Freundlich adsorption coefficients K and 1/n in each soil. Thus, the application of Mg significantly increased the Freundlich K values and decreased 1/n compared to the control treatment in each soil. This suggests that more P was sorbed on soil and less was present in the soil solution. In a second step, the effects of Mg content on the magnitude of P adsorption in Walloon soils were determined. Our results show that the addition of Mg influences the PO4-P in soil solutions. Thus, more the addition of Mg increased, more the PO4-P in soil solution decreased. This suggests that addition of Mg decreased the PO4-P in Walloon soils tested.

This study has shown that the Mg is an important parameter which governs P availability in agricultural soils of Wallonia. However, further studies are needed to understand the impact of Mg fertilization such as, Mg liming and struvite, on soil P

availability.

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Keywords：*Effects of magnesium contents, Batch equilibrium experiments, Freundlich adsorption isotherm constants, phosphorus availability, agricultural soils of Wallonia*

P3-400

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Sorghum (sorghum Bicolor L) Response to Residual Ground Rock Phosphates in Legume-And Cereal-Based Crop Rotation Schemes on Two Contrasting Alfisols

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Proper fertilizer nutrient management that ensures adequate utilization of the residual value of fertilizer materials coupled with healthy crop rotation contributes significantly to sustainable crop production. This study evaluated residual effects of Morocco Rock Phosphate, RP (33.3% P2O5 by weight), Sokoto RP (34.2% P2O5 by weight) and Single Super Phosphate, SSP (18% P2O5) on sorghum performance with a no-fertilizer treatment as Control. The experimental soils included a strongly acidic (pH 5.3), sandy clay-loam Alfisol and another slightly acidic (pH 6.7), loamy-sand Alfisol. The soils were low in available-P prior to being subjected to the phosphate treatments (applied at 200kg P2O5/ha). They were planted to either a cereal crop (maize) or a legume (cowpea or soybean) at the Department of Agronomy, University of Ibadan, Nigeria between February and June, 2013. The direct (main) and residual (long-term) trials were 2×2×4 factorial experiments in completely randomized design with the treatments replicated three times to give a total of 48 pots, each containing 5kg soil. The effects of the cereal crop (sorghum) following another cereal (maize) or legume (soybean or cowpea) in rotation were thus evaluated. The test crops performed better on the slightly acidic loamy-sand than on the strongly acidic sandy clay-loam in the first cropping. The performances of the crops were improved by P supply in both the first and second cropping. Single superphosphate proved to be more efficient in the first cropping than the RPs but not as effective as MRP in the second cropping when the latter had more residual effect. Soil acidity however enhanced the effectiveness of SRP. In the second cropping, sorghum performed better on soils previously cropped to cowpea or soybean while Morocco RP had the highest residual effect among the P-fertilizer sources. Sokoto RP was less than 50% efficient in the two soils compared to SSP for the test crops. In the second cropping, the slightly acidic loamy-sand produced higher biomass than the strongly acidic sandy clay-loam when sorghum was the test crop. Each of the legume-based (Soybean-sorghum and cowpea-sorghum) crop rotation schemes produced greater sorghum biomass than the all cereals (cereal-based i.e. maize-sorghum) crop rotation scheme. The interaction among the experimental factors (crop, soil and phosphate-sources) was not significant. The order of the effectiveness of the P-sources for the growth and biomass yield of the test crops is SSP ≥ MRP > SRP in the first cropping while there was no difference in performance in the second cropping. It is evident that soil pH and clay contents as well as the crop type concerned determine the efficiency of finely ground rock phosphates in the crop rotation schemes. It is also evident that rock phosphates could be used as substitutes to the conventional phosphorus fertilizer besides the advantage of their long-term (residual) effects in the soils. The positive effects of healthy rotation of crops as well as the differential effects (positive or negative) of low soil pH (depending on specific rock phosphate employed) are also quite obvious, permitting the farmer to make a choice.

Keywords：*Rock-phosphates, Residual-phosphates, Crop rotation, Alfisols*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Effects of Fertilization on Rice Grain Yield and Incidents of Pests and Diseases

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To study the effects of fertilization on rice growth and disease infection, we carried out a field experiment in the suburb of Shanghai. Four fertilizing treatments were designed, including CK, CM1, CM2 and CF, with the amounts and types of base fertilizers applied being no fertilizer, 0; cake manure, 1500 kg/h ㎡; cake manure, 3000 kg/h ㎡; chemical fertilizer, 450 kg/h ㎡, respectively. At the middle stage of rice growth, 40% of the fertilizing amounts of all the treatments were applied once more as top dressing. Each fertilizing treatment is in replicate and each plot is 30 m2 in area. No any pesticides and herbicides were applied throughout the entire experiment. During the entire period of rice growth, the incidents of pests and diseases and soil enzyme activities at each plot were investigated continuously. The grain yield of each plot was weighed after harvesting. The results are as follows: (1) During the middle and late stages of rice growth, the incidence of rice stem borer with the CF treatment, 4.87% on average, is significantly higher than that with the other treatments, CK, CM1 and CM2, which all is 0. But the incidence of Cnaphalocrocis medinalis of the rice with all the treatments during the entire period of rice growth is not significantly different. At the late stage of rice growth, the incidence of planthoppers with the CF, 16.83 per hill, is also significantly higher than that with the others. (2) During the entire period of rice growth, the activity of dehydrogenase (DH) in the soils with the CF is 3.83% lower than that with the CK; while that with the CM1 and CM2 is 64.22% and 36.47% higher than with the CK, respectively. This suggests that the DH activity is reduced by chemical fertilizer, but highly enhanced by cake manure. (3) At last, the grain yields with the CK, CM1, CM2 and CF are 3123.88 kg/hm2, 5340.96 kg/hm2, 7020.71 kg/hm2 and 6067.54 kg/hm2, respectively. All the above fully suggest that the application of chemical fertilizer to the fields can intensify the incidences of rice pests and diseases and inhibit the activity of soil enzymes; the application of cake manure, on the contrary, can reduce the incidences of pests and diseases, optimize soil micro-environment and raise soil enzyme activity, and finally increase grain yield significantly.

Acknowledgements: This work was supported by the National Natural Science Foundation of China (No. 41130526).

Keywords：*Fertilization; Cake manure; Incidence of pests and diseases; Rice; Soil enzyme activity*

P3-402

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Root-Zone Fertilization- A Case Study to Improve Nitrogen Use Efficiency of Rice (Oryza Satival.)

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The low efficiency of nitrogen (N) fertilizer in rice (Oryza sativaL.) is mainly attributed to the losses of N via ammonia volatilization, denitrification, leaching, and runoff in rice field. A lot of research to improve N use efficiency of irrigated rice has been carried out, but most work has focused on amount, form, and timing of applied N to reduce losses from volatilization and denitrification. In contrast, less attention has been paid to the placement of N fertilizer and the relationship of the rice root development and diffusion of N nutrient in soil. A field experiment was conducted on a clay loam soil in Jingshan county of Hubei province, which aimed to evaluate the effect of root-zone fertilization on yield and N use efficiency of rice. Seven N application patterns including CK without N fertilizer, traditional fertilization (TF, N 225 kg/hm2, surface split application), traditional fertilization with reduced N （TF-N, N 165 kg/hm2) and four N placement treatments (PF1~4, N 165 kg/hm2). The N fertilizer of PF applied in small holes as base fertilizer but in different position to test whether the N fertilizer was applied within the root-zone or not. The results revealed that different N application patterns had marked impact on rice yield. The highest yield (7552 kg/hm2) treatment was the possible root-zone fertilization (RZF) treatment, for which the N was applied in 5cm horizontal distance and 5cm vertical distance from rice plant. Nevertheless, with the vertical distance and horizontal distance increased, the yield-increasing effect declined. The yield was only 5581 kg/hm2 when N applied in 9.5cm horizontal distance and 10cm vertical distance from rice plant. The yield of TF-N was 15.9% lower than TF means that reduced N amount under the condition of surface split application resulted in yield decline. Experimental data also showed that RZF could significantly improve the N use efficiency of rice. The apparent N recovery of TF and TF-N were 28.4% and 25.2% respectively. However, the apparent N recovery of RZF were more than 52.8% which reduced N amount and applied N within the root-zone. But we also found that if N application position was too far (9.5cm horizontal distance and 10cm vertical distance from rice plant), it would lead to low apparent N recovery (only 32.3%).In conclusion, N application pattern played an important role in saving N fertilizer amount and improving apparent N recovery. A combination of reducing N fertilizer and root-zone fertilization is the key method to avoid N losses and to improve N use efficiency.

Keywords：*Root-zone fertilization; rice; urea; N use efficiency*

P3-403

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Effects of Citrate Addition into the Rhizosphere on P Acquisition Efficiency of Phosphatase Gene-Modified Plants and P Availability in the Soil

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Phosphorus (P) is difficult to absorb directly due to its low solubility in soils, although P is one of the essential elements for plants. To improve the utilization of organic P in soils, the *LASAP2* gene encoding secreted acid phosphatase (APase) of white lupin had been transformed to tobacco plants. The potential for organic P mobilization by *LASAP2*-overexpressing (L2-OX) tobacco plants was examined in our previous study. It was shown that L2-OX line had somewhat improved organic P utilization than wild type tobacco (WT), although utilization of phytate in soil was not very high (Wasaki et al. 2009, Maruyama et al. 2012). It was concluded that chelation by organic acids was important for further improvement of unavailable P utilization in soil. However, the details of effect by citrate on soil P component is still less known. Therefore, for the present study, we investigated the P uptake of L2-OX plants with citrate addition into the rhizosphere and the P fraction of the rhizosphere soil by Hedley's sequential extraction. L2-OX plants were grown in sterile by autoclave or non-sterile soils. Either 100 mg-P/kg of inorganic phosphate (+Pi) or phytate (+Po) was supplemented to soil as the sole P source; and no P supplement treatment (No P) was also prepared as a control. For citrate treatment, 2 mL of 100 mM citrate solution (pH=5.5; adjusted with NaOH) was added into soil every 2 days. Plant shoots and roots were collected at 31 day after sowing to analyze P concentration. Rhizosphere soils of all plants were collected for P fractionation according to Hedley's procedure.

Shoot dry matter productions of the plant were no difference between with and without citrate addition regardless of P application. On the other hands, root dry matter productions were reduced by citrate addition in all P treatments. In all P treatments, shoot dry matter production in autoclaved soil was lower than non-sterile soil. An increase of P accumulation by citrate addition was found in autoclaved treatment. Particularly, P accumulation of citrate treated plants in +Po and +Pi treatments were significantly higher than without citrate treatment in autoclaved soil. The plant P uptake in No P, +Po, and +Pi treatments in autoclaved soils was 25, 53, and 97% increased by citrate addition, respectively. No significant difference was found between the plants with or without addition of citrate grown at the non-autoclaved soils. These results suggested that the soil microorganisms were interacted with P uptake of plant and P mobilization by citrate in the rhizosphere. To understand the effect of citrate addition on the utilization of different P forms in soil, Hedley's sequential fractionation was conducted. Resin-P was increased in +Po and +Pi condition by the addition of citrate. On the other hands, Residual-P was decreased in all treatments by citrate treatment. This result revealed that addition of citrate has a potential for improving P solubility despite organic and inorganic fractions. In our previous study, the P uptake of L2-OX plants was increased by 34% in +Po treatment compared to WT plants (Maruyama et al. 2012). Moreover, it was shown in this study that P uptake of L2-OX plants grown in +Po treatment was 25% higher in citrate added treatment than in without citrate. These results indicated that increment of both APase and citrate in the rhizosphere could contribute to improve phytate utilization compared to increase of either APase or organic acid. Therefore, we concluded that introducing an APase gene such as *LASAP2* into other plants and increment of citrate concentration in the rhizosphere is a promising strategy for improving P mobilization, including phytate, although the effect was limited in a specific soil and sterile condition.

Keywords：*phosphorus, citrate, acid phosphatase, phytate, white lupin, rhizosphere*

P3-404

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Boosting Smallholder Cowpea and Soil Productivity through Use of Green Input in the Guinea and Sudan Savannah Zones of Ghan

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Inoculation of legumes with effective rhizobia strains is a cheaper source of nitrogen for increased crop yield. In addition, it offers the opportunity to integrate smallholder farmers into the green economy being a green input that reduces fertilizer use and ensures effective utilization of biological material for optimizied Biological Nitrogen Fixation (BNF). Reports indicate that the native bacteria strains of Savannah agro-ecological zones of Ghana are moderately effective therefore require inoculation with effective strains. In addition, phosphorus which enhances Biological nitrogen fixation (BNF) is the second most limiting nutrient after nitrogen in the savannah zone. Thus this study investigated the best rate of phosphorus and potassium that will complement the newly introduces BR3269 rhizobia strain in increasing the yield of cowpea in the Upper West region of Ghana. The study was carried out at Lawra (Sudan savannah) and Nyoli (Guinea savannah) both in the upper west region of Ghana. It comprised of a field experiment with 6 treatments of N - P - K kgha-1: 0 – 0 – 0, IN* – 0 – 0, IN* – 45 – 30, IN* – 30 – 20, 20 – 30 – 20 and IN*/20 – 30 – 20 (IN- rhizobia inoculant). Results show that Inoculant applied with phosphorus and potassium at 30 and 20 kgha-1 gave of yield of 1.64 and 1.86 at both sites with was 207 and 139% more than the control respectively. It also fixed 11.21 kg of nitrogen against the control that fixed 6.52 kg of nitrogen. Combined application of the inoculant and nitrogen fertilizer at 20 kgha-1 suppressed grain yield which was 48% and 28% more than the control respectively. It was concluded that for increased grain yield and more returns on investment, combined application of the inoculant with 20 and 30 kgha-1 of phosphorus and potassium is the best for cowpea production in the Guinea and Sudan savannah zones of Ghana.

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P3-405

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Managing Paddy Soils to Improve Zn Bioavailability and Agronomic Performance of Fine Grain Aromatic Rice

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INTRODUCTION

Growing rice under water saving cultivation have great implication for Zn bioavailability due to changes in soil moisture and physico-chemical properties. Zn application has large impact on its soil availability, plant uptake and grain loading (Rehman et al., 2012). Recent studies indicate that when paddy soils are provided with temporary drainage during critical growth stages of rice it may affect the plant Zn availability (Beebout et al., 2013, Rehman et al., 2012). Beebout et al. (2009) reported that modertaley aerobic conditions due to increase in redox potential maintained througout rice growing period can result in increased Zn uptake and grain accumulation. We also hypothesized that Zn applied at transplanting may improve nursery seedling growth in different rice systems and result in high grain Zn if temporary drainage period is provided during later growth stages.

METHODS

Rice nursery seedlings (22 days old) of cv. Super Basmati were transplanted in continous puddle field with split plot arrangement in randomized complete block design. Zinc (Zn using 15 kg ha-1, ZnSO4 33%) was applied within each subplot and no Zn plots were taken as control. Rice systems studied were transplanting in system of riceintensification (SRI), aerobic condition (AR) and alternate wetting and drying (AWD) in comparison to continous flooding (CF) as control. Soil was of silt loam with 0.85 mg kg-1 DTPA extrcatbale Zn, pH 6.99, ECe 2.64 dSm-1, 4.49 mmolc L-1 HCO3-1. After soil analysis, 143 kg N, 88 kg P and 68 kg ha-1 of K were added. Measurements for nursery seedling growth, soil and plant Zn at seedling and physiological maturity, agronomic and yield traits, spikelet sterility and grain Zn were determined. Plant, soil and grain Zn were analyzed through atomic absorption spectrophotometer using wet digestion method and DTPA extractbale method.

RESULTS AND DISCUSSION

Among production systems, Zn application improved plant height with maximum seedling fresh and dry weights, number of leaf and roots, tillers per plant, chl “a” and “b” contents in conventional flooding followed by alternate we. This improved seedling performance was followed by system of rice intensification. Improved seedling performance was correlated with high soil Zn availability under flooded condition. Likely at physiological maturity, maximum panicle length, number of panicles, zinc contents in leaves, roots, stem and grain were attained in conventional system by zinc application. This was followed by alternate wetting and drying at this stage due to water deficit prevailed in system of rice intensification. Paddy harvesting showed that maximum biological, kernel and straw yield was obtained by Zn application in conventional flooding system, spikelet sterility was reduced by Zn application while days to maturity were decerased to some extent. This was followed by alternate wetting and drying.

Performance of aerobic rice at all stages of investigation while of system of rice intensification at physiological maturity and harvesting was poor. Soil analysis at different stages revealed that at initial stages maximum DTPA-Extractable zinc was present in conventional flooding where Zn was applied while at physiological maturity AWD gave higher soil Zn contents followed by CF and at harvesting system of rice intensification was having more Zn in soil than all other systems with similar results.

High soil Zn availability and plant uptake during grain filling stages might be contributed to increased soil redox potential under aerobic conditions after soil drainage period. Thus for high soil Zn availability, plant uptake for grain Zn and improved yield performance, soil management should be integrated with water management during critical growth stages.

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Keywords：*water shortage, redox potential, soil fertility, aerobic rice, flooded rice, Zn application*

P3-406

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Accumulation of Major Nutrients in Calcareos Soils under Intensive Cultivation and Pressurized Irrigation Practices in Jordan

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Jordan has limited agricultural resources including water, land and climate, where it falls under the arid region of the Mediterranean environment. Soils of Jordan are indigenously low fertile due to the long historical period of land cultivation without replenishment of depleted nutrients. The soils are dominantly calcareous and characterized, among others, by highly content of CaCO3 (>40%), high pH and extremely low organic matter (<2%).Availability of most nutrients is extremely low under the prevailing characteristics which enhance the insolubility and precipitation and thus low mobility or loss by volatilization as in case of nitrogen.

Irrigated agriculture during the last few decades, has witnessed substantial expansion under protected environment (plastic houses). Vegetable crops, including cucumber, tomato, eggplant, squashes and potato, where intensively planted under pressurized fertigation systems. Farmers tend to provide these cash crops with all needed production inputs with no limitations including fertilizers. The increasingly use of fertilizers of all kinds (solid and liquid) and grades, especially the readily soluble fertilizers, has exceeded the crop requirements in all seasons. The addition of mineral (inorganic) fertilizers was practiced on the top of the previously added organic fertilizers.

More than 200 farms were randomly selected and monitored for more than 25 years. Different vegetable crops were grown and subjected to different fertilization practices through fertigation systems. Extractable (available) forms of the major nutrients, Nitrogen, phosphorus and potassium levels in soil were periodically measured.

Under the different crops , major accumulation of major nutrients as compared to the base line was 5 to 10 fold (> 200 ppm)for N ,and 10 to 15 fold (>800 ppm) for P, and 4 to 6 fold (> 2025 ppm) for K.

The possible environmental impact of such extremely high levels of nutrient elements and their impact on soil quality and sustainability are under evaluation.

Keywords：*nitrogen ,Phosphorus,potassium ,calcareous soils ,fertigation*

P3-407

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Isolation of Phosphate Solubilizing Bacteria from Two Types of Calcareous Soil and Evaluating Their Ability to Solubilize Various Sources of Rock Phosphates

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Phosphorus (P) after nitrogen is the second macronutrient which limits plant growth and it is one of the major essential elements for plant biological growth and development and it constitutes 0.2% of the plant weight. Most of Iranian soils are phosphorus deficient or in critical condition. Phosphorus chemical fertilizers such as mono- and diammonium phosphates and triple superphosphate have the potential to supply urgently the phosphorus which is needed by the plant, but the high price of these fertilizers has urged many people in different countries like Iran the direct use of rock phosphate which is a cheaper source of phosphate fertilizer for crop production. In order to increase the solubility and efficiency of insoluble phosphates and also using rock phosphates, one of the best strategies is the use of phosphate solubilizing microorganisms (PSM). The soil samples were taken from two areas of Kordan and Gonbad, Iran. In vitro studies of phosphate solubilization by bacterial isolates have been carried out based on visual detection of phosphate solubilization ability of the isolates using plate screening method and observing clear zones around colonies in Sperber solid media containing insoluble mineral phosphate (Calcium Phoshate). Thus phosphate solubilizing bacteria (PSB) isolated from soil samples using Sperber solid media and 9 superior isolates were selected for further studies. Other experiments of bacterial incubation by the use of Sperber liquid media with three different sources of phosphorus (Yasuj rock phosphate, Yazd rock phosphate and Tunisian Gufsa rock phosphate were performed in a completely randomized design with three replications at 27°c for 15 days. After 5, 10 and 15 days, the flasks were sampled and the amounts of Solubilized phosphorus and pH changes were measured. The results showed that isolated PSBs of Kordan were more efficient than Gonbad isolates to solubilize different sources of rock phosphate. All bacterial isolates had significantly solubilized ($P \leq 0.01$) greater values of rock phosphate in comparison with the control non-inoculated treatment. The maximum solubilization was related to K24 (21.08 mg/50ml) of Tunisian Gufsa rock phosphate in an incubation period of 15 days. Also an inverse correlation between the solubilized phosphorus content and pH of media has been observed which is probably due to the organic acids production by bacteria. However it has not observed any relationship between pH and soluble phosphorus content and different amount of solubilization was observed at the same pH. This could possibly indicate that the mechanism used by bacteria for inorganic insoluble phosphate solubilization is different from each other.

Keywords：*Phosphate solubilizing bacteria, Rock phosphate, Phosphate solubilization, Insoluble phosphate*

P3-408

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Soil Nutrient Dynamics and Maize Yield as Influenced by Integrated Nutrient Management

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Achieving food security for rapidly expanding population in the tropics means intensifying food production through enhanced nutrients input and recycling. Thus judicious integration of both organic and inorganic or crop residues and animal manures sources of nutrients incorporation may be seen as options. Field experiments were conducted at Oyo State College of Agriculture Research farm in Igboora, southwest Nigeria to characterize Farm yard manures with its maize base composted materials mixture of equal quantities (cow-dung, poultry, and pig manures with maize stover in 3 of plant maize stover to 1mixed manures) and NPK fertilizer separately and combined on the soil nutrient dynamics and productivity of Maize spanning from 2010-2012 growing seasons. The treatments included control (C), compost (CMP), poultry (PM), pig (PGM) and cow dung (CD) manures at 5 t/ha, NPK (120kg/ha) and their integrations (CMP + NPK, PM +NPK, PGM + NPK and CD + NPK) at 2.5 t/ha and 60 kg/ha. It was arranged in a Randomized Complete Block Design replicated three times and repeated for residual evaluation in 2012/13 season. Growth data taken biweekly were plant height, leaf area, stem girth and leaf number. Soil characters evaluated includes: OM, N, available P, exchangeable bases (K, Ca and Mg), micronutrients (Fe, Mn and Zn) and pH, while the yield and yield components were taken at harvesting. Data were analyzed using ANOVA and the means were separated using Duncan Multiple Range Test. Treatments increased significantly ($P<0.05$) growth parameters, soil chemical properties, and yield components considered. . However, immediately after treatments application the combined organo -minerals produced yields, which were significantly higher than organic/ inorganic alone and control. The highest grain yields (6.2 tons/ha) and dehusk cob weight (0.783kg)/cob was recorded by the use of CM +NPK fertilizer while control had the least. Similar trend were also produced by soil and maize tissue characters considered. The variation in nutrient content of the treatments and the nutrient uptake values which were higher in the combined application than sole application confirms the trend of the result. The combined application of inorganic fertilizers (NPK 20-10-10) at 5 tons ha-1 plus farmyard manure mixtures compost (poultry manure, swine and cow dung) with maize stover at 3:1 applied at 2.5 t/ha-1 is therefore considered for immediate response. After two years, the percentage nutrient reserves of OM (133%), N (305%), P (318.48%), K (142.86%) CMP plots to control soil. Whereas, a decrease of 67.95%, 155%, 103% and 92.86% in the (NPK + CMP) and NPK had 62%, 15%, 77.85% and 50% respectively. The study clearly indicated that the application of organic un-amended compost fertilizer at 5 tha-1 full dose would ensure a long term residual effect by 62.5% percent yield higher than the control with no fertilizer application in the cropping season. The use of high tonnage of organic manures to sustain yield in Maize production could be possible since the practice would maintain or increase soil organic reserves when adopted. The integration of waste as compost and CMP+NPK fortification have potential to increase yield, protects the soil and will contribute to its restoration.

Keywords：*Compost, Poultry manure, Pig manure, Cow-dung manure, Organo-mineral , NPK.*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Bioavailability of Manganese in Two Acid Latosols (oxisols) under Different Rate Covers

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Manganese is a nutrient essential for plants and animals and its bioavailability in tropical acids soils are between 2 to 50 mg / kg (1.0 M NH4OAc). In well-aerated soils, the Mn content increases with acidity soils and available decreases with pH increases, due the insoluble hydroxide formation. On the other hand, in poorly aerated soils or anaerobic soil environments, the solubility of Mn increases the microbial reduction of MnO2 and reduces the reoxidation of Mn2+ O2 after water drainage. Thus the aim of this study was to evaluate the availability of manganese in different environments under rate of vegetation cover. Samples of two acids Latosols, Dystropherric Red Latosol ? DRL1 with clayey texture and Dystrophic Red Latosol? DRL2 with clayey texture were collected at 5 to 25 cm depth. These soils has the following chemical properties: (DRL1: pH 4.58, carbon organic content 9.95 g / kg, 7.75 cmol / kg, clay 760 g / kg, silt 170 g / kg and 70 g / kg of sand and DRL2: pH 4.18, organic C 20.28 g / kg, H + Al 12.36 cmol / kg, 420 g / kg of clay, 50 g / kg of silt and 530 g / kg of sand) incubated with 150 days 137.5 mg / kg of Mn2 +. The experiment was conducted at the Experimental Station of the Agronomic Institute of Parana - IAPAR in Londrina County, Northern of the State of Parana - Brazil. The concentration of available Mn (1.0 M NH4OAc) after seven days to 150 days of incubation ranging from 3.0 to 123.5 mg / kg in the acid soil DRL1, and 69.8 and 2.5 mg / kg in acid soil DRL2. After incubation, these soils were dried / burned between 25 ºC to 800 ºC and available Mn and total Mn2+ (three successive extractions with EDTA at concentration 0,1 M).The levels of available Mn extracted from DRL1 and DRL2, with different drying temperatures / incineration were : T = 25 ºC : 3.0 and 2.5 mg / kg ; T = 105 ºC: 131.5 and 89 5 mg / kg, T = 220 ºC : 73.5 and 35.5 mg / kg; T = 800 ºC : 26.4 and 25.2 mg / kg. The values of the total Mn2+ were extracted: T 25 ºC : 330.2 and 112.4 mg / kg ; T = 105 ºC: 327.8 and 114.9 mg / kg ; T = 220 ºC: 281.2 and 98.4 mg / kg , T = 800 ºC : 50.5 and 33.1 mg / kg. Mn concentration of available soil increased from T 25 to T 105 ºC (the increases were 43.8 times for DRL1 and DRL2 35.8 times), but decreased above 220 ºC and T decrease was greater for T 800 0C . On the other hand, the total Mn2+ showed similar values until to T 105 ºC in both soils, decreased to above 220 ºC and lower values was for the temperature equal to 800 ºC.
The increases in Mn available were for the treatments T = 25 ºC to 105 ºC, which was probably due to the decomposition of the organic complex ligands MnLn by heating and drying. The decomposition of these organic complex ligands increaseases the solubility of Mn2 +. The increase in available Mn observed in land areas without covers should also be by this mechanism . On the other hand, the decrease in soils with Mn incubated available suggests the formation of stable complexes with organic ligands MnLn exudates of microorganisms. The decreases observed in available Mn and Mn 2 + to total soil T 220 ºC , suggests the adsorption of Mn 2 + in oxides of Fe and Mn from soils and T 800 ºC was by thermal oxidation of Mn2+, forming insoluble MnO2 .Based on the results, Mn2+ bioavailability on the soil surface is related to wetting and drying cycles. Also, the increases in the Mn2+ bioavailability is due to organic complexes ligands MnLn decompositions caused by direct solar radiation on the soil surface. The decreases of available Mn might be due formation of complexes among manganese and organic exudates liberated by microorganisms.

Keywords : *wetting and driyng cycles, manganese dynamics, organic complexes ligands*

P3-410

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Effect of Different Potassium Level on Growth and Fruit Yield of Camellia Oleifera Chang-Lin Series

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INTRODUCTION

Camellia oleifera Abel in the genus camellia L. of family Theaceae, is one of the specific woody-oil plants in China, and most important economic tree in Jiangxi Province, southern of China. Many works have been done on the nutrient management of C. oleifera Abel, but most were focus on the young or low-yielding C. oleifera Abel. With the large area of young C. oleifera Abel entered to the mature stage, the nutrition requirement of C. oleifera Abel, especially for the demand of potassium (K) and phosphorus (P), is dynamical changed during different growth stages. But in most part of the C. oleifera Abel planting regions the soil is red, which is weak in keeping the potassium, so it is essential to acquire the demand and the optimal fertilizing of potassium.

METHODS

The experiment was studied in three blocks of Chang-Lin series C. oleifera Abel cultured in 2005 in Yongfeng in the middle part of Jiangxi Province. All of the three blocks include both species Chang-Lin 27 and Chang-Lin 53. Six gradient concentrations (K0: 0, K1: 60, K2: 120, K3: 180, K4: 240, K5: 300 gram/strain) of K were set in each block, based on the determination of optimal nitrogenous and phosphate fertilizer. Five strains have been taken up as the replication in each concentration. All the trees in this experiment were fertilized twice a year (Apr and Oct), with the same nutrients except the concentration of potassium. The length and diameters of spring shoots, area of leaves, SPAD of each strain were detected at the same time in 2011 and 2012. The fruits were harvested in October and oil yield was detected based on the Soxhlet extraction method.

RESULTS AND DISCUSSION

Variance analysis has been made on the length and diameters of spring shoots, area of leaves, SPAD, fruit yield and oil yield under different levels of potassium. The results showed that potassium has significant effect on leaf area, diameter of spring shoots and fruit oil yield of C. oleifera Abel, but not so much effect on the length of spring shoots, fruit yield and SPAD in short time. The results showed as follows:

(1) All potassium treatments showed higher values of SPAD than that of the control samples (K0, K2O 0 g/strain), and the optimal treatment was K3 (K2O 180 g/strain). Interestingly, The Chang-Lin 53 species have more obvious increasing range than the Chang-Lin 27 species.

(2) Potassium didn't affect obviously the length of spring shoots, but affected the diameters of spring shoots and the area of leaves. The best option was K3 (K2O 180 g/strain). It was obviously different with other treatment.

(3) The two series has different rule of potassium needs. The fruit yield and oil yield increased by 51.52% and 26.54% in Chang-Lin 53 series respectively under the treatment of K3 (K2O 180 g/strain).But fruit yield and oil yield increased by 139.90% and 25.64% in Chang-Lin 27 series respectively under the treatment of K4(K2O 240 g/strain).

(4) Strain was the main point effect on fruit yield, but the oil yield was mainly determined by potassium level.

CONCLUSIONS

Potassium showed positive stimulation on the growth and fruit yield of Camellia. Based on overall consideration of various factors, the optimal concentration of K3 (K2O 180 g/strain), which has significant effect on the value of leaf area, diameter of spring shoots and oil yield.

ACKNOWLEGEMENT

Acknowledgement:The work reported here has been funded by IPNI (Jiangxi-29) and the National Natural Science Foundation of China (31260194）,(30960312),（31360177）and National Science and Technology Support Project (2012BAC11B06),The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports..

Keywords：*Camellia oleifera*；*Potassium;Chang-Lin series*

P3-411

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Nutrient Contents in Various Purple Soils and Their Effects on Nutrient Distribution in Flue-Cured Tobacco in Jiangxi Province

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Soil and tobacco samples were collected by point to point (namely the location of soil sample was same to that of the tobacco sample) in purple soil (Purpli-Orthic Primosols) and were tested in 2009 to investigate nutrient distribution in flue-cured tobacco planted in different types of purple soil in Jiangxi province. Results showed that soil available N, P, K and total N, P, K was 52.8mg/kg, 14.4mg/kg, 152.2mg/kg, 0.78g/kg, 0.75g/kg, and 17.7g/kg, respectively in purple soil. Purple soil, in generally, was characterized low nitrogen, low phosphorus and high potassium, correspondingly tobacco phosphorus content were low and potassium content was high, suggesting that application of phosphate fertilizer should be moderate in purple soil. Among the studied tobacco in different purple soils, there was no significant difference in tobacco nitrogen content and phosphate content, but absorption of nutrients of potassium was better in alkaline purple soil. Nutrients distribution in tobacco leaf were that content of phosphate rose with position of leaves from lower to upper in acid and neutral purple soils, and content of nitrogen and phosphate showed no significant difference with the position of leaves. the exchangeable Ca was sufficient and greatly variable, while the exchangeable Mg was low and the ratio of exchangeable Ca to Mg was high, so the concentration of Ca in leaves was variable and the concentration of Mg was low; the concentration of Mg in tobacco leaves was neutral purple soil > acid purple soil > alkaline purple soil. In the neutral purple soil, the concentrations of Ca and Mg in difference position of leaves were not significant difference, but in the acidic and alkaline purple soils the concentrations of Ca and Mg in the upper leaf were higher than those in the middle and lower leaves.

Keywords：*purple soil; flue-cured tobacco; nutrient distribution; leaf position*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Effect of Molybdenum on Nitrogen Fixation and Rhizobial Diversity of Hairy Vetch (*vicia Villosa* Roth) in Korean Soil

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Molybdenum (Mo) is an essential micronutrient for plants and microorganisms. It plays an important role in nitrogen (N) metabolism and protein synthesis. Hairy vetch (*Vicia villosa* Roth) is a leguminous cover crop used with barley as green manure, the most popular practice in South Korea for reducing use of chemical fertilizer and maintaining soil fertility. In root nodules of Hairy vetch (HV), Rhizobia (R) bacteria require Mo to fix atmospheric or molecular N. In N_2 fixing systems, Mo acts as a co-factor of the proteins responsible for electron transfer in the synthesis of the nitrogenase complex which is responsible for conversion of N_2 into ammonium. The symbiosis association (R-HV) induces important physiological changes in each partner that lead to reciprocal benefits, mainly in nutrient supply like improve N_2 fixation, nitrogenase activity, nitrate reductase activity and crop biomass production. A pot experiment was conducted in green house of College of Agriculture and Life Science, Gyeongsang National University, South Korea during 2012 to study the effect Mo enhance in nodulation, nitrogenase and nitrate reductase enzyme activity that influence on biomass production and nitrogen fixation. For this study, Mo was applied 0, 0.25, 0.5, 1.0, 2.0 kg ha^{-1} before seed sowing and native soil rhizobia inoculation were performed nodulation. To know the effective nitrogen fixation, nitrogenase activity of hairy vetch root nodule was measured by acetylene reduction assay. Mo applications were increased nodule number and weight of hairy vetch that in turn enhanced nitrogenase and nitrate reductase activity of nodules. Mo application 1kg ha^{-1} produced highest plant nodule number (60 nodule $plant^{-1}$), nodule weight (52.3 mg $plant^{-1}$), root biomass (0.35 g $plant^{-1}$) and above ground biomass (5 g $plant^{-1}$), chlorophyll content (34.9 chl. cm^{-1}), nitrogenase activity (1797.5 μmol C_2H_4 $plant^{-1}$ $hour^{-1}$) and nitrate reductase activity (3.91 mg kg^{-1}) compared to native control soil, respectively. The highest nitrate-N content of Mo 1kg ha^{-1} treatment might be contributed to the highest nitrogenase and nitrate reductase activity of hairy vetch plants. The increased nitrate reductase activity from hairy vetch leaf and root due to Mo application in hairy vetch cultivation indicated that Mo application in leguminous crop is an important factor to determine N fixation and transformation in plant. Immunofluorescence microscopy results were indicated that cell growth and function of nodules were optimum in Mo 1kg ha^{-1} applied Hairy vetch plants . Rhizobial 16S rRNA gene cloning and sequencing results indicated that a wide range of Rhizobium bacteria posses in different cluster regulated in N_2 fixation. Therefore, optimum Mo application (1kg ha^{-1}) was probably the best appropriate dose showed better performance than that of native soil in respect of plant biomass production, nodulation and nitrogen fixation of Hairy vetch.

Keywords：*Molybdenum, nitrogenase activity, nitrate reductase activity, biomass, 16S rRNA gene, Hairy vetch.*

P3-413

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Enhancement of Phosphate and Zinc Solubilization by a Novel Plant Growth Promoting Bacteria Strain Gluconacetobacter Sp. In Soil Amended with Humic Acid

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Phosphorus (P) is one of the essential nutrients required for plant growth. But the concentration of soluble phosphate in soil is usually low because a great portion of phosphate ion is rapidly immobilized into insoluble form by clay mineral cations, which can be regarded as unavailable to plants. On the other hand, the high phosphate levels are one of the most common causes of zinc (Zn) deficiency in crops encountered in the world. Zn is also the trace element found in soil with various concentrations, which is necessary for healthy growth and increasing reproduction rate of crops. Consequently, the deficiency of plant-available P or Zn cause the usage of excess chemical fertilizers, leading to cause environmental and economic problems.

To solve these problems, some eco-friendly materials were researched for a number of years. Plant growth promoting bacteria (PGPB) is one of the material that are able to exert a beneficial effect upon plant growth. For example, increasing the concentration of bioavailable phosphate by solubilization of insoluble phosphate (IP) form is well known mechanism to enhance plant growth, directly. Another material is humic acid (HA) that is a principal component of humic substances and the major organic constituents of soil produced by the microbial degradation of various organic matters. HA affect not only on the dissolution of IP, but also absorption of Zn in soil. Although interactions among these components have been recognized, the actual mechanisms are still not completely understood. Therefore, the purpose of the present study was to characterize novel PGPB strain and HA to maintain appropriated level of P and Zn in soil instead of using chemical fertilizers.

Novel PGPB strain was isolated from the rhizosphere soil and the leaves of bamboo. Strain G1 was selected and identified as the Gluconacetobacter liqufaciens with 97% homology by alignment data of 16S rRNA gene nucleotide sequences. (GenBank KF 744432) Solubilization of phosphate by G1 was quantified using tricalcium phosphate in NBRIY and the assay of soluble phosphate production was measured by the vanadomolybdophophoric acid colorimetric method. The highest soluble phosphate production under optimal condition was 732mg/L after 4 days of aerobic incubation. It was associated with a drop in the pH of the culture medium. Strain G1 could readily tolerate several environmental condition, especially high level of salt and various IP. Strain G1 showed other beneficial influences on plant growth, indirectly; (1) producing 22μg/ml of indole-3-acetic acid for enhancing plant biomass, and (2) having antifungal activity against plant pathogenic fungi by producing siderophore and hydrolytic enzyme.

To test the effect of PGPB and HA on solubilization of IP, bacterial suspension in sterile deionized water was added to sterile soil (pH 6) treated with 500mg/kg HA and various level of tricalcium phosphate (0, 200, 400, 800mg P / kg soil). Plant-available phosphate was analyzed using ICP-OES for the Olsen-P method. G1 inoculation increased the phosphate solubilization 31.5%, 29%, 29% and 27.8%, respectively. Compare to the control groups, these result suggest that both HA and PGPB could give positive effect on solubilization of phosphate in soil.

Also, we carried out the experiment to investigate the interaction among these components on Zn solubilization. Plant-available Zn was extracted by CaCl2 and analyzed using ICP-OES. First, we assured that G1 mobilized unavailable Zn by their organic acid and enzyme production. Second, plant-available Zn was decreased in the HA containing group by absorption capacity of HA. Lastly, in the presence of IP, plant-available Zn value was lower than the soil in the absence of IP. This result indicates that phosphate salt may immobilized Zn in the soil. Therefore, the addition of phosphatic fertilizer is probably relevant to zinc deficiency.

In conclusion, novel PGPB strain G1 with HA is suitable to maintain appropriated level of P and Zn in agricultural soil.

Keywords：*Plant growth promoting bacteria, Humic acid, Solubilization, Phosphate, Zinc*

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[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Influence of Chelating Agents and Nitric Acid on the Growth of Cherry Tomato and Solubilization of Accumulated Phosphate in Soils

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Intensive agriculture in the plastic film house has applied a high level of inorganic fertilizers and livestock composts, which were resulting in the phosphate accumulation in cultivated land of Korea. The techniques for utilizing the accumulated phosphate in the plastic film house are considerably needed. This study is to evaluate the effects of chelating agents and nitric acid for the reduction of accumulated phosphate and the improvement of plant growth in plastic film house of on-farm. The available phosphate content was 1,972 mg kg-1, which was about 4 times higher than that of optimum range for crop growth. The treatments were control, chemical fertilizers application(NPK), chelating agents application(citric acid, oxalic acid, acetic acid, EDTA and DTPA), chelating agents plus chemical fertilizers(NK) application(citric acid+NK, oxalic acid+NK, EDTA+NK and DTPA+NK), and nitric acid. The Citric acid, oxalic acid, acetic acid, EDTA, DTPA , and nitric acid were treated with by concentration 0.001, 0.005, and 0.01M. The application of chelating agents was induced to the increase of P solubilization with 0.01M of DTPA, EDTA and citric acid. The growth and phosphate uptake in Cherry tomato were increased more in mixed treatments(chelating agent plus NK fertilizers) than in single treatments with chelating agents. Especially, the yield and phosphate uptake of cherry tomato was treatment was higher in DTPA 0.001M+NK treatment than the other treatments. Consequently, DTPA was effective as chelating agents to improve phosphate availability and crop productivity in soil of highly accumulated phosphate.

Keywords：*Chelating agents, phosphate accumulation, phosphate solubilization, uptake efficiency, cherry tomato*

P3-415

[C3.3-2] Advances in Rhizosphere Regulation and Soil Nutrient Management

Biomass Production in Pure and Mixed Barley-Hairy Vetch Green Manure and Its Effects on Rice Production

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The use of green manure crops such as barley and hairy vetch is the most popular practice in Korea for reducing use of chemical fertilizer and maintaining soil fertility. The mixtures of legumes and non-legumes can be an efficient tool to combine the benefit of the single species in the cover crop practice. However, there is a lack of information on how the species proportion may affect biomass production and nitrogen (N) accumulation and how this can influence to the subsequent rice production. In this study the effect of barley and hairy vetch grown in pure stands or in mixtures with different sowing proportion on biomass production and nitrogen accumulation was tested. All aboveground biomass of green manure was incorporated for rice cultivation before one week of rice planting. The standard sowing rates was 180 kg ha^{-1} for barley and 90 kg ha^{-1} for hairy vetch. The following seed mixture ratios were selected according to the replacement principle: barley 100% (180 kg ha^{-1}, B100), barley 75% + hairy vetch 25% (135 + 22.5 kg ha^{-1}, B75H25), barley 50% + hairy vetch 50% (90 + 45 kg ha^{-1}, B50H50), barley 25% + hairy vetch 75% (45 + 67.5 kg ha^{-1}, B25H75) and hairy vetch 100% (90 kg ha^{-1}, H100). No chemical fertilizer was used in green manure and rice cultivation but only standard fertilizer (N-P_2O_5-K_2O:90-45-58 kg ha^{-1}) was fertilized in control plots (NPK) without green manure cultivation. The experimental design was completely randomized block with three replicates in 2012-2013. Aboveground biomass and N accumulation of mixture was higher compared with that of pure barley and hairy vetch. Among the mixture, the highest aboveground biomass and N accumulation was observed in B75H25 in 2012 and B25H75 in 2013. The N accumulation of the mixture ranged from 99 kg ha^{-1} to 131 kg ha^{-1} in 2012 and 169 kg ha^{-1} to 186 kg ha^{-1} in 2013 which was much higher than amount of standard N fertilization rate (90 kg ha^{-1}) for rice cultivation in Korea. The C/N ratio of pure barley was high (C/N 44) which greatly affected by mixture with hairy vetch (C/N ranging from 26 to 35). All mixture produced 7-8% higher rice yield than the conventional cultivation (NPK) but B100 was 4-5% lower yield than that of NPK. These results indicate that adopting mixtures between barley and hairy vetch can be efficient strategy for rice production without nitrogen fertilizer.

Keywords：*Barley, Hairy vetch, Green manure, Cover crop, Nutrient balance, Nitrogen*

P3-416

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Contributions of Manures to Soil Phosphorus Fractions and Their Relationship with Maize Dry Matter Yield and P Uptake in Two Tropical Soils

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The aims of the experiments were to determine the effect of manure amendments on P fractions of two tropical soils. Cured poultry (PM), cattle (CM), goat (GM) and horse (HM) manures were incubated for two weeks at 120 kg P ha-1 for single manures and 60 kg P ha-1 each for two manure mixtures. Treatments were control, PM, CM, GM, HM, PM+CM, PM+GM, CM+GM and PM+HM. Sequential extraction was done for available P, labile P, Al and Fe P, Ca-P and residual P. Maize was grown in the manure amended soil for 6 weeks and analyzed for P uptake. PM increased the P fractions except Al and Fe P in acid soil while cattle manure increased available and labile P. PM + GM complemented the effect of sole addition of GM, at increasing soil labile P, Ca-Po and residual P. Cattle and goat manure mixture increased all P fractions compared with applying either of the manures singly. Bray-1 and NaHCO3 extracted P had positive correlation with maize plant height, root weight, shoot weight and P uptake. Poultry manure because of its richer nutrient composition should be use in combination with other manure types when considering manure mixture.

Keywords：*Animal manures ; maize P uptake; phosphorus fractions; Tropical soils; manure mixtures*

P3-417

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Experimental Assessment of Phosphorus from Bounded Runoff Plots under Natural Rainfall as Affected by the Application of Manures

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Among the nutrient elements, phosphorus (P) is second to nitrogen in its impact on the productivity and health of terrestrial and aquatic ecosystems. Low P availability in agricultural soils leads to major social and environmental problems, forcing farmers to clear more lands in order to produce enough food to survive. The cleared lands are subjected to erosion that further degrades the soils and pollute rivers and streams with sediment laden runoff. This study presents experimental findings on the effects of phosphorus on the environmental quality relate to soil P land degradation caused by very little supply of P and accelerated eutrophication caused by too much P. The research was conducted in continuous cropped arable runoff experimental plots located at Faculty of Agriculture Teaching and Research Farm (FATRF), Afaha-Oku, University of Uyo, Nigeria. The experimental field measuring 0.5 ha on a slope of 15 % was prepared 12 plots; each 60 x 5 m2, separated from each other by earthen bounds was prepared by ploughing and harrowing during the season. Poultry manure of 30 t ha-1 and NPK fertilizer, 600 kgha-1 were allocated to the experimental plots planted to cassava in three replicates inorder to measure P concentration between fertilizer types. The samples were analysed for Bray-PI, Mehlich III-P, and water extractable P. It is worthy of note that, the extractable fractions of phosphorus in soil are the possible content which can be taken up by the plant roots, while the amount in the runoff often give an idea of the size of pool that might be emptied into the water body and caused eutrophication. The data were statistically analysed using SPSS for Windows. The plots amended with manure tremendously increased the P concentration in water above 0.03 mg/L limit of dissolved P which eutrophication is likely to be triggered.

Keywords：*Phosphorus, runoff, slope, manure, cassava, rainfall*

P3-418

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Development of an Alternative to the Olsen Test for Determining Corn Plant-Available Phosphorus in Calcareous Soils

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Corn is the highest-yielding cereal and regarding the total value of the production, it is considered the third world's cereal product after wheat and rice. Precise extracting and measuring the amount of phosphorus (P) which the plants will uptake during growth period is impossible before its cultivation, though it is possible to extract the P from its different chemical fractions from the soil by different extractants which have statistically good correlation with the uptake P by plants. Since 1954, P extraction by Olsen's test was one of the most used tests for non-acidic soils. Olsen's method is mainly based on phosphate solubility in calcareous soils though this method has been used in acid and neutral soils. In many countries, a 0.5 M solution of NaHCO3 at pH 8.5 is widely used as a soil test for P. Most of workers have used this pH and concentration but the shaking time has varied from 30 minutes to 2 hours up 16 hours. As an extractant, NaHCO3 acts through pH and ion effect to remove soil solution inorganic P, plus some organic P and some labile solid-phase P compounds such as phosphate adsorbed to free lime, slightly soluble calcium phosphate precipitates, and phosphate loosely adsorbed to Fe and Al oxides and clay minerals. NaHCO3 also removes labile organic P forms that may be readily hydrolyzed to inorganic forms and contribute to plant-available P or be re-assimilated by microorganisms. In this research, several chemical extractants and modified Olsen methods were studied in 25 surface-calcareous soils (0-30 cm) for determining available phosphorus (P) for corn (Zea mays L.) plant. In this experiment, the highest correlation was obtained between extracted P by Olsen and Colwell methods (NaHCO3-extractable P) and dry weight of corn shoot (r =0.67 and 0.75, $p<0.01$, respectively). Therefore, effects of varying effective conditions of extraction such as the period of shaking, the concentration and pH of NaHCO3 solution on the amount of P extracted from the soil and its correlation with growth parameters of the corn plant was investigated. The results showed that increasing the pH of NaHCO3 solutions, solution: soil ratio, shaking period and concentration of NaHCO3 solution significantly increased the extracted P from the soils, but could not significantly increase the correlation between P extracted from the soil and growth parameters of the corn plant. The highest correlation was obtained between modified Olsen method (with 4-hour shaking period and the solution: soil ratio of 6) and shoot dry weight ($r=0.75, p<0.01$) which did not have significant difference (?r=0.08)with Olsen's test(0.5hourshaking time and solution: soil ratio of 20). The results of this study showed that P buffering capacity, PBC (Olsen-P/Paawu-P) could be the best method for predicting the available P by the corn plant.

Keywords：*phosphorus, Olsen test, corn, calcareous Soils*

P3-419

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Effects of Different Fertilizer Treatments on Nutrient (phosphorus) Release Pattern in an Ultisol of Anyigba, Kogi State

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Incubation study was carried out to assess the effect of Pacesetter A and B organic fertilizer, Sunshine organic fertilizer, Cowdung and Single super phosphate fertilizer treatment on soil nutrient (P) release pattern. The study was conducted in Soil and Environmental Management Laboratory, Kogi State University, Anyigba in 2013. Two levels of Pacesetter A and B at 100kg/ha, sunshine at 100kg/ha, Cowdung at 100kg/ha, SSP at 100kg/ha and combination of PSA + SSP at 50kg/ha, PSB + SSP at 50kg/ha, Sunshine + SSP at 50kg/ha, Cowdung + SSP at 50kg/ha and a control were used. These fertilizers were separately mixed with soil constituents. The design was CRD of ten treatments replicated three times giving a total of thirty experimental units. The treatments were replicated thirty (30) times on completely randomized design and samples were taken at 2, 4, 6, 8, 10 weeks intervals after incubation respectively for analysis. Thirty sub-soil samples were dried, analysed and discarded each weeks. The results indicated that Pacesetter A and B (fortified) and Sunshine releases more phosphorus content following application of equal rate of organic fertilizer at 100kg/ha, while Cowdung and SSP recorded low releases. The usage of sole organic fertilizer was effective compared to inorganic in terms of responses of some parameters. The sole organic phosphorus proportion of 100kg/ha gave the best responses to nutrient released in almost all the parameters in the experiment.

P3-420

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Soil Organic Phosphorus Transformations along a Coastal Dune Chronosequence under New Zealand Temperate Rain Forest

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The chemical composition of soil phosphorus can vary markedly during pedogenesis, which influences phosphorus availability to plant and microbial communities during long-term ecosystem development. We used NaOH?EDTA extraction and solution 31P NMR spectroscopy to examine changes in soil phosphorus composition along the Haast chronosequence, a 6500 year chronosequence of coastal dunes under lowland temperate rain forest on the west coast of the South Island of New Zealand. We previously reported a rapid decline in primary mineral phosphate and parallel accumulation of organic phosphorus during podzol development along the sequence, with parallel shifts in the community composition of plants and microbes. Sols along the chronosequence contained a variety of inorganic (orthophosphate, pyrophosphate, and long-chain polyphosphate) and organic (phosphomonoesters, phosphodiesters, and phosphonates) phosphorus compounds. However, long-chain polyphosphates were detected only in the organic horizon and phosphonates only in mineral soil. The concentrations of most compounds increased initially during the first few hundred years of pedogenesis, and then declined as soils aged. However, the concentrations of phospholipids, DNA, and long-chain polyphosphate all increased markedly in the organic horizon in older sites. The four inositol hexakisphosphate stereoisomers (myo, scyllo, neo, and D-chiro) accounted for a considerable proportion of the phosphomonoesters in mineral soil (36-52% of the organic phosphorus), but were not detected in the youngest soil or the organic horizon at any site. Concentrations of the two most abundant isomers (myo¯ and scyllo) declined along the chronosequence, but the scyllo isomer increased markedly as a proportion of the extracted phosphorus as soils aged. Amorphous aluminum and iron oxides (i.e. extractable in acid-ammonium oxalate) increased continually throughout the chronosequence, indicating that the associated decline in inositol hexakisphosphate is linked in part to strengthening phosphorus limitation and selection of phytate-degrading organisms rather than a decline in stabilization potential, as was previously suggested for the nearby Franz Josef chronosequence. Overall, these results provide further evidence that the composition of the organic phosphorus pool varies markedly during pedogenesis, and have important implications for our understanding of biologically-available organic phosphorus during ecosystem development.

Keywords：*Haast chronosequence, phosphomonoesters, phosphodiesters, DNA, inositol phosphate.*

P3-421

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Changes in P Pools over Three Months in Two Soils Amended with Legume Residues

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To assess the importance of soil properties and residue addition on soil P pool concentrations, we added residues from three different legumes to two soils with contrasting physical and chemical properties and measured the concentration of P pools over three months. Three legume residues differing in total P and N and water-soluble P concentrations were used: faba bean (Vicia faba) (high), chickpea (Cicer arietinum) (medium) and white lupin (Lupinus albus) (low), were added to the soils at a rate of 20 g residue kg-1 soil. The size of various P pools was assessed by sequential P fractionation on days 0, 14, 28, 56, 70 and 98.The alkaline Monarto soil which had a low organic matter content, was characterised by high concentrations of HCl-Pi whereas the concentrations of NaHCO3-Po, NaOH-Pi and Po and residual P were high in the acidic Mt. Bold soil with high organic matter content. Addition of faba bean and chickpea residues increased the concentrations of resin P, microbial P, NaHCO3-Pi temporarily whereas amendment with white lupin residues had little effect on P pool concentrations. The decrease in NaHCO3-Po and NaOH-Po towards the end of the experiment coincided with an increase in NaOH-Pi in Mt. Bold soil and of HCl-Pi in Monarto soil. These temporal changes were more pronounced in soils amended with faba bean and chickpea residues than in the unamended soil or after addition of white lupin residues. The principal component analysis (PCA) plot showed that the P pool concentrations on days 0 and 98 were quite similar and differed from those on days 28, 56 and 70 suggesting clear temporal patterns. The results of this study show that the concentration of various P pools is strongly affected by soil properties such as pH and organic matter content which are further modulated by the properties of the residues. However, residue addition had a limited long-term effect on P pool concentrations.

Keywords：*C/P ratio, legume residue, P fractionation, soil properties*

P3-422

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Zinc Requirement for Optimum Grain Yield and Zinc Concentration Depends on Phosphorus Application to Wheat Cultivars

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Zinc (Zn) and phosphorus (P) deficiencies are common on calcareous soils hampering wheat yield. Both of these nutrients interact in soil as well as in plants influencing their availability. Cultivars vary in their requirement and uptake capacities of P and Zn, hence their interaction may also differ among different cultivars. The experiment was conducted to study the differential behavior of 4 wheat cultivars to applied P (0, 60 and 120 mg kg-1 soil) and Zn (0 and 6 mg kg-1 soil).

Application of both Zn and P increased grain yield of all the tested wheat cultivars (Shafaq-2006, Auqab-2000, Pasban-90 and Pak-81). Calculations of deficiency stress factors for P and Zn confirmed higher demand of one nutrient at a higher application rate of the other nutrient. On average, P stress factor was 12 % decreased with Zn application in all four wheat cultivars. The content of Zn and P in grains also increased with the application of both Zn and P. However, concentration of either nutrient in grain was decreased with the application of the other. In general, application of P increased while application of Zn decreased the grain P concentration which ranged from 3.8 (in Auqab-2000 supplied with 6 mg Zn and 0 mg P g-1 soil) to 7.0 mg g-1 (in Pak-81 supplied with 0 mg Zn and 120 mg P g-1 soil). Concentration ratio of P to Zn in wheat grains was influenced by Zn application to wheat cultivars especially at higher rates of P application. Pasban-90 and Pak-81 had greater P:Zn concentration ratio in grains (390 and 400) at 120 mg P g-1 soil. At 60 mg P g-1 soil, however, only Shafaq-2006 had significantly less P:Zn concentration compared to other cultivars. Concentration of Zn and P:Zn concentration ratio were much more dependent on Zn application to the tested wheat cultivars especially at higher rates of P application. Therefore, Zn application aiming at optimum grain yields and grain Zn concentration depends on genotypic variation in wheat cultivars and rate of P.

Keywords：*Calcareous soils, P-Zn antagonism, Wheat grain*

P3-423

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Study on Phosphorus Leaching Risk and Quantitative Assessment of Cultivated Soils in Subtropical Area of China

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Phosphorus (P) leaching, associated with the excessive fertilizer application and subsequent P accumulation in surface soil, has widely been considered as an important pattern of agricultural non-point source pollution. However, up to now, there is still no suitable approach for quantitative assessment of soil P leaching risk. In this study, a simple soil column method was developed to determine the thresholds of P leaching risk and to evaluate the P leaching intensity of surface soil. Twelve representative cultivated soil samples belonging to five orders (Agrudalf, Fluvents, Orthents, Orthox, and Udalfs) were selected from subtropical area of southern China and soil basic properties such as soil organic matter (SOM), pH, active Fe/Al/Ca/Mg contents, cation exchangeable capacity (CEC), and clay/sand contents, were tested. A series of soil P levels were adjusted by adding P fertilizer into each type of soil. The soil column was 20 cm in length and 5 cm in diameter, and distilled water was continuously supplied from the top. The volume and dissolved reactive P (DRP) concentrations of leachate were measured. Results showed that DRP concentrations increased slowly for low soil Olsen-P (OP) levels but rapidly for high OP levels. Depending upon these two-phase changes in the DRP with OP, the thresholds of soil P leaching risk, ranging from 32.0 to 142.0 mg kg-1 (OP) for the twelve tested soils, was noticed. These values were basically comparable to those, ranging from 30.9 to 122.8 mg kg-1 (OP) determined using chemical extraction method depending on the relationship between soil 0.01 M CaCl2-extracted P and OP, which was developed by Heckrath et al. (1995). The assessed annual P leaching intensities (LI) varied in a wide range from detected for Orthents to 2.77 kg P ha-1 for Fluvents, which increased by 3 to 540-fold provided OP at the level of 20 mg kg-1 and annual infiltration amount by 700 mm. Results of principle component analysis showed that the thresholds were positively related to CEC and SOM, while LI was positively related to sand% and SOM but negatively related to SOM and clay% at a similar soil OP level. This study is an attempt to develop a new method by which could simultaneously assess the threshold and intensity of soil P leaching risk.

Keywords：*phosphorus leaching;extraction method; soil column method; soil property; subtropical area of China*

P3-424

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Plant Species Richness but Not Management Affects Microbial Phosphorus Concentrations in Grassland and Forest Soils

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There is growing evidence that phosphorus (P) nutrition is crucial for productivity both in grassland and forest ecosystems. One pathway that could further constrain P supply for plant growth is microbial P (P_{mic}) immobilization in soil.

Our objectives were (i) to identify the abiotic variables controlling P_{mic} concentrations in grassland and forest soils and to assess the effect of (ii) land use and (iii) plant diversity on P_{mic} concentrations in soil. Our study forms part of the "Biodiversity Exploratories" comprising experimental plots of differing land-use intensity (LUI) and differing biodiversity in the Swabian Alb (ALB), Hainich-Dün (HAI), and Schorfheide-Chorin (SCH), Germany. Each region comprises 50 plots in grassland and 50 plots in forest soils resulting in a total number of 300 plots. The mean concentrations of P_{mic} in grassland and forest soils followed the order ALB > HAI > SCH. For grasslands and forests, P_{mic} concentrations correlated positively with total organic P concentrations ($r = 0.29$ and 0.43, respectively, $p < 0.01$) indicating the importance of organic matter as substrate for microorganism metabolism. In line with other studies, neither land-use types (pasture, mown pasture, meadow) nor LUI nor management measures (fertilization) had significant effects on concentrations of P_{mic} in grasslands. Similarly, we found no effect of tree species or management intensity (managed versus near-natural) in forests. However, with increasing plant species richness, P_{mic} and C_{mic}:P_{mic} ratios increased in grassland and forest soils ($0.30 < r < 0.43$, $p < 0.001$). Thus, microorganisms exploited the bioavailable P pool in soil very efficiently in ecosystems of high plant species richness maybe because of an increased contribution of mycorrhizal fungi as compared to less diverse ecosystems. Comparing high and low plant species richness, we already showed higher P exploitation by highly diverse plant communities. Therefore, particularly in ecosystems of high plant diversity the competition for P between plants and microbes in soil plays a role for plant P nutrition.

Keywords：*microbial phosphorus, plant diversity, grassland and forest soil, land use*

P3-425

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Predicting Soil Organic Phosphorus Using Near-Infrared Reflectance Spectroscopy

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Organic phosphorus (OP) is abundant in soil and is an essential source of phosphorus for plants. To date, however, there is no direct method to quantify the total concentration of OP in soils. Indeed, OP can only be estimated indirectly by ignition (Saunders and Williams, 1955) or extraction (Hedley et al., 1982; Tiessen and Moir, 2008). Near-infrared reflectance spectroscopy (NIRS) is a direct, rapid, inexpensive, and accurate analysis technique for a wide variety of materials and it is increasingly used in soil science. The aim of this study was to examine the potential of NIRS to predict total soil OP. Soil samples (n = 120) were taken from an experimental site near Indian Head, SK, Canada, from short-term (8 years) and long-term (>28 years) conservation tillage plots of a field pea □ spring wheat rotation receiving P fertilizer annually (0, 11, 22, 33, or 45 kg P2O5 ha-1). Samples were collected at three soil depths (0-7.5, 7.5-15, and 15-30 cm). Soil total OP was determined by the ignition method (Saunders and Williams, 1955). Calibration NIRS equations were developed using 80% of the soil samples and the partial least squares regression while the remaining 20% of samples were used for validation. The predictive ability of NIRS was evaluated using the coefficient of determination of validation (R2) and the ratio of standard error of prediction to standard deviation (RPD). Results show a moderately successful NIRS prediction for total OP ($0.80 \leq R2 < 0.90$ and $2.25 \leq RPD < 3.00$). The NIRS predictive ability of OP appears to be related to the relationship with soil organic carbon. This NIRS prediction model should be validated with a greater number of samples of more diverse soils. Further studies are needed to evaluate the potential of NIRS for predicting the chemical forms of soil OP.

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Keywords：*Organic phosphorus, NIRS*

P3-426

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Unbiased Statistical Analysis of Soil P Forms Determined by 31p-Nmr Spectroscopy

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Phosphorus (P) forms determined by 31P nuclear magnetic resonance spectroscopy (31P–NMR) are computed as proportions of total P (TP) and hence are constrained between 0 and 100%. As such, these P forms can be defined as compositional data, i.e. strictly positive data characterized by a constant sum and considered to be parts of a whole, providing only relative information (Aitchison, 1986; Egozcue et al. 2003). Because compositional data are intrinsically related to each other and do not follow a normal distribution, a simple log transformation, variable by variable, or any other transformation of the single compositional variables provide statistically erroneous results that depend on measurement scale (Reimann and Filzmoser, 2000; Filzmoser et al., 2009), and may lead to contradictory interpretations (Aitchison, 1986). Compositional data analysis using isometric log ratio (ilr) coordinates was introduced by Egozcue et al. (2003) to avoid these difficulties and preserve sub-compositional coherence in the analysis.

The objective of this study was to compare classical and compositional methods for the statistical analysis of 31P–NMR P forms expressed as proportions of TP or concentrations relative to soil dry mass. Two datasets for P forms determined by 31P-NMR from soils under different systems for tillage (Cade-Menun et al., 2010) and for tillage and P fertilisation [Abdi et al. (in review)] were used. The raw 31P-NMR P forms that were initially computed as relative percentages of TP and as raw concentrations on a soil dry-mass basis were ilr-transformed using the R 'compositions' package (van den Boogaart et al., 2011). Analyses of variance (ANOVA) and regression analysis were conducted on raw and ordinary log transformed 31P-NMR P forms (as proportions or concentrations), and ilr-transformed 31P-NMR P forms. The P forms were also correlated to soil pH.

Contradictory F-statistics values and coefficients of correlation with soil pH were observed for the raw and ordinary log transformed 31P-NMR P forms expressed as proportions or concentrations due to spurious correlations resulting from change of measurement scale. However, we obtained the same statistical results regardless of the measurement unit when P compounds were ilr-transformed, due to scale invariance. Using orthogonal ilr coordinates, 31P-NMR P forms can be correlated to soil properties and to each other and synthesized into a multivariate distance across the Euclidean space without methodological bias.

We conclude that the variance and regression analyses of molecular P species are scale-dependent and that the ilr coordinates should be used to unbiasedly analyse and synthesize P compounds and avoid conflicting interpretations.

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http://CRAN.Rproject.org/package=compositions.

Keywords：*soil P forms, 31P-NMR, compositional analysis*

P3-427

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Phosphorus Availability in an Organically Amended Vegetable Soil

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The utilization of organic amendments in vegetable productions has become an alternative practices to inorganic fertilizer in recent years as a more sustainable approach. However, little research has been carried out on the impact of organic amendments on soil P availability and dynamics. In this study, the shifts in soil P fractions were determined in response to different organic amendments. Soil samples collected from a vegetable production field in Camden near Sydney, Australia were sequentially extracted and analysed using modified Hedley et al. (1982) and Condron et al. (1996) fractionation scheme by including an analysis of the residual P using nitric perchloric acid digestion by Olsen and Sommers (1982). The experiment had 7 treatments within a randomised block design with 4 replicates. There were 3 main input treatments using industry recommended rates of poultry litter and inorganic fertilisers (Conventional); a full compost treatment of 125 t/ha at the beginning of the experiment (Compost); and a mix of half compost-half fertiliser treatment (Mixed). These treatment were repeated under high (HP) and low (LP) background soil P levels and together with a no input control. Total P (Pi and Po) released by individual extract ranged from 280 to 760 mg P/kg soil, where the highest was for conventional HP treatment and the lowest was mixed LP with 720 and 430 mg P/kg respectively while total P for control was 250 mg P/kg. The results indicated that concentration of mostly labile Pi fractions (ABi and BPi) were highest in the compost treatments for both high and low input P and compost treatments with high and low input P contained relatively equal amount of labile Pi. This indicated that compost treatment was high in plant available P. However, moderately labile Pi (N(I)Pi) were dominant in conventional treatments accounted for 34 to 42 mg P/kg compared to other treatments. The recalcitrant Pi fractions (HPi and N(II)Pi) were greater in conventional treatment, followed by compost and mixed treatments. On the other hand, the organic P was the most labile (easily mineralizable Po) (BPo) in conventional treatments followed by mixed and compost suggesting that conventional treatment could increase the accumulation of extractable soil P. However, the recalcitrant Po fractions (N(II)Po) were found to be highest in compost treatments. Overall, these results indicated that compost treatment was effective in increasing P availability while reducing the accumulation of extractable soil P compared to conventional practice in vegetable productions.

Keywords：*Compost, phosphorus, organic, inorganic, fractionation*

P3-428

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Applicability and Limitations of Enzyme Addition Assays for the Characterisation of Soil Organic Phosphorus across a Range of Soil Types

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Characterisation and quantification of organic P classes in soil is essential for the understanding of soil P dynamics. Solution 31P NMR spectroscopy is a powerful tool for this purpose, with potential limitations due to costs and accessibility of the equipment as well as relatively large amounts of sample needed. A recent alternative approach for the quantification of specific organic P classes is the use of substrate-specific phosphoesterase enzymes which cleave the inorganic orthophosphate from the organic moiety. The released orthophosphate is detectable by colorimetry. Conclusions about the hydrolysed class of organic P can be made based on the comparison of inorganic P concentrations in enzymatically treated and untreated samples.

The aim of this study was to test the applicability of enzyme addition assays for the characterisation of organic P classes on a) NaOH-EDTA extracts, b) soil:water filtrates (0.2 μm) and c) soil:water suspensions. The organic P classes in NaOH-EDTA extracts were also determined by 31P NMR spectroscopy, enabling a comparison between methods. Ten different topsoil samples from four continents (five cambisols, two ferralsols, two luvisols and one lixisol) varying in total P (83 – 1,560 mg kg-1), pH(H2O) (4.2 – 8.0) and land management (grassland or cropped land) were analysed. Four classes of organic P were determined using the enzyme addition assay: 1) monoester like-P (by an acid phosphatase known to hydrolyse simple monoesters, pyrophosphate and ATP), 2) DNA-like P (by a nuclease in combination with an acid phosphatase), 3) inositol phosphate-like P (by a phytase known to hydrolyse all monoester like-P plus myo-inositol hexakisphosphate and scyllo-inositol hexakisphosphate) and 4) enzyme stable-P (enzymatically not hydrolysed organic P forms). For the enzyme addition assay in the soil:water suspensions, soil specific amounts of EDTA as chelating agent were added to reduce P sorption capacity of the soil and thus to increase the recovery of enzymatically released P for colorimetric detection. The 31P NMR spectra on NaOH-EDTA extracts were evaluated by a combination of integration (orthophosphate, pyrophosphate, phosphonates, phospho-monoesters and -diesters) and deconvolution of the monoester-P region (α- and β-glycerophosphate as degradation products of phospholipids, myo-inositol hexakisphosphate, scyllo-inositol hexakisphosphate, other monoesters and non-identified monoesters with high molecular weight). Organic P classes detected by 31P NMR spectroscopy were then grouped according to the four enzymatically determined classes: α- and β-glycerophosphate, pyrophosphate and other monoesters ≙ monoester like-P; phosphodiesters ≙ DNA-like P; myo-inositol hexakisphosphate and scyllo-inositol hexakisphosphate ≙ inositol phosphate-like P; and phosphonates and non-identified monoesters with high molecular weight ≙ enzyme stable P.

NaOH-EDTA-extractable organic P ranged from 6 – 1115 mg P kg-1 soil. From that, 33 – 92 % was enzyme-labile, with inositol phosphate-like P being the largest organic P class in most soils (15-51 %), followed by monoester-like P (10-47 %) and DNA-like

P (0-15 %). Deconvolution of 31P NMR spectra was not possible for two soils. For the other eight soils, the four soil organic P classes detected by either 31P NMR spectroscopy or enzyme addition assays were well correlated with each other (R2 0.93 – 0.99). However, the enzyme addition assays tended to detect higher amounts of the three enzyme labile P classes.

For enzyme addition assays on soil:water filtrates, 0.1–4.1 mg enzyme labile P kg-1 soil were detected, mainly in the inositol phosphate-like P fraction. In some soils, low absolute amounts of water soluble organic P in filtrates were the main constraint for a detailed analysis.

For soil:water suspensions, enzyme-labile organic P ranged from 4.3–12.6 mg P kg-1 soil. The main obstacles were i) the inhibition of added enzymes to some soil:water suspensions and ii) the non-accountable hydrolysis of organic P classes by soil intrinsic enzymes. Thus, a characterisation of organic P in soil:water suspensions was achieved in only three out of the ten soils.

In conclusion, enzyme addition assays appear to be a promising approach for a rapid determination of four main soil organic P classes in NaOH-EDTA extracts. The small amount of sample required for the analysis (< 1 ml) and the relatively simple instrumentation enable a rapid and cheap analysis on these extracts. Application of this method is also possible on soil:water filtrates, but low amounts of organic P may hinder detailed analysis.

Keywords：*enzyme addition assays,31P NMR spectroscopy,soil suspensions and filtrate,organic P characterisation*

P3-429

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

A Comparison of Phosphorus Characterization in Animal Manure by Conventional Procedures and Solution Phosphorus-31 Nuclear Magnetic Resonance Spectroscopy

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Eutrophication of surface water by phosphorus (P) in runoff from agricultural land amended with animal manures is one of the greatest threats to water quality in China. Knowledge of P fractions in animal manure is important for environmental protection and soil fertility. In this study, we comparatively characterized P in dairy manure, swine manure, and broiler litter using a conventional procedure, a simplified two-step procedure and solution 31P NMR spectroscopy technique.

A sequential fractionation procedure originally developed for soils was applied to characterize P in three contrasting manure using deionized water, 0.5 M NaHCO3, 0.1 M NaOH, 1.0 M HCl and H2SO4-HNO3. The NaHCO3/NaOH+EDTA fractionation procedure developed firstly by Turner and Leytem, (2004), which divided manure P into structurally defined fractions with environmental relevance, was also applied to manures involving extraction of readily soluble P in 0.5 M NaHCO3 followed by extraction of stable P in a solution containing 0.5 M NaOH and 50 mM ethylene diaminetetraacetic acid (EDTA). Then solution 31P Nuclear Magnetic Resonance (NMR) spectroscopy was applied to determine the direct information on the structural composition of the manure P in the NaHCO3/NaOH+EDTA procedure.

For sequential procedure, deionized water extracted 38.15, 22.47, and 31.14%, NaHCO3 extracted 48.51, 25.60 and 36.66%, NaOH extracted 8.02, 8.69 and 13.88% and HCl extracted 3.10, 42.95 and 18.16% of the total P in dairy manure, swine manure and broiler litter, respectively. The sequential fractionation procedure obtained the information on the relative proportions of inorganic and organic P in all three types of manures. Especially, the information determined through the procedure demonstrated that 86.66, 48.07and 67.80% of total P were labile P (water-NaHCO3 extractable) in dairy manure, swine manure and broiler litter, respectively. That a major portion of P in the manure samples was present as soluble fraction indicated a great risk of P runoff or leaching from manure if surface over-applied to soil with a low holding capacity. Total P extracted by NaHCO3/NaOH+EDTA procedure were 7537, 32501 and 15700 mg P kg-1 in dairy manure, swine manure and broiler litter, respectively. The NaHCO3/NaOH-EDTA procedure was suitable to be used as a simple and efficient test method to estimate the magnitude of vulnerable P with environmental relevance in manures, which could help farmers identify optimal management techniques and treatments to reduce potential P runoff loss on farms. The solution 31P-NMR detected that 9.0, 34.9 and 29.4% of total P were phytic acid in dairy manure, swine manure and broiler litter, respectively. Based on the accurate analysis of organic P in NaOH-EDTA extracts by 31P-NMR, orthophosphate monoesters, especially phytate, were identified to be the dominant P species in swine manure and broiler litter. Thus, feeding management including the use of feed additives such as phytase and reducing over-feeding to minimize excessive dietary P could be a necessary and critical practice to reduce total P excretion in manures to reduce the potential risk of P loss to environment associated with surface application of manures. This would particularly be useful for areas where limited arable land is combined with intensive animal farming.

These results determined by three different methods indicated that P forms, availability, and quantities were expected to differ between dairy manure, swine manure, and broiler litter. Different management systems of manures should also be made considering on their potential impact on soil and water quality.

Keywords：*Manure P Characterization, Sequential Fractionation, NaHCO3/NaOH-EDTA Procedure, 31P NMR Spectroscop*

P3-430

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

What Effect Does Pig Waste Have on Microbes Involved in the Phosphorus Cycle in Soil?

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Recycling pig waste, which is characteristically high in phosphorus (P), is gaining increased attention to reduce the use of conventional inorganic P fertilisers. We have previously shown that pig waste by-products are high in P-solubilisation, P-mineralisation and P-immobilisation microorganisms which are generally assumed to be the main contributor of P turnover in soils. However, information on the identity of individual taxa/species of bacteria/fungi involved in P transformation is largely unexplored in soils amended with piggery waste by-products. This study examined the influence of composted pig waste, manure, and pelletised pig compost at recommended application rates in combination with nitrogen/phosphorus/sulphur (NPS) inorganic fertiliser in pots sown with wheat (Triticum aestivum L. cv. Wyalkatchem) on P mediating microorganisms, including arbuscular mycorrhizal fungi (AM). Microbial community structure in soil and mycorrhizal diversity and abundance in roots were investigated. Significant differences were found between treatments for plant growth and mycorrhizal colonisation. Overall, application of piggery wastes in combination with NPS inorganic fertiliser lead to increased shoot growth and a decrease in the percentage of root length colonised by AM fungi. Microbial identity and function to P transformations in response to different fertiliser inputs are being studied using metagenomic analysis. Improved understanding of these interactions can be used to optimise P-use efficiency by identifying appropriate blends of piggery waste by-products for soil amendment.

Keywords：*Arbuscular mycorrhiza, pelletised pig compost, composted pig waste, metagenomics*

P3-431

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Soil Organic Phosphorus in Critical and Non-Critical Hydrological Source Areas

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Critical source areas (CSAs) are zones in the landscape where easily connected hydrology coincides with a phosphorus (P) sources in the soil. In agricultural soils across the world, P transfer from soil to receiving waters contributes to the eutrophication of many rivers and lakes. The P export risks in CSAs are hypothesised to be higher compared with non-critical source areas (Non-CSAs) and specifically that the magnitudes of P forms in CSA areas were higher than Non-CSAs. However, P export risk not only depends on the magnitude of P in the soils but also on the forms of P. Past research on CSAs has often neglected forms of organic P, such as DNA which is among the most potentially biodegradable organic P compounds. The objectives of this study were i) to quantify the magnitude of organic P compounds in agricultural soils and specifically determine whether these magnitudes differed significantly between CSAs and Non-CSAs; and ii) determine the variation of P magnitude between and within individual fields. The study focussed on soils collected in April 2013 from the Morland sub-catchment of the River Eden catchment in Cumbria, England. CSA and Non-CSA pairs were identified using the SCIMAP modelling and field assessment providing five CSA – Non-CSA pairs in total. They are labelled as CSA 1, 2, 3, 4, 5 and Non-CSA 1, 2, 3, 4, 5, respectively. The results showed that there are no significant differences in the total P (TP) concentrations, the proportions of DNA-P, WETP (water extractable total P), WERP (water extractable reactive P) and WEUP (water extractable unreactive P) between CSA and Non-CSA pairs. However, soil P analyses demonstrated large spatial variability within and between individual fields. TP concentrations of the point samples ranged from 491.3 (Non-CSA 1) to 2143.3 (CSA 2) mg kg-1. The mean WETP content of moist soil as a proportion of soil TP of the ten areas was small, ranging from 0.03 to 0.15%, almost half of which was in organic form. DNA-P in the ten areas accounted for a considerable proportion of soil TP (4.9 to 16.6%) and showed a good correlation with TP. Given the potential lability and bioavailability of DNA-P, our data demonstrate that soil organic P could be a potential pool to support plant nutrition and a potential contributor to water pollution problems.

Keywords：*Organic phosphorus; Critical source areas; DNA; Water extractable phosphorus*

P3-432

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Phosphorus Losses from Tile Drained Agricultural Lands in Canada, An Overview

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Artificial tile drainage, that is both agronomically and economically beneficial, has been increasingly implemented by farmers in Canada and the world. Adoption of tile drainage alters the fate of soil phosphorus (P) and the pathways of its losses, which can be a function of agricultural management practices, in addition to soil indigenous properties and topographies. This presentation attempts to summarize the results from long-term studies (up to 45 years) in Canada that were consistently maintained and meanwhile equipped with automatic monitoring and sampling systems for continuous flow volume recording and determination of P contents to evaluate the inherent effects of a range of crop, soil, and water management practices on soil P loss in tile drainage water (SPLTD). Of the annual total soil P loss, from 36 to 97% was attributed to tile drainage discharge. Effects of cropping system on SPLTD followed the order of continuous sod > rotation corn > continuous corn. Dissolved reactive P predominated SPLTD for continuous sod with fertilization, accounting for 72%, while particulate P predominated SPLTD, accounting for 62 to 74%, for continuous corn and rotation corn with and without fertilization, and continuous sod without fertilization. Dry matter based compost application resulted in substantially greater P loss with swine manure compost than with chemical fertilizer and yard waste compost, due to both of its high P content and high P loss potential. No-tillage increased dissolved reactive P loss in tile drainage when surface soil P levels were high, relative to conventional tillage. Compared with regular drainage, controlled drainage with sub-irrigation reduced SPLTD through the reduction of tile drainage flow volume and particular P content. Contribution of each management practice to SPLTD varies, and some of the current BMPs may need to be re-evaluated, or supplemental practices developed, if SPLTD is incorporated into the risk assessment of soil P.

Keywords：*Phosphorus, tile drainage, water quality, agriculture phosphorus loss; sub-surface runoff*

P3-433

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Unravelling Microbial P Cycling in Soils Receiving Organic P Fertiliser Inputs

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Agriculture is under increasing pressure to meet human demands for food yet crop productivity is often phosphorus (P) limited. Consequently, large quantities of inorganic fertilisers are applied to agricultural soils but P is a finite resource and alternative P sources are urgently required. One possibility is recycling animal waste by-products as P fertilisers but their effect on the microbial P cycling is largely unknown due to methodological constraints. The aim was to develop isotope and molecular techniques for monitoring microbial P cycling under different P fertiliser regimes. We used a metagenomic approach to compare the microbial community structure and P functional gene diversity in P-responsive and P non responsive soils receiving different fertiliser and manure inputs. An understanding of microbial P processes is fundamental for sustainable organic fertiliser re-use.

Keywords：*Manure inputs, microbial P cycling, sustainable agriculture, metagenomics, P genes*

P3-434

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Organic Phosphorus Contribution and Chemical Characterization of Residual Fraction Derived from Hedley Fractionation in Andisol

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Andisols are characterized by a high phosphorus (P) fixation capacity, which is a limiting factor for crop production. Continuous application of P fertilizer results in an accumulation of P in soils, mainly as insoluble organic P forms (Po). Although Hedley fractionation has been widely used to evaluate impacts and land use management, this method has been criticized for application of Po determination. Its main limitation is the assumption that non-extractable fraction (residual fraction) is composed of Po. However, this hypothesis has not been tested. On the other hand, it is well known that in Andisols interaction with noncrystalline materials such as allophane, imogolite type materials and aluminium (Al) and iron (Fe)-oxides are dominant process for organic matter stabilization. Therefore, we hypothesized that this mechanism may also be important for Po stabilization. The aim of this study was to determine (i) the Po contribution in chemical recalcitrant P in Andisols and (II) to examine if they are stabilized by complexation with iron (Fe) and Aluminum (Al) in the residual fraction. We used modified Hedley fractionation to isolate the recalcitrant residual fraction from fertilized and unfertilized Andisols under grassland and agriculture use. Chemical composition of residual fraction was characterized by 31P-Nuclear Magnetic Resonance (31P-NMR). In addition Al and Fe pyrophosphate were determined in this fraction, in order to evaluate the relationship with Po. The results showed that total P ranged from 981.9 to 2494.9 mg kg-1. Similarly, total Po was higher in the fertilized soil than in unfertilized soil, ranged from 337.3 to 739.3 mg kg-1. After Hedley fractionation on average more than 50% of the total P was remained in the residual fraction. The contribution of Po in the residual fraction was assigned to inositol phosphates, ranged from 84.3 to 427.6 mg kg-1, which corresponds mostly to myo-inositol hexakisphosphate (phytate) (means 14% of total P). On the other hand, a significance correlation was observed between inositol phosphates and Al pyrophosphate in residual fractions, which suggests that most recalcitrant P could be stabilized through Al-humus complexes. Thus, it can be concluded that the inositol phosphates are the most recalcitrant Po forms found in Chilean Andisols and can be stabilized through humus complexes.

Keywords：*Recalcitrant Phosphorus, Al/Fe Humus complexes, Inositol phosphate.*

P3-435

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Assesment of the Aluminium, Iron and Silicium Role on Phosphorus Fractions in Grasslands Andisols

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The main constraints for farming in Southern Chile is acidity condition of volcanic soils, which causes an increase in the content of aluminum (Al) a reduction of phosphorus (P) use efficiency, and consequently affecting crop food quality and yield. Furthermore in these soils, high inorganic P fixation and, in turn, low P availability and high Al soluble concentrations at low pH are the most important limiting factors in crop production. Therefore, it is very difficult to separate the effects due to low P or high Al in plant because Al toxicity and P deficiency often coexist in acid soils, and these factors may strongly interact to each other through chemical and biochemical reactions.

Soil P and its dynamics play a key role for the sustainable agriculture. Andisols are characterized by a high content of total P (PT), with organic P (Po) mainly present as inositol penta and hexaphosphates that comprises between 30 -82% of PT in topsoils. In spite of the high P content, available P (Olsen P) is scarce in these soils.

There are few reports of simultaneous P-Al-Fe- Si extractions in literature. In Chilean Andisols, there are several reports of soil P fractionations but simultaneous determinations of these elements still lacking. Therefore, the objective of this research was to determine the role and interactions of Aluminium, Iron and Silicium on Phosphorus fractions in grassland Andisols

For this purpose, soil rhizosphere samples (0-10 cm) associated to grassland species were collected in winter season from four different sites placed at the central valley of central south Chile belonging to Andisol series. By each site, squares of ca. 30*30 cm of plants plus rhizosphere adhering soil were cut and removed from the bulk soil.

Aluminum was the element that were most related to P availability, affecting almost all P fractions. Specially pyrophosphate Al and Al-NaHCO3-o fraction (linked to organic matter) affected negatively P availability as shown by negative correlations between these parameters. The elements Fe and Si affected only labile Po fractions (especially NaHCO3-Po), thus reflecting that labile P immobilization in organic matter and mineralization are also influenced by Fe and Si contents in soil. Therefore, the results show that soil organic matter-Al complexes are regulating P availability. Also, the Al-organic matter complexes affect P metabolism by microbes, as microbial P is affected by pyrophosphate Al. Furthermore, stable (oxalate and Al-H2SO4) Al fractions are associated with NaOH-Po, suggesting Al control over NaOH-Po accumulation.

Furthermore organic matter and pyrophosphate Al and Fe content were correlated positively for all soils ($r=0.62$, $p=0.009$ and $r=0.79$, $p=0.000$, respectively), suggesting that Fe and Al control the degree of organic matter stabilization and P availability is regulated mainly by organic matter- Al complexes in the rhizosphere. Furthermore, we observed an important relationship between Al in H2SO4 fraction and organic phosphorus accumulation in soil extracted by NaOH and NaHCO3.

Keywords：*Phosphorus fractions, Aluminium, Iron, Silicium, Organic matter*

P3-436

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Microbial Mobilization of Inorganic P is a Key Process to Promote P Availability in Highly-Weathered Soils

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Highly-weathered soils are most important land resources for crop production in more than 50 nations in tropical and subtropical zones, but usually have low P content and availability, due to P loss and physical-chemical fixation by Fe and Al oxides. In order to understand the dynamic of P with microbial transformations and the effects on P availability, intensive lab simulation and field experiments with crop straw incorporation into highly-weathered soils from the subtropical China were conducted. Results show that microbial biomass P responded to straw incorporation with large increases (generally 2 folds) in bulk soils and soil aggregates. It was found that the P microbial-immobilized was released from originally Fe-P and Al-P fractions. Further studies with bacterial and fungal inhibitors (tetracycline-streptomycin sulphate, and actidione, respectively) suggest that fungal and bacterial communities successively immobilize P, with fungal community immobilized P in the earlier phase (2 weeks) and bacterial community dominated the later phase. These studies promote understandings on P processes and demonstrate an useful practice to improve P availability in highly-weathered soils worldwide.

Keywords：*Soil aggregates; Highly-weathered soil; Phosphorus immobilization; Bacteria ; Fungi; microbial inhi*

P3-437

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Edaphic Phosphate Mineralization Mediated by Rhizobacterial Organic Acids

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Phosphorus (P) is one of the essential nutrients for plant development in spite of its low availability in the majority of agricultural soils. The inoculation of phosphate solubilizing-bacteria (PSBs) is a real alternative to make available this element for crop plants. The microbial phosphate solubilization in the soil is mediated by phosphatases, phytases and organic acids. The subject of this work is to contribute to the knowledge of soil phosphate solubilization, emphasizing the role of the organic acids produced by PSBs. The bacterial genera with outstanding production of organic acids are: Pseudomonas, Bacillus, Rhizobium, Burkholderia, Achromobacter, Agrobacterium, Micrococcus, Flavobacterium and Erwinia. The organic acids synthesized by the PSBs act directly in the acidification, chelation, precipitation and oxide-reduction reactions in the rhizosphere.

The medium MMSFCP-Mg was the more efficient compared with other ones. Bacteria grown on MMSFCP-Mg solid plates exhibited phosphate solubilization halos highest than 3.8 cm at 14 days of incubation, when tricalcic phospahate was used as P source. On the other hand, bacteria grown in MMSFCP-Mg liquid medium showed solubilization phosphate values highest than 380 mg/L of soluble phosphate at 6 incubation days. We found that the presence of a prominent solubilization halo on culture plates not necessarily implies a high phosphate solubilization in liquid medium.

Synthesis of 2-ketogluconic acid and gluconic acid were detected as the main products of the direct oxidation of glucose. Although the phosphate solubilization in culture medium has been correlated with an increase in the synthesis of 2-ketogluconic acid, some studies have demonstrated that this correlation not necessarily occurs.

Keywords：*Phosphate-solubilizing bacteria, organic acids*

P3-438

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

What are the Major Forms of Organic P in Vertisols?

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Vertisols are a major soil type used for food and fiber production in Africa, India, America and Australia. The Vertisols of the northern grains region (NGR) of eastern Australia produce some of the world's highest yielding cotton, in part due to their high soil phosphorus (P) fertility. However, soil P fertility has declined over the past 30 years due to continuous cultivation and crop P removal (i.e. P exports are greater than P imports). Recent studies have found the depletion of organic P fractions were not as great as those for inorganic P fractions after 18 crop cycles in a Vertisol soil of the NGR. This may suggest that organic P forms are relatively stable and only slowly available to plants. However, there is a paucity of information on the chemical structure of organic P forms in Vertisols. The aim of this study was to understand the form and abundance of organic P in the Vertisol soils of the NGR.

Vertisol soil was collected from seven locations in the Liverpool Plains of the NGR at two depths (the topsoil, 0 – 10 cm; and subsoil, 10 – 30 cm layers), and then prepared for chemical and spectroscopic analysis. Soil analyses included total organic P as determined by the 'ignition' method, total soil P determined by aqua regia digestion, and solution 31P nuclear magnetic resonance (NMR) spectroscopy on the NaOH/EDTA extracts.

Total organic P measured by the ignition method ranged from 100 to 263 mg P kg-1, which was on average 27 % of total soil P. In contrast, organic P measured by 31P NMR in NaOH/EDTA extracts ranged from 18 to 75 mg P kg-1, which was on average 7 % of total soil P. The organic P concentration as measured using both techniques was greater in the topsoil layer than in the subsoil layer. However, the ratio of organic P to total soil P was similar in both topsoil and subsoil layers.

Orthophosphate monoesters were the only 'class' of organic P detected using solution 31P NMR spectroscopy in the Vertisols, except for a small quantity of orthophosphate diesters in one soil. The quantity of orthophosphate monoesters was strongly correlated with organic P measured in the NaOH/EDTA extract. Further division and quantification of organic P forms in the orthophosphate monoester region was not attempted using deconvolution because of low spectral quality (i.e. low signal to noise) of the 31P NMR spectra.

In order to gain some insight into the major organic P forms in Vertisols, the solution 31P NMR spectra for the topsoil and subsoil layers were normalized to the α-glycerophosphate peak and averaged. The averaged spectra contained spectral features consistent with that of humic P (i.e. a broad peak) and two 'sharp' peaks likely to be that of lipid P (detected as α- and β-glycerophosphate in the NaOH/EDTA extracts). However, there was insufficient evidence to support the presence of myo- and scyllo-inositol hexakisphosphates and various nucleic acids. Interestingly, the organic P forms in the topsoil layer looked qualitatively similar to those in the subsoil layer.

The form and abundance of organic P in Vertisols remains unclear. However, for the first time this study provides some insight into the likely forms of organic P in the Vertisol soils of the NGR. It is likely that humic P, a relatively stable form of organic P, is the dominant form of organic P in Vertisols. The implications of this are that the cycling of organic P forms is less likely to affect fertilizer P use efficiency than cycling of inorganic P forms in Vertisols. Nevertheless, more research is needed to improve our understanding of the form and abundance of organic P in Vertisols.

Keywords: *Chemical extraction, cotton systems, organic P speciation, P stratification, Vertosol, P-31 NMR*

P3-439

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Shifts in Soil Organic Phosphorus Composition and Phosphatase Activities in Response to Conversion of the Native Forest to the Plantation Forest

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Conversion from the native forest to the plantation forest can have significant impacts on the transformation of soil carbon and associated nutrients (including soil phosphorus (P)). Adjacent natural forest (NF), and first (1R) and second rotation (2R) hoop pine plantations in south-east Queensland, Australia, were selected to investigate the effects of conversion of natural forest to hoop pine plantations and forest management (harvesting and site preparation of plantation) on the size and the nature of P pools in surface (0-10 cm) soils. The site is located within the Yarraman State Forest, SEQ, Australia (26o52' S, 151o51' E), lying in the upper catchment of the Mary River. The soil is a Snuffy Mesotrophic Red Ferrosol (Soil Survey Staff, 1999). Altitude at the site is 428 m. Annual rainfall varies from 433 to 1110 mm, with an average of 791 mm. Winter temperatures range from 4 to 20°C, and summer temperatures from 17 to 29°C. The NF site is classified as a rainforest/bastard scrub and dominated by bunya pine (Aravcaria bidwilli), yellowwood (Terminalia oblongata), crows ash (Pentaceras australis) and lignum-vitae (Premna lignum-vitae), with emergent hoop pine (Araucaria cunninghamii). The 1R hoop pine plantation was established in 1949 at approximately 1540 stems ha-1, and then thinned to a final stocking of 430 stems ha-1. The 2R hoop pine site was planted in November 2000 after the clearcut harvest of part of the 1R hoop pine plantation in September 1999. Each (ca 30 m x 100 m) of the research areas under adjacent NF, 1R and 2R hoop pine plantations was divided into five subplots for soil sampling. A total of 25 soil cores (0-10 cm) were randomly collected with an auger of ca. 7.5 cm in diameter from each subplot and bulked. These soil samples were subject to the analysis by solution 31P NMR spectroscopy and chemical fractionation. Results demonstrated that conversion from natural forest to hoop pine plantations did not substantially affect soil total P (1290, 1289 and 1190 mg P kg-1 for soils under NF, 1R and 2R, respectively). However, soil labile P (sum of solution P (APi) and NaHCO3 extractable P) decreased from 125 mg P kg-1 under NF to 79 mg P kg-1 under 1R and 59 mg P kg-1 under 2R. The recalcitrant P pools (sum of the second NaOH extractable and residual P) increased from 504 mg P kg-1 under NF to 537 mg P kg-1 under 1R and 623 mg P kg-1 under 2R. Results from the 31P NMR spectroscopy also showed that the concentration of orthophosphate was higher in soil under NF compared with those under 1R and 2R hoop pine plantations. The concentration of orthophosphate diesters was also greater in soil under NF than those under 1R and 2R plantations. These results consistently demonstrated that conversion of native forest to hoop pine plantation reduced soil P availability. This vegetative conversion also led to the reduction in both phosphomonoesterase and diesterase activities. Overall, results from this study have significant implications for the sustainable management of forest land.

Keywords：*Vegetative conversion, native forest, plantation forest, soil organic phosphorus, 31P NMR*

P3-440

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Comparing Phosphorus Mineralization from Decomposing Plant Materials Incorporated into Savanna and Forest Soils of Ghana

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A study was carried out at Kwadaso, Ghana with the objective of estimating P mineralization kinetic from decomposing plant residues. Three complementary experiments were carried out to estimate the potential release with time of P in C. odorata, G. sepium, L. Leucocephala and P. maximum. In experiment 1, microbial P biomass in the 5-cm soil layer under decomposing plant materials was estimated following chloroform fumigation and extraction. In the second experiment P in decomposing plant residues remaining in litter bags was estimated to monitor P release kinetics. Thirdly plant materials mixed with forest and savanna soils were incubated and leached with Bray-l P and 0.01M CaCl2 extractants at 7, 14, 21, 28, 35, and 42 days. P concentration in decomposing plant materials increased from 0.12 to 0.18% for Panicum maximum, 0.18 to 0.22% for C. odorata, 0.10 to 0.15% for maize stover, 0.22 to 0.32% for Leucaena leucocephala and from 0.20 to 0.30% for Gliricidia which was attributed to P immobilization. Irrespective of the type of organic material incorporated into the soil, P mineralization was higher in the savanna soil than the forest soil. Incorporation of 10 g kg-1 C.odorata in the savanna soil increased phosphorus release by 75% whereas in the forest soil phosphorus release increased by 7.1%. Incorporation of 30 g kg-1 maize stover in the two soils increased P release by 500 and 133% for the savanna and forest soils respectively. Application of organic materials caused significant increase in P mineralization in the savanna soil compared with the forest soil. Whereas net P mineralization occurred in savanna soil, net immobilization occurred in the forest soil following plant residue incorporation. Improved use of plant residues in savanna and forest farming systems of the tropics could improve soil productivity and crop yields.

Keywords：*phosphorus mineralization, savanna soil, forest soil, immobilization, plant residues, C:P ratio, mic*

P3-441

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Adsorption and Precipitation of Myo-Inositol Hexaphosphate on Amorphous Aluminum Hydroxide

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Adsorption, desorption, and precipitation reactions of P at environmental interfaces govern the mobility, transformation, and dynamics of inositol phosphate in terrestrial and aquatic environments. Generally, a substantial part of inositol phosphate in natural systems consists of myo-inositol hexaphosphate. In this study, the surface complexation-precipitation process and mechanism of (myo-inositol hexaphosphate) IHP on amorphous aluminum hydroxide (AAH) were investigated by macroscopic sorption experiments, ζ-potential measurements, in situ ATR-FTIR, XRD, and solid state NMR. The results show that amorphous aluminum hydroxide (16.01 μmol m-2) exhibits much higher sorption density than that of boehmite (0.73 μmol m-2) and corundum (1.13 μmol m-2). Sorption kinetics of IHP on AAH and OH- release indicate that firstly IHP is probably adsorbed onto AAH by forming inner-sphere complexes by ligand exchange (aquo groups and hydroxo groups on the surface), followed by a partial dissolution of AAH and the formation of ternary complexes by the reaction of the released Al cations and the sorbed IHP. Lastly, the ternary complexes transformed to surface precipitates analogous to Al-IHP. With the decrease in pH and increase in IHP loading, the transformation processes become pronounced. The ζ-potential of phytated AAH dramatically decreases initially, and then increases gradually. The ζ-potential values for the sample with lower concentration IHP return almost to the original ζ-potential of the unphytated AAH. It indicates that the speciation of IHP sorbed on AAH alters, that is, surface complexes are gradually transformed to surface precipitates, the decrease of surface negative charge resulting the increasing of ζ-potential. The ATR-FTIR spectra indicate that IHP sorbed on AAH gradually transformed to surface precipitates analogous to Al-IHP model compound, which confers to the results of XRD analysis. Solid state 31P and 27Al NMR analysis show that the δP of sorbed IHP shifts from −0.5 ppm to −6.5 ppm, and with the increase of reaction time, the new δP and δAl of AAH sorbed with IHP occur at −11.0 ppm and −8.0 ppm, respectively, resembling/conforming those of Al-IHP, which further confirms that IHP surface complexation transforms to Al-IHP surface precipitation. This study indicates that active oxide, such as AAH affects the speciation and behavior of inositol hexaphosphate, such as IHP and due to the transformation of surface complexation to surface precipitation, the availability and mobility in environment are greatly decreased.

Keywords：*myo-inositol hexaphosphate; organic p, adsorption, surface precipitation, amorphous aluminum hydroxi*

P3-442

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Overcoming Phosphorus Deficiency in Soil by Using Municipal Waste Compost Enriched with Rock Phosphate and PSB

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Effect of enriched compost prepared by combining municipal solid waste with rock phosphate and PSB for raising crop was investigated. Rock phosphate can serve as a source of plant available P but it is highly insoluble. Possibility of solublizing rock phosphate by combining it with municipal solid waste and P solublizing bacteria was studied. Municipal solid waste was composted in different combinations with two charge rates (5 and 10%) of rockphosphate and two P solublizing bacteria including Klebsiella pneumonia and Burkholderia cenocepacia. The treatment with MSWC+ RP @ 10% + PSB1+PSB2 gave highest P content (1.9 %) and was selected for raising maize under greenhouse conditions. In greenhouse study the treatments included half and full dose of P fertilizer, application of enriched compost for 50, 100, 150 and 200 % of recommended P rate and a mixture of compost for 50% P and 25 % of P fertilizer. Highest concentration of N, P and K (18.2, 7.8, 162 mg kg-1) in soil were recorded with highest dose of enriched compost and two strains of P solublizers. K in soil increased with successive addition of enriched compost. Highest uptake of N, P, k by maize plants (2.9, 0.47, 0.72 %) was also recorded from the highest dose of enriched compost. Highest plant height (24.2 cm) was recorded with recommended dose of fertilizer and it was followed by highest enriched compost application. However highest fresh (125.1g) and dry weight (32.3 g) were obtained from highest enriched compost application closely followed by recommended fertilizer treatments. The mixture treatment involving application of compost for 75 % P and 25% P from P fertilizer was found to be superior and economical combination of enriched compost and chemical fertilizer. It was concluded that RP after composting it with MSW along with PSB could serve as an effective and cheap fertilizer with more chances of acceptability by the farming community in developing countries.

Keywords：*municipal waste compost, rock phosphate, PSB, phosphorus, maize*

P3-443

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Effect of Phosphorus Fertilizer Fortified with Molybdenum on Nitrogen Fixation in Cowpea (vigna Unguiculata (l.) Walp.) in the Northern Guinea Savanna of Nigeria

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A study was carried out in the screen house of Abubakar Tafawa Balewa University, Bauchi to determine the effect of phosphorus fortified with molybdenum on nitrogen fixation in cowpea (Vigna unguiculata (L.) Walp.). The treatments consisted of three levels of phosphorus (P) fertilizer 0, 17.6 and 35.2kgP/ha applied as single superphosphate fortified with four levels of molybdenum (Mo) at 0, 0.5, 1 and1.5mg/kg/plant applied as sodium molybdate dihydrate ($Na_2MoO_4.2H_2O$). The treatments were laid out in a completely randomized design and replicated three times. A composite soil sample was collected prior to planting and analysed using standard laboratory procedures for soil pH, organic carbon (OC), total nitrogen (N), available P and Mo. The amount of N-fixed in the cowpea was determined by the differences between the total N in the plant and soil at 8 weeks after sowing (WAS). The soil was moderately acidic, low in OC and total N. Available P and Mo were also low. Application of P fertilizer at 17.6kgP/ha significantly ($P \leq 0.05$) produced higher number of leaves and nodules/plant than the other levels. Application of Mo at 0.5mg/kg significantly ($P \leq 0.05$) produced higher number of leaves and nodules. Similarly, application of P significantly ($P \leq 0.05$) influenced higher amount of N-fixed than the other levels. Molybdenum application at 0.5mg/kg significantly ($P \leq 0.05$) gave higher N-fixed in cowpea than the other levels used. However, the interactions showed that the application of P fertilizer at 17.6kgP/ha fortified with Mo at 0.5mg/kg significantly ($P \leq 0.05$) produced higher number of leaves, nodules and fixed higher N in the cowpea plants than the other levels.

Keywords：*Phosphorus, Fortified, Molybdenum, Nitrogen Fixation, Cowpea, Northern Guinea Savanna*

P3-444

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Impact of Manure, Straw and Nitrogen Application on Phosphorus Fractionation in Soil and Leachate in Greenhouse Vegetable Field

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High phosphorus (P) input, including over 50% derived from manure, determined very high P accumulation, low C/P ratio and possible P leaching risk in soil-bound vegetable greenhouses. In the study, a long-term field trial was conducted in a typical soil-bound greenhouse with double tomato planting in a year at Shouguang, China, in order to understand the influences of manure, straw and nitrogen application on P fractionation in soil and leachate in the greenhouse. The results showed that the proportion of organic P only accounted for less than 8.5% in total P of the soil, and organic P extracted by water (H2O-Po) in the surface soil layer (0-30 cm) ranged from 20 to 30%, even 40 to 50% of the total organic P in the deeper soil layer (30-60 cm). Manure application significantly increased inorganic P (Pi) fraction, with higher proportion of Pi in labile form than stable form, much more than the increase on the organic P fraction. Excessively high P accumulation resulted in the high degree of soil P saturation (DPS) and the risk of P leaching, as evidenced by the consequent increase in soil testing P (Olsen-P and CaCl2-P) at the soil layers of 30-150 cm. High N fertilizer input in conventional treatment significantly increased inorganic P (H2O-Pi) and organic P (H2O-Po) extracted by water and decreased the proportion of P extracted by HCl (HCl-Pi) in the 0-30 cm soil depth that, in turn, contributed to the higher P leaching. Inorganic P, as the dominant form, accounted for 65-80% of total P in leachate. Manure application strengthened the proportion of organic P in leachate. On the contrary, increasing chemical N input decreased the proportion of organic P in leachate. Straw incorporation did not significantly change the P fractions, but alleviated the P leaching due to reducing leachate volume. The results indicated that high manure and chemical fertilizer input not only significantly increase P accumulation, but also cause the change of P fractions in soil profile and consequent P leaching.

Keywords：*Greenhouse vegetable; Manure application; Straw incorporation; Nitrogen application; Soil and leachate P fractionation; Organic P; P leaching*

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[C3.3-3] Ecological Significance of Soil Organic Phosphorus

Radiation Crosslinking of CMC-NA/PVP Composite Hydrogel and its Application as a Fertilizer for the Recovery of Nutrient Ions from Livestock Wastewater

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Currently, the consumption of livestock products is increasing with overall improvement in standards of living. As a result, each year the amount of livestock wastewater treated could be increasing gradually with production of livestock waste. So many researchers focused on the recycling technique of livestock wastewater and/or waste sludge as source of organic fertilizer instead of chemical fertilizer in the soil. It could be used as manure for soil improvement with increase of a crop yield using compost and liquid fertilizer of livestock waste and/or wastewater. But these methods includes many problems, such as high loss rate of nitrogen, emission of CO2, high operating and maintain cost, low coefficient of utilization of nutrient and pollution of groundwater by fast release of livestock liquid fertilizer. Thus, there is now a need to apply new recycling method relating reuse as a fertilizer for the agricultural land of livestock wastewater. In order to satisfy this technique, also it needs to apply the eco-friendly and biodegradable material for use as a fertilizer of agricultural land with adsorption of nutrient ions from livestock wastewater.
Hydrogels have been used as polymeric materials due to unique property such as water absorbency (swelling), adsorption and controlled release. It has been applied for the adsorption of dye and remove of metal ions in the industry wastewater. In the horticulture field, it can also be used to obtain a better growth rate of plants with soil improvement.
But, no report has been merely found in the literature on recycling as a fertilizer of soil for the recovery of nutrient ions using hydrogel from livestock wastewater. The objectives of this study, therefore, was investigated the characterization of property with adsorption of nutrient ion form various livestock wastewater in a series of biological treatment process using sodium carboxymethyl cellulose/polyvinylpyrrolidone (CMC-Na/PVP) hydrogel crosslinked by radiation.
The CMC-Na/PVP composite hydrogel (6:4 ratio) was irradiated using -radiation with dose of 20kGy for crosslinking of its. After that the product was dried for 48h at 50-C until constant weight. And then, it was immersed into distilled water and filtration solution of different biological treatment reactor, which is influent, anaerobic digestion reactor (ADR), nitrification and sequencing bio-reactor (SBR), respectively. And the composite hydrogel was characterized in terms of gel fraction, swelling (water absorbency), adsorption of ions such as NH4+-N, NO3--N and PO43-.
The gel fraction of CMC-Na hydrogel was about 40% in distilled water, whereas the CMC-Na/PVP composite hydrogel by addition of PVP increased to about 60%. But it was considerably increased up to >90% in filtration solution, regardless of ionic strength difference in its. The swelling ratio of CMC-Na/PVP composite hydrogel markedly decreased in the filtration solution. These conflicting results could be explained in accord with not only the osmotic pressure difference between hydrogel network and the external solution, but also the charge screening effect caused by various ions (anion & cation) in filtration solution. The CMC-Na/PVP composite hydrogel swelling in different filtration solution is in the order: distilled water > SBR > influent nitrification > ADR. It is well known that the swelling of a hydrogel was greatly affected by ionic strength as external parameter. But, interestingly, the hydrogel swelling in influent showed a similar behaviour with filtration solution of nitrification in spite of relatively high ionic strength of its. And swelling rate (g/hr) in various solution is in the order: distilled water (0.697) > nitrification (0.159) > SBR (0.145) > influent (0.075).
We also studied ion adsorption by CMC-Na/PVP composite hydrogel in various filtration solutions having different ion concentration. The maximum adsorption capacity of NH4+-N, NO3--N and PO43- was 362mg/g, 66.8mg/g and 36mg/g hydrogel, respectively. But it showed a relative low adsorption in the filtration solution of nitrification and SBR.
Consequently, our study showed the possibility that CMC-Na/PVP composite hydrogel crosslinked by radiation could be applied an alternative technique instead of conventional method relating reuse as a fertilizer of livestock wastewater.

Keywords：*hydrogel, ion adsorption, livestock wastewater, radiation crosslinking*

P3-446

[C3.3-3] Ecological Significance of Soil Organic Phosphorus

The Soil Environment Factor Affecting Vegetation-Diversity at Pond Wetland in Agricultural Landscape, Korea

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The pond wetland is significantly distributed in the rural area of Korea. It has undertake an important role to secure the bio-diversity in Korea. Therefore, it is required to present the conservation value and establish the restoration plan. However, there is insufficient system to evaluate the biodiversity function of the pond. By finding out the major microbes in the pond, formulating the growth environment factors influencing on the bio-diversity and selecting the environmental index of the bio-diversity, following conclusion has been drawn to facilitate such conclusion on promotion plan of bio-diversity for pond within the declining rural area where it is decreased from indiscrete reclamation, building up the deployment assessment system and substitute habitat and others.

Vegetations of total 457 taxa including 108 families, 309 genuses, 392 species, 59 varieties, 5 forma, 1 subspecies were found in the surveyed area. The average appeared specified for each subject site has the confirmation of 31.13±7.42 and 61.23±16.85 types to confirm the average appearance vegetation in the pond. As a result of the growth type classification, hemi-cryptophytes and therophytes are selected for principal growth types and, by analyzing the distribution for each family, the representative families of the pond is analyzed for Gramineae and Composita.

Naturalized plants are confirmed as low in mountain-type and as high in house-type and upland-type to confirm with influence on road, settlement, human interference and so forth, and it has presented the regression analyses result to increase the number of vegetation as the number of naturalized plants increase, rather than having the naturalized plants to decrease the species diversity of vegetation.

As a result of formulating the vegetation environment index influencing on the vegetation diversity, it has presented soil texture, mineral content in the soil, soil pore, heavy metals, mineral content in water and so forth. Therefore, from the diversity of vegetation species in the wetland, it states the environment with high content of silt, high contents of suspended solids and high environment of electrical conductivity and suggests to facilitate on restoration and establishment of wetland.

This study has formulated for the vegetation environment factors influencing on the bio-diversity in order to present the conservation value of the pond and facilitate in establishing the restoration that are most widely distributed in the rural area of Korea. By facilitating the research result, it is facilitated in the promotion of the bio-diversity of the pond and expect to use it for the wetland restoration project.

This study was supported by 2014 Post-doctoral Fellowship Program (Project No. PJ009412) of National Academy of Agricultural Science, Rural Development Administration, Republic of Korea.

Keywords：*Palustrine wetland, Biodiversity, Naturalized, Restoration, Plant*

P3-447

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Conservation Agriculture for Enhancing Resource Use Efficiency, Carbon Sequestration, Soil and Crop Productivity

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Conservation agriculture (CA) and resource conservation technologies have great relevance to restore the degraded ecologies of India, where low farm income and fatigue in yield have become a major concern. Long-term field experiments on CA were conducted in the Inceptisols of New Delhi during 2002-11, on various tillage (zero tillage, conservation tillage and conventional tillage) and crop establishment (flat and raised bed planting) practices in different cropping systems. Rainy season crops, viz. soybean, greengram performed better under raised-bed than flat bed system. Soybean performed significantly superior in zero tillage raised-bed (permanent-bed) than zero tillage flat-bed planting. Performance of cotton and pigeonpea were similar under conservation tillage and conventional tillage.

In a wheat-based cropping system, residue application resulted varying levels of increment in grain yield in all the crops in comparison to non-residue application both under conventional as well as zero-tillage conditions. Effects of residues were more visible under zero-tillage than the conventional. For all the crops, zero-tillage recorded significantly lower grain and biological yield except cotton, where, seed cotton yield under zero-tillage were similar to that of conventional tillage. Performance of maize was relatively poor under zero tillage situations compared to other kharif crops. The performance of five kharif crops was: cotton > pigeon pea > groundnut > soybean > maize. The carbon sequestration, soil biological health, viz. phosphatase activity, glomalin content and soil respiration were positively influenced under conservation tillage than conventional tillage.

In a greengram - mustard - cowpea cropping system, the yields of greengram, mustard and cowpea were significantly influenced due to different tillage and crop establishment practices. System productivity in terms of mustard equivalent yield (MEY) was highest with bed system with 4.20 to 4.28 t/ha followed by flat sowing (4.14 t/ha) and zero-tillage (3.89 t/ha). Fertilizer application supplemented with residues resulted in significantly higher yield of all the three crops. All the crops responded positively to the application of residues with varying levels of improvement in grain yield. The highest system productivity of 4.761 t/ha (MEY) was recorded in treatment receiving fertilizer supplemented with crop residues. The interaction effect of tillage and crop establishment practices with fertilizer and residues for mustard crop was significant. Conservation tillage (zero-tillage followed by fertilizer and residue application) produced the highest mustard yield (1.71 t/ha) showing that mustard performed equally good under conservation and conventional tillage system. Economics calculated for the 3rd cropping cycle, revealed that zero-tillage produced the highest net return (Rs. 47,582) among the tillage and crop establishment practices. The treatment receiving residue and fertilizer resulted in highest net return (Rs. 53,851). Carbon sequestration rates under zero tillage were higher than conventional tillage. Soil organic carbon level increased with residue application both in conventional and zero-tillage. The energy requirement of the system under conventional tillage was 15-20% higher in different crops compared to zero-tillage. Influence of residues of previous crops (cereal or legumes) was significant during latter years. Carbon sequestration was 20-30% higher (based on 5 years rotation) under conservation tillage than conventional practice. Soil biological parameters, viz. dehydrogenase, acid

phosphatase and alkaline phosphatase, soil microbial count and respiration were significantly influenced due to tillage and residue management.

Aggregate size distribution of surface soil was influenced by tillage and residue management practices. The soil aggregation as indicated by mean weight diameter (MWD) was significantly higher in zero tillage than conventional tillage. The MWD of the surface soil under zero tillage with residue recorded 12% higher than the conventional tillage with residue. Similarly aggregation without residue application was 33% higher in zero tillage than the conventional tillage. On an average zero tillage recorded higher MWD than conventional tillage showing the better soil aggregation under the former. The distribution of micro-aggregates (< 2 mm) was higher in conventional tillage than zero tillage performing the better aggregate stability under zero tillage situations. Soil aggregation was not significantly influenced due to cropping systems.

Conservation agriculture involving conservation tillage and residue management helped in enhancing grain yield of most of the cereal and legume based system crops. This practice also helped in enhancing carbon sequestration, soil biological health, soil aggregation and energy saving in the system.

Keywords：*Conservation agriculture, Cropping systems, Grain yield, Energy, Carbon sequestration*

P3-448

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Rice Straw Managements with Fertilizer Types on Enhancing Growth, Yield and Carbon Stock in Rice

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To study the long term effects of rice straw management with fertilizer type on enhancing growth, yield, carbon stock and improve some soil properties of rice in 2010-2012. The experiment was using 2x2 factorial in CRD as consist of 1) rice straw management (rice straw burning; R1 and remain rice straw; R2) and 2) fertilizer type (chemical fertilizer; F1 and organic fertilizer; F2) with 4 replications. The results shown that plant height was the highest and significantly different in remain rice straw and chemical fertilizer application. Tiller number was the highest and significantly different in chemical fertilizer application, but do not significantly different rice straw management combined with fertilizer types. In addition, yield was the highest in remain rice straw and chemical fertilizer application, but do not significantly different all of treatment. Percentage normal seed was the highest and significantly different in chemical fertilizer, but do not significantly different in rice straw management combined with fertilizer types. The total CO_2-C emission was the highest and significantly different in remain rice straw with organic fertilizer application. While, total carbon content in plant was the highest and significantly different in remain rice straw however, total carbon content in plant was not significantly different in fertilizer type and rice straw management combined with fertilizer types. Soil carbon stock was gave the result as same the total carbon content in plant. In addition, soil bulk density and soil organic matter were increased and significantly different in remain rice straw management and remain rice straw combine with organic fertilizer application. The pH value was not significantly different all of treatments. Soil organic matter were increased and significantly different in remain rice straw management and remain rice straw combine with organic fertilizer application. Available P in soil was increased and significantly different in chemical fertilizer and remain rice straw combined with chemical fertilizer application. Exchangeable K was the highest in chemical fertilizer, but do not significantly different all of treatments.

Keywords：*carbon, fertilizer, rice, rice straw, soil*

P3-449

[C3.5-3] Management and Reclamation of Mining Site Soils

General Characteristic of Soils in Ecologically Vulnerable Mining Areas around Kajaran Town in Armenia

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Modern industrial and agricultural production results in toxic effects on biota that appears to be one of the main factors of man-caused ecological risk.

Kajaran town is situated in the south-east of the Republic of Armenia. The lands of the area belong to the type of mountain cambisols. Developed mining and smelting industries can be observed in this area. This economic sphere is one of the main sources of soil pollution with heavy metals which are considered as dangerous pollutants causing the desertification of soils. The accumulation of these contaminants in the environment has become a concern due to the health risks to humans and animals.

The location of the main sources of pollution considered, six of the most risky sites in this area and an unpolluted site as a control were selected for the study. During laboratory studies the content of humus was determined by method of Tyurin, pH of water suspensions potentiometrically, the content of heavy metals - by means of ELAN 9000 ICP Mass Spectrometer (PerkinElmer, Inc). The coordinates of the sample locations and the altitude of territory above sea level having been recorded with a global positioning system (GPS) receiver as well as the landscape, relief, pattern of slopes, vegetation, stoniness, degree of erosion, soil types, structure of soils, content of carbonates and mechanical composition of soils have been described for their general evaluation.

The studies revealed that the surface of soils was well covered by vegetation in this area and the naked soils generally made only 0-15% in all. The studied soils are basically weakly eroded and they are classified from good to moderately bad according to texture. In some soil samples much stoniness has been observed. At the time of studies the root systems were comparatively well-developed almost in all soil samples. The pH of studied soil samples was from slightly acidic to slightly alkaline and ranged from 6.84 to 7.78. The content of humus ranged from 3.39 to 7.66 % in the upper A horizon.

The study of pollution of soils with heavy metals and metalloids revealed the significant increase (1.5-17 times) in contents of As and the following metals: Co, Ni, Cu, Zn, Cr, Sr, Mo, Cd, Pb compared with control sample. Experiments have led us to the assumption that pollution of soils with mentioned elements in studied territory is conditioned by human activities, particularly by mining and smelting industries.

Keywords：*Soil pollution, heavy metals, mining industry, recultivation of soils, hydroseeding method*

P3-450

[C3.5-3] Management and Reclamation of Mining Site Soils

The Role of Reclamation Research in Re-Establishing Functional Ecosystems in the Oil Sands Region of Northeastern Alberta

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Oil sands mining in northeastern Alberta, Canada removes much of the pre-disturbance boreal landscape, leaving behind overburden dumps, tailings, and other waste streams that need to be reclaimed. With oil sands development, the total area of disturbance in the region is expected to increase in the coming decades. One of the fundamental goals of oil sands mine reclamation is the re-establishment of functional ecosystems on reconstructed soils that have the equivalent land capability of the area prior to surface mining. Such re-establishment relies on the generation and refinement of knowledge on successful ecosystem development on reclaimed lands. Knowledge development occurs collaboratively through various multi-stakeholder organizations with members from government, industry, environmental groups and Aboriginal groups. This presentation will review some terrestrial reclamation research programs and explore future research opportunities in the context of developing recommendations on reclaiming mining site soils in the oil sands region.

P3-451

[C3.5-3] Management and Reclamation of Mining Site Soils

Soil and Mining Problem in the Kyrgyzstan

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It is known that the mountains occupy 1/5 of the land surface and are the largest ecological system of the planet. A mountainous area is home to more than 10% ofthe world's population, over 50% of mountain resources used in the economy. The natural features of the mountain systems are complex and fragile. Dynamism of relief, soil erosion, high seismicity, landslides, avalanches, torrents of water, falling rocks, etc. cause a complex condition for human life. These processes occur in the mountains many times in the tens - thousands of times more intense than other natural landscapes (eg , soil erosion, biogeochemical processes).

The man consumer attitude to the mountains as a source of natural resources, has led to the fact that on the eve of the third millennium, the socio-economic situation of mountain areas on all continents of the world has become negative (mountain soil degradation, loss of biodiversity, loss of endemic species, poverty, population, migration, information problems, etc.).

The mountainous areas in Kyrgyzstanaccount 94% of the total area, nearly half the population lives at elevations of 1000-2000 m (36 %) and 5% at altitudes of over 2,000 m above sea level, the mountains of Kyrgyzstan is very rich in different kinds of minerals. Scientists estimate that in Kyrgyzstan there are more than 10,000 mineral deposits (Bakirov, 1997), of which 1,000 are considered promising. The main socio-economic problem at present in the country, is decided on the basis of extensive accelerate and expand the economic development of the mining industry, on the other hand, the trend of environmental degradation (degradation of soils, pastures, destruction of geochemical environment, the deterioration of the quality of water drinking and in general biogeochemical processes violation).

Mountain areas in different heights are unequal in environmental biogeochemical response. In Kyrgyzstan, every ridge and intermountain basins are clearly distinguished characteristics of trace elements in the soil cover (Pb, Cu, Ni, Be, Hg, Se, F, Au, Ag, U, Th, Ra , etc.), the lack of or an excess of micro and macro causes a variety of diseases (endemic) of animals and humans. For example, in soil in KyrgyzstanI drawback to 95%, Co-31%, Cu-28%, Zn-24%

excess - Mo, Cu, Pb, Zn, Sr, and other elements (Kovalskii, 1974, Djenbaev, 2009). However, the biological responses of soil and organisms in mountain ecosystems are different, which are determined by variable concentrations and ratios of many chemical elements.

P3-452

[C3.5-3] Management and Reclamation of Mining Site Soils

Reclamation Cover System Design Based on Environmental Impact Evaluation due to Phosphate Mining Activities

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This study presents the selection of a reclamation cover system based on a modeling application, in which potential environmental impacts to water resources due to a proposed phosphate mine were evaluated. The proposed mine consists of an open pit that would be mined in three panels. Relevant mining activities include construction of overburden piles and ore stockpiles, pit backfilling, and reclamation of impacted areas. Several surface water bodies exist within or near the project area, one of which is a Special Resource Water recognized as needing protection to maintain characteristics and current beneficial uses.

The proposed mining activities have the potential to impact surface and groundwater resources due to metals and other constituents that could be released into the environment. Site-specific geochemical characterization studies for the project were prepared to evaluate the geochemical characteristics and leaching behaviors of the overburden and ore that would be produced from the proposed mine. Columns were prepared to evaluate the potential release of metals and other constituents from the proposed mine facilities, and leaching tests were conducted over several leach cycles to obtain leachate concentrations for all potential source areas. A numerical groundwater flow and solute transport model has been developed to support the water resource impact analysis for the project environmental impact statement. The numerical modeling conducted in this study was the most sophisticated three-dimensional flow and transport modeling to date for any mine in the Idaho 'Phosphate Patch'.

Three scenarios were evaluated using the constructed model: (1) Proposed Action, (2) Alternative 1A, and (3) Alternative 1B. Three types of cover systems were considered in the three scenarios: the Base Case cover system, the Simple 1 cover system, and the “Complex 2” GCLL cover system. The specific objective of the study was estimate potential impacts to groundwater and surface water quality associated with leachate from mine facilities, including open pits, backfills, external waste dumps, and ore stockpiles, and aid in the selection of the final reclamation cover system.

Keywords：*Phosphate Mining, Reclamation, Geochemistry, Numerical Modeling*

P3-453

[C3.5-3] Management and Reclamation of Mining Site Soils

Monitoring of Soils in Ecologically Vulnerable Mining Areas around Shamlnogh Town in Armenia

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Currently the impact of human activities on natural landscapes has reached to such a level that it surely affects both their qualitative and quantitative characteristics. Chemicals entered into the ecosystem circulation accumulate within different links of trophic chains, concentrate in air, water, soil and sediments, and get the property of long-term after-effects. The prime emphasis among environmental advocates has always been the protection of human health, with the implicit recognition that human well-being is inextricably intertwined with the health and stability of natural ecosystems of which we form an integral part. Some of today's most prevalent ills are increasingly blamed on toxic environmental contaminants heavy metals/metalloids that become pollutants as a result of previous industrial, mining or other activity, synthetic chemical wastes carelessly dumped in waterways or landfills, products of combustion spewed into the air, pesticide residues and chemical additives in the food we eat. Contamination of soils by heavy metals is a significant problem, which leads to negative influence on soil characteristics and limitation of productive and environmental functions. Heavy metals are included in the main category of serious environmental pollutants due to their persistence and bioaccumulation problems.

Mining industry is also developed in the Republic of Armenia and similar problem exists here, in particular in the lands around Shamlugh town of the Lori Marz. Shamlugh town is situated in the north-east of the Republic of Armenia. This economic sphere has been the mainstay of the Armenian economy for over 20 years. Since last decades of the twentieth century, mining and benefication of a variety of minerals, in particular copper and gold, have been the driving force behind economic development, particularly in Lori Marzes of the Republic of Armenia. This branch of industry is one of the main sources of soil pollution with heavy metals/metalloids (Pb, Cu, Ni, Cd, Mo, As etc.) which are considered as dangerous pollutants causing desertification of soils. In spite of adverse effects of mentioned risk elements industries are required for the economy modernization and development of the cities like Alaverdi, Akhtala and Shamlugh. Appropriate management of surroundings of open mines, active tailing dams, sites adjacent to ore-dressing and processing enterprises as well as suggestion of ways for prevention of pollution in surrounding territories are very important.

The location of the main sources of pollution considered, two of the most risky sites in this area (surroundings of open mine and active tailing dam of) and an unpolluted site as a control were selected for the study. From two most risky sites was taken 17 soil samples. During laboratory studies the content of humus was determined by method of Tyurin, pH of water suspensions potentiometrically, the content of heavy metals - by means of X-ray fluorescence analyzer. The coordinates of the sample locations and the altitude of territory above sea level having been recorded with a global positioning system (GPS) receiver as well as the landscape, relief, pattern of slopes, vegetation, stoniness, degree of erosion, soil types, structure of soils, content of carbonates and mechanical composition of soils have been described for their general evaluation.

The studies revealed that the surface of soils was well covered by vegetation in this area and the naked soils generally made only 0-25% in all (only in three site observed a to 50% naked soils). The studied soils are basically non eroded or weakly eroded (only in one site observed a medium level of erosion) and they are classified from fine to medium according to texture (Clay Loam, Clay, Silty Clay and Loam). In some soil samples much stoniness has been observed. At the time of studies the root systems were comparatively well-developed almost in all soil samples. The pH of studied soil samples was from slightly acidic to slightly alkaline. The content of humus ranged from 3.91 to 12.26 % in the upper A horizon.

The study of pollution of soils with heavy metals and metalloids revealed the significant increase in contents of the following metals: Co, Ni, Cu, Zn, Cr, Sr, Mo, Cd, Pb compared with control sample. Experiments have led us to the assumption that pollution of soils with mentioned elements in studied territory is conditioned by human activities, particularly by mining and smelting industries.

Keywords：*Heavy metals, mining, soil degradation, environmental contaminant*

P3-454

[C3.5-3] Management and Reclamation of Mining Site Soils

Trace Metal Concentrations in Schoolyard Soils; Talcahuano, Chile

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It is well documented that infants and children have a greater intake per unit of body weight of soil, air and water. The objective of this study was to determine the occurrence and concentrations of potentially toxic metals in soils to which children might be exposed during outdoor school activities. A total of 76 soil samples from 38 schoolyards throughout Talcahuano, Chile were collected. For each schoolyard site, a sample of the topsoil (ts, 0 to 10 cm) and subsurface soil (ss, 10 to 20 cm) were collected for analysis. The processed samples were analysed by Aqua Regia for the following elements Ba, Cr, Co, Ni, Sr and V. The median concentrations (mg/kg) obtained were Ba 133 (range 29 - 911 mg/kg), Cr 29 (range 14 - 253 mg/kg), Co 13 (3 -23 mg/kg), Ni 30 (7 - 79 mg/ kg), Sr 99 (13 - 272 mg/kg) and V 138 (57 - 3254 mg/kg). The distribution of Ba, Cd, Cr, V along with pH and CEC (cation exchange capacity) show depth-dependent changes, and appear to be responsive to anthropogenic influences. The ratios analysis between ts and ss show anthropogenic sources for the trace elements in the schoolyard soils of Talcahuano. Some of the samples exceeded the limits set for soils based on the Dutch guidelines system.

Keywords：*trace metals, schoolyards, Talcahuano, Chile*

P3-455

[C3.5-3] Management and Reclamation of Mining Site Soils

Mineralogy Characteristics of the Soils in the Site Stockpiled by Chromite Ore Process Residue (corp) and its Decontamination by Ex-Situ Washing

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Chromite ore process residue (CORP) is a kind of waste product with a high proportion, 0.3-1.5% in general, of the soluble hexavalent chromium. The sites stockpiled with CORP were usually found a severe contamination of chromium in soil and groundwater. A cumulative of 6.7 million tons of CORP has been produced in the past decades and over 80 storage places were distributed in the 19 provinces of China. Although the CORP stockpiled in those places have been cleared by now, the sites are still polluted by chromium and other toxic metals and hence need to be cleanup prior to property development.

The selected stockpile site is located in Zhejiang Province, east of China. A total chromium content of the polluted soil was as high as 2.3% and the total hexavalent chromium was 6200 mg/kg in the site. The mineralogy characteristics of the polluted soil were analyzed by x-ray diffraction (XRD), scanning electron microscope coupled with Energy Dispersive X-ray Detector (SEM-EDX). An ex-situ soil washing based on particle-size separation was tested in the laboratory to decontaminate the soil. The results indicated that a large proportion of primary minerals such as calcite, brucite, brownmillerite, etc could be found in the soil. The chromium mainly occurred in the minerals including stichtite, brownmillerite, donathite, bentorite, nordstrandite. The surface of calcite was not found chromium precipitation. Donathite, brownmillerite and nordstrandite were resistant to acid washing and rather stable in the soil. The soil has a high proportion of sand fraction (>70%) which accumulated a higher content of hexavalent chromium than other fractions. Hence, the method of soil washing might be an appropriate option when remediation. A total of 6 types of solvents were selected to testing and the 0.5M citrate acid was found with a comparatively higher washing rate of hexavalent chromium from the polluted soil. The dynamic release of the chromium from the soil during the washing was studied by a column leaching experiment. The results indicated that releasing of the hexavalent chromium were dominated by dissolving of the minerals containing magnesium.

Keywords：*COPR, soil pollution, chromium, soil washing*

P3-456

[C3.5-3] Management and Reclamation of Mining Site Soils

Development of Microbial Community Diversity during Remediation of Alkaline, Saline Tailings: Towards Improved Remediation Strategies

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Bauxite residue, a highly alkaline (pH >11), saline (EC>4 mS/cm), fine-grained tailings material generated during the Bayer process used for alumina production, poses a hostile environment for microorganisms. After closure of bauxite residue storage facilities, various chemical and physical amendments are applied to remediate the extreme salinity and alkalinity of these tailings to values more typical of non-Technosolic soils, and to support development of a sustainable ecosystem. Stimulation of microbial communities is generally acknowledged as beneficial to tailings remediation; however, microbial community dynamics during remediation are poorly understood, particularly for alkaline, saline tailings. No previous study has combined geochemical, physical, and metagenomic analyses for bauxite residue across a variety of field sites in order to identify relationships between environmental conditions and microbial community composition. Salinity and sodicity (water extractable Na+) were identified as the major drivers of bacterial community composition and diversity across remediated and unremediated tailings widely ranging in pH (4-11); whereas titratable alkalinity and gravel concentration were the major drivers of fungal community composition and diversity. Results identified that improvement of the physical properties of bauxite residue, by enhancing drainage and aeration, and encouraging structure development, is essential to establishing a diverse microbial community with a composition similar to that of undisturbed soils. Successful remediation can be expected to reduce the dominance of Proteobacteria and Firmicutes within bacterial communities, and Ascomycota within fungal communities, and encourage the development of more diverse microbial communities.

Keywords：*microbial ecology, Technosol, tailings remediation, pedogenesis, geomicrobiology*

P3-457

[C3.5-3] Management and Reclamation of Mining Site Soils

Lead Accumulation in Native Plants Growing on Mining Soils of Peruvian Andes

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Soil pollution by trace elements due to mining and smelting activities is a worldwide problem. Conventional techniques that are used for remediation for contaminated soil are costly, disruptive and labor intensive. Two major options can be envisaged, phytoextraction and phytostabilization. Efficient phytoextraction requires plant species combining both high metal tolerance and elevated capacity for metal uptake and metal translocation to easily harvestable plant organs (e.g. shoots). South American countries are rich in valuable ore deposits and mining activities that have quickly developed all over the continent. In general, the environmental impact of mines in Europe and North America has been evaluated in detail. In contrast, data on impact assessment of the mining activities in South America countries are still very poor. Soil and plant samples were taken in Peru, at a polymetallic mine (mainly Ag, Pb and Cu) in Cajamarca Province, Hualgayoc district. Top soils (0–20 cm) were analysed for physical and chemical properties by standard methods. Total As, Cd, Cu, Pb and Zn concentrations in top soils were determined by ICP-OES. Similar metals in plants were analyzed separately (aerial and root system) by ICP-MS. Ti content was used as an indicator for contamination of plant samples with soil particles. Translocation Factor (TF) and Shoot Accumulation Factor (SAF) were determined to assess the tolerance strategies developed by these species and to evaluate their potential for phytoremediation purposes. The non-polluted soils had near neutral pH (6.8±0.1), a great content of organic carbon (42 ± 4.0 g•kg−1) and a silt loamy texture. Soil and plant samples were taken at three locations with different levels of As and polymetallic contamination (Cu, Pb and Zn). The range of total soil values in mg•kg−1 is as follows: As 580-1081; Cu 532-1376; Pb 11717-16633 and Zn 16700-28000 mg•kg-1, respectively). The non-polluted values around the mine were As 65, Cu 46, Pb 124 and Zn 384 mg•kg-1, respectively. Unusual elevated concentrations of Pb were detected in shoots of Ageratina sp (from 1253 to 5045 mg Pb•kg−1) and Achirodine alata (from 1352 to 1650 mg Pb•kg−1) in two of the three studied locations. Ageratina sp and Achirodine alata had a TF greater than one, but the BF was smaller than one. Despite the low BF index, the great TFs for Pb indicate that these plant species effectively translocate this metal (i.e., 2.4 for Ageratina sp and 1.5 for A. alata). It seems that the BF is not a reliable index when the metal soil concentration is extremely large. Controlled-environment studies must be performed to definitively confirm the Pb hyperaccumulation character of Ageratina sp and Achirodine alata.

Keywords：*heavy metals, hyperaccumulation, Peru, polymetallic mine*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Heavy Metal Extraction by Spontaneous Plants Growing on Multi-Metal Contaminated Site in South Brazil

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Environmental contamination of heavy metals has caused innumerous problems to human health and to the other components of the ecosystem. Plants can be used as remediation strategy to cleanup heavy metal pollution. Based on that assumption, the aim of this study was to determined heavy metal concentrations in biomass of plant species growing on a multi-metal contaminated site as possible heavy metal extractor for phytoremediation. Seven plant species and associated rhizospheric soil were collected from mining disposal site and analyzed for heavy metal concentrations. While plant Cu, Zn, Cd, Ni, Pb, As and Ba concentrations ranged from 8.8 to 21.1, 56.4 to 514.3, 0.24 to 2.14, 1.56 to 2.76, 67.8 to 188.2, 0.06 to 1.21 and 0.05 to 0.62 mg kg-1, respectively. None of the plants were identifies as hyperaccumulator. Those in the rhizospheric soil ranged from 10.5 to 49.1, 86,2 to 590.9, 0.33 to 2.0, 3.6 to 8.2, 19.1 to 232.5, 2.0 to 35.6 and 85.8 to 170.3 mg kg-1, respectively. However, Zn, Cd, Pb and As concentrations in the soil outside of rhizosphere zone were 499, 2.0, 631 and 48 mg kg-1, respectively. The plants with bioconcentration factor (BCF, metal concentration ratio of plant roots to soil) and translocation factor (TF, metal concentration ratio of plant shoots to roots) greater than one have the potential to be used for heavy metal extraction. The plants of Senecio leptolobus had BCF and TF greater than one (3.6 and 1.03, respectively) being most effective in extracting Zn and Pb; for plants of Baccharis trimera the BCF and TF were 4.63 and 1.30, respectively for Cd and the plants of Senecio brasiliensis had BCF and TF of 1.49 and 1.13, respectively for Pb. The Senecio brasiliensis was most effective in extract Cu, Cd, Ba. For Zn and Pb translocation, Baccharis trimera was most effective and for plants of Dicranopteris nervosa (Kaulf.) and Hyptis brevipes Poit. were most effective for As extraction. Our results shown that native plant species growing on multi-metal contaminated site in the South of Brazil may have potential for heavy metal extraction and remediation.

Keywords：*Native plants, Translocation, Bioconcentration, Metal accumulation, Phytoremediation,*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Leaching of Nutrients and Plant Growth in Bauxite Residue Sand after Addition of Amendments

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In an alumina refinery, bauxite is ore is treated with sodium hydroxide at high temperatures and pressures using the Bayer process. For every tonne of alumina produced, about two tonnes of alkaline, saline, bauxite processing waste is also produced. At Alcoa, in West Australia, processing residue is separated into residue mud (<150 μm) and residue sand (>150 μm). The residue sand is used to construct the outer embankments of the residue storage areas and the residue mud (after dewatering/thickening and direct carbonation) is deposited within them. The storage area is built as a progressive stack and periodically the perimeter embankments are built higher with sand and the volume then filled with residue mud. It is the sand fraction of the outer walls that is revegetated. The residue sand is amended with gypsum and fertilizers and planted with a mixture of shrubs and trees native to a West Australian sand dune ecosystem. Growth of these native plants can be disparate and sometimes poor, and there is little regeneration of the vegetation. Suggestions for more effective revegetation include better mixing of gypsum with residue sand, particularly in the subsoil, and addition of amendments to the surface layer such as residue mud (to increase water holding capacity) and organic wastes, such as animal manures (to increase soil microbial activity and nutrient supplying capacity).

The purpose of this study was to examine (1) the effect of organic (poultry manure) and inorganic (residue mud and phosphogypsum) amendments on nutrient leaching losses from residue sand and (2) whether amendments improve the growth of plants in residue sand. To this purpose, a leaching column experiment was established under glasshouse conditions. Much of the Na+, K+, Cl- and SO42- was lost in the first four leachings. Additions of phosphogypsum to both the surface and subsurface horizons resulted in partial neutralization of soluble alkalinity. Mean pH of leachates ranged from 8.0 to 8.4, the major cation leached was Na and the main balancing anion was SO42-. Where gypsum was not applied to the subsurface, mean pH of leachates was 10.0-10.9, the main cation leached was still Na and the main balancing anions were a combination of SO42- and HCO3-/CO32-. As a result, at the end of the experiment, concentrations of exchangeable Na in the subsurface layers were similar regardless of whether gypsum had been applied to that layer or not. Yields of Acacia saligna were promoted by additions of poultry manure to the surface layer. The continued supply of Ca2+ from dissolution of phosphogypsum resulted in displacement of fertilizer K+ and Mg2+ from exchange sites and their subsequent leaching out of the profile. The resulting Mg/K deficiency in plants was corrected by nutrient release from the added manure. Plant growth tended to be increased by additions of residue mud but were unaffected by phosphogypsum incorporation into the subsurface. It was concluded that lack of reaction of gypsum in the subsurface layer is unlikely to be a major factor limiting revegetation of residue sand since without phosphogypsum addition the excess Na leaches with residual alkalinity (HCO3-/CO32-) rather than SO42-.

Keywords：*bauxite processing residue; poultry manure; red mud; revegetation*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Characterization of Soils in Wetlands of the Lower Basin Babahoyo River (Ecuador)

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The lower basin of the Guayas River (Ecuador) is a zone of coastal wetlands where rice (Oryza sativa) is grown in an area of 350,000 ha. In this study, an experimental area of 100 km2 was established on the banks of the Babahoyo river which is a tributary of the Guayas River, in Samborondon and Yaguachi cantons. There are different sources of pollution such as agricultural inputs, ureas and pesticide, discharges of the industries to the Guayas river subsequently its waters serve as irrigation for agriculture, and Tungurahua volcano which is regularly erupting from 2008. 26 sampling stations were established to study the heavy metals in soils, their relation to soil pedologycal properties and their concentration in rice plants using multivariate analysis. Also Oryza sativa was monitored on 5 sampling stations. At each site 12 variables were measured resulting over the 26 sites in the following average: organic matter 4%, clay 32,7%, loam 49,8%, sand 17,5%, pH 6.6, electrical conductivity 7,9 mS m-1, metal concentration in mg kg-1 Cu 48,8, Fe 8.734, Mn 343, Zn 34, Hg not detected, Cd 0,15 and Pb 4,4. Statistical analysis revealed that 40,7% of the spatial variability in heavy metals in the topsoil is explained by the first two principal components, loam and clay (CP1) and clay and cadmium (CP2). In addition, the 26 sites could be grouped in 6 distinct classes at an euclidian distance of 3,22 km. Based on the concentration the heavy metals in the topsoil rank from high to low as follows: Fe > Mn > Cu > Zn > Pb > Cd. The concentration of Pb in the sites where also the Pb concentration was measured in the rice plants, 5 locations in total, ranged in the topsoil between 6,55-8,87 mg kg-1, in the roots between 3,30-4,40 mg kg-1, in the stems between 2,01-2,60 mg kg-1, and in the leaves between 1,80 and 2,00 mg kg-1 so these levels are not toxic for the crop.

Keywords：*Heavy metals, Ecuador, Rice crop, Fytotoxicity, Topsoil*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Spatial and Temporal Variability of Salinity Soil in Rice Wetlands of the Lower Guayas Basin (Ecuador)

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The spatial and temporal variability of soil salinity was examined in the rice farming converted wetlands situated in the Lower Basin of the Guayas River. A series of soil physical and chemical characteristics of the top layer were determined at a two year screening interval (2006-2008). Differences were checked using the t-Student test, and the relation between characteristics examined using cluster and principal component analysis. Rice cultivation in the study area is restricted by the high salinity level in the top layer of 0 to 20 cm deep. Over the two years an average value was recorded of 19.7 and 15.8 dS m-1 in the surface layer (0 cm), decreasing to 4.9 and 4.5 dS m-1 at a depth of 20 cm. Whereas the salinity level decreased significantly from 2006 to 2008 at the depths 0, 5 and 10 cm, no significant difference was found for the depths 15 and 20 cm. The decrease in salinity level at the top is likely due to the more than normal precipitation in the period 2006-2008. Based on the observed properties, the 26 sampling points could be divided into three homogenous groups using the cluster and principal component analysis. Saline intrusion from the tidal affected Babahoyo River and the poor external and internal soil drainage seem to be the main causes of the salt accumulation at the soil surface

Keywords：*Soil salinity, Spatial and temporal variation, Rice, Weatland, Ecuador*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Using Landform Evolution Models to Assess the Erosional Stability of Waste Encapsulation Structures at the Millennial Timescale

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The Newcastle group have over the last 20 years pioneered the use of landform evolution models (LEM) for the assessment of the long-term stability of encapsulation structures for the mining industry (uranium among them; the wastes have included mine tailings, pyrite and other potentially environmentally sensitive waste) and low level nuclear waste repositories around the world. This work has focused on design lifetimes of 100 to 1000 years, sufficient time for the landforms and ecosystems on them to have changed due to runoff and erosion, so that traditional, fixed landform, erosion models (typically developed for agricultural applications) and remediation solutions are not appropriate. Accordingly we have had to pioneer new ways of (1) calibrating models to data, (2) validating the predictions of the models, (3) methods for analyzing the assessment results, and (4) tools for facilitating the assessment task. In recent years other groups have started using our software or similar tools. This paper will summarize current science and technical capabilities, highlight science challenges that have arisen out of this work that should be resolved, and impediments to the use and acceptance of these approaches in practice.

The presentation will present some examples of landform assessments going back to the early 1990's using LEMs showing how the LEM assessment can elucidate aspects of the landform stability that more traditional erosion models cannot including above-grade structures, geomorphically optimal designs and multi-layered armoured caps and covers. The discussion will highlight the new insights that can be made using LEMs. However, they are not without their limitations at the current time.

The main issue with LEMs is that many hillslope properties that can be directly measured for an existing hillslope actually evolve in concert with an evolving hillslope. This complicates the modelling of an evolving hillslope because this indicates that we need sub-models for the evolution of these hillslope properties and these sub-models must respond dynamically to the evolution of the hillslope. The best example of this need for sub-models is the evolution of the grading of soil on the surface of the hillslope. As a slope or gully evolves erosion strips out the finest fraction of the soil on the surface leaving behind a coarse armour that is relatively more resistant to erosion. As the surface erodes further even more fines are eroded and the surface continues to coarsen. Thus the erodibility of the surface is intimately tied to the cumulative erosion from the surface. To illustrate the scale of this problem consider that for a typical batter on a waste repository edge 20m long and 10m high a change in elevation of 10cm will make only a slight difference to the hillslope gradient and slope (and thus erosion if the erodibility is unchanged), but might make a dramatic difference to armouring of the surface and thus the erodibility of a surface. This suggests that for waste repositories the changes in the surface grading may be as significant, and sometimes more, than the changes in slope. Recent advances in our group have overcome this problem and results to date from a soil pedogenesis model capable of being coupled with a LEM will be discussed.

Keywords：*mining, encapsulation, erosion, waste*

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[C3.5-3] Management and Reclamation of Mining Site Soils

The Fluvial Transport of Lead (pb) from an Orebody in an Arid Australian Landscape

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Located in western New South Wales, Australia, the town of Broken Hill receives an average annual rainfall of around 260 mm and is built around the Line of Lode orebody, one of the richest lead-zinc-silver deposits in the world. Various surveys of soil lead (Pb) concentrations have shown that a 'halo' of elevated Pb values (more than 1000 ppm) exist within approximately 0.5 km of the Line of Lode. Beyond this distance, topsoil Pb concentrations diminish to less than 100 ppm and at the edges of the township the topsoil Pb concentrations are no different to those of average soil and sediment materials. Approximately 15 km to the east of Broken Hill lies the Stephen's Creek Reservoir, one of the two water storages holding the town's drinking water supply. Three different catchments contribute water into the Stephen's Creek Reservoir, and one of these, the Willa Willyong Creek catchment, drains the Line of Lode. In the late 1970s, measurements of metal concentrations in the sediments and water of the drying Stephen's Creek Reservoir showed that Pb concentrations were highest (~650 ppm Pb in the sediment) near the inflow point of the Willa Willyong Creek, and that the other catchments were essentially providing only background levels of Pb to the reservoir. During much of the first decade of the 21st century, Broken Hill received well below average rainfall, but this was followed in 2010 and 2011 by very wet years yielding more than double the annual average rainfall. Much runoff occurred during this time and the Stephen's Creek Reservoir was filled. Here, we report the results of a 2013 survey of soil and sediment Pb concentrations along two tributaries of the Willa Willyong Creek that drain the eastern parts of Broken Hill, and of the main Willa Willyong Creek channel that drains into the reservoir. Paired sites were sampled where possible, with sediment taken from the creek bed and topsoil taken approximately 10-20 m from the creek bank. Sediment and soil samples were analysed for total Pb concentration using a portable X-ray fluorescence spectroscope (pXRF) in both the field and laboratory modes, while the Pb concentrations of the clay- and coarse sand-sized fractions of each sample were assessed by pXRF in the laboratory. Our results show that, in general, the alluvial topsoils close to the creek contained greater concentrations of both clay and total Pb than did the creek bed sediments, and that both creek bed and topsoil samples contained more Pb than soils not located in a catchment draining the Line of Lode. At the most downstream paired sampling site, located 15 km downstream of the Line of Lode and just 1.5 km from the reservoir inflow point, the Pb concentration of the alluvial topsoil was approximately 500 ppm, more than 10 times that of the 'background' topsoil Pb concentration. At some locations near the Line of Lode, the coarse sand fraction of samples yielded distinctly higher Pb concentrations than the bulk soil/sediment, indicating the short-range fluvial transport of particulate lead-bearing minerals such as galena and cerrusite, but at further distances from the orebody the clay-sized fraction generally yielded greater Pb concentrations than the bulk soil/sediment. Due to the generally greater amounts of clay in the alluvial topsoils than in the creek bed sediments, total Pb concentrations were generally greater in the former. Of the two sub-catchments sampled, the southern sub-catchment, which drains the south-eastern flank of the Line of Lode, was found to host larger soil/sediment Pb concentrations; although the northern sub-catchment drains the north-eastern flank of the Line of Lode, it also drains a large, mostly paved urban area that includes an artificial wetland which appears to effectively trap sediment. Despite the arid climate of Broken Hill, it is clear that the infrequent high volume rainfall events experienced there play a significant role in mobilizing Pb in the landscape through sheet wash and ephemeral creek flow. Storm water management remains a priority for local authorities to ensure that drinking water supplies are not compromised.

Keywords：*lead, alluvium, erosion*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Geochemistry of Heavy Metals in Soils of Mineralized and Non-Mineralized Areas, Western Thailand

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Abandoned mine land is one of the legacies of historic mining activities, causing a wide range of environmental problems worldwide. The western part of Thailand is a traditional mining region with Pb, Zn and Sn mines. Heavy metals such as Pb, Cu, As, Ba, Fe and Zn have been released and transported from mining sites to the adjacent landscape. The objective of this work was to evaluate contents of heavy metal in soils of mineralized and adjacent non-mineralized areas in western Thailand and to relate heavy metal concentrations to soil characteristics. One hundred sites were sampled at three depths (Ap, Ap-60 and 60–100 cm). Heavy metal contents were determined by extraction with aqua regia followed by ICP-OES analysis. Principal component analysis was used to interpret the dataset and identify affinity groups of samples and properties. In soils of the mineralized area there is a close association among As, Ba, Be, Ca, Cd, Mn, Ni, Pb, S, Sr and Zn. Crest soils were associated mainly with elevated Cu, Cr, Mo, Ti and V concentrations, upper footslope sites with As and Ni and lower footslope with Co. For soils in the non-mineralized area there is a close association among Ag, Ba, Be, Ca, Co, La. Pb, Sr and Zn. Valley floor soils were associated with elevated Ca and Pb. All of the heavy metals consistently showed higher median concentrations in topsoils and in soils of lower geomorphological settings. The median concentrations of Pb and Zn present in both mineralized and adjacent non-mineralized areas were higher than the limits listed in Thailand Soil Quality Standards for Habitat and Agriculture. Valley floor soils within mineralized and non-mineralized areas have the highest accumulations of Pb and Zn and valley floors are the prime agricultural and habitat zones. A high proportion of Pb was present in the oxalate soluble fraction in the valley floor soils, probably due to is accumulation with Fe-oxides.

Keywords：*Heavy metal, mineralized area, non-mineralized area, geomorphology*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Effect of Amendments and Microorganisms Application in the Evolution of Spontaneous Plant Colonization in Tailing Ponds

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Intense mining activities in the past were carried out in Cartagena-La Unión mining district, SE Spain, and caused excessive accumulation of toxic metals in tailing ponds which poses a high environmental and ecological risk. One of the remediation options gaining considerable interest in recent years is the in situ immobilization of metals. Sorption or precipitation reactions induced by soil amendments decrease the concentration of the mobile metal pools in the amended soil. A corresponding reduction in the plant-available metal fraction allows re-vegetation and ecosystem restoration of the heavily contaminated sites. In addition, the use of microorganisms to improve the soil condition is a new tool used to increase spontaneous plant colonization.
The aim of this research was to assess the effect of amendments (pig manure, sewage sludge, and lime) and microorganisms on plant cover establishment, as a consequence of metal immobilization and the improvement of soil properties.
The study was carried out in two mine ponds (acid and alkaline) from Cartagena-La Unión mining district. Twenty seven square field plots, each one consisting of 4 m2, were located in each pond. Four different doses of microorganism (0 ml, 20 ml, 100 ml and 200 ml of microorganism solution in each plot) and one dose of pig manure (5 kg per plot), sewage sludge (4 kg per plot) and lime (22 kg per plot) were used to provide nutrients and organic compounds and to raise the pH and reduce the metal mobility. Organic amendment doses were calculated according to European nitrogen legislations, and lime dose was calculated according with the potential acid production through total sulphur oxidation. Three replicates of each treatment (organic amendment + lime + microorganism dose 0, 1, 2, or 3) and control soil (with no amendments) were carried out. Plots were left to the semi-arid climate conditions of Murcia province after the addition of amendments to simulate real potential applications of the results. Identification of plant species and biodiversity was determined on each plot, after 2, 4, 6 and 8 months of amendment addition.
The results showed that, in those plots without application of microorganism, 8 months after applications the number of species and individuals of each species that were be able to colonize sewage sludge amended plots (Acid tailing pond: Piptaterum mileaceum(2) and Fagonia Cretica(1); and alkaline tailing pond: Zygophylum fabago(14)) were less than those found in pig manure amended plots (Acid tailing pond: Piptaterum mileaceum(11), Sonchus tenerrimus(4) Dittrichia viscosa(2) and Fagonia cretica(2); and alkaline tailing pond: Zygophylum fabago(31) and Piptaterum mileaceum(9)). Higher number of species and individuals of plant found in pig manure–amended plots compared to sludge could be related to the highest contents of seeds of pig manure and a higher and easier release of nutrients under Mediterranean climate.
In relation to the effect of the microorganism's doses in spontaneous plants colonization, there is an increase in the number of species and individuals when the dose of microorganism was increased for both organic amendments, especially in pig manure amendment plots. Eight months after amendments application and in plots with dose 3 of microorganism, a maximum of 4 species (Sonchus tenerremus(2), Malva silvestris(2), Piptaterum mileaceum(7), and Dittrichia viscose(1)) and 2 species (Zygophylum fabago(4) and Piptaterum mileaceum(1)) in the plots amended with sewage sludge were found in acid and alkaline ponds respectively; and 7 species (Sonchus tenerrimus(3), Malva silvestres(1), Piptaterum mileaceum(23), Dittrichia viscosa(4), Fagonia cretica(8), Polypogon monspeliensis(1) and Diplotaxis lagascana(1)) and 5 species (Zygophylum fabago(80), Malva silvestres(4), Piptaterum mileaceum(19), Diplotaxis Lagascana(1) and Sonchus tenerrimus(1)) in the plots amended with pig manure in acid and alkaline ponds respectively.
These proved that improvement of mine soil conditions by the addition of carbonates, organic matter and microorganisms enhanced the spontaneous establishment of plants.

Keywords：*amendment, microorganism, tailing ponds, plant colonization*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Assessment of Heavy Metal Contamination of Soils and Water Properties in and around Open Cast Mines of Enyigba Area, Ebonyi State, Nigeria and the Implication for Landuse Management

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Soil is considered a non-renewable natural resource thus adequate soil management techniques should be put in place for optimum soil productivity. Obvious significant negative environmental impacts of mining such as pollution of water bodies and farm lands leads to decrease in soil fertility and soil quality as well as land degradation and changes in landscape. In view of the foregoing, this research was conducted to evaluate the impact of solid minerals mining at the Enyigba Lead-Zinc mining district in Abakaliki L.G.A of Ebonyi State and to document the present state of soil heavy metal status of both soil and surrounding water bodies. The study examined the extent to which heavy metals from mining activities have contaminated the soil as well as the surface waters within the vicinity of mine sites. In the study, two factors were considered: factor A - Soil depths (surface soil: 0-15 cm and subsurface soil: 15-30 cm) and factor B - Distances from mine pits (100 m, 200 m, 300 m, 400 m and 500 m away from mine pit). Four mining sites (Mbaraeke Enyigba, Mkpoda Ugwvu, Nwamgbam Uchakuru and Azu Enyigba) within Enyigba mining vicinity were selected for the study to represent four replications. These were compared alongside a control (located 1.5 km away from Enyigba mining vicinity). Heavy metal concentrations (Arsenic (As) 0.166 mg/kg, Cadmium (Cd) 20.373 mg/kg, Copper (Cu) 2.042 mg/kg, Lead (Pb) 0.498 mg/kg and Zinc (Zn) 4.769 mg/kg) at the mine sites were significantly ($p < 0.05$) higher compared to the control (As 0.025 mg/kg, Cd 11.097 mg/kg, Cu 0.702 mg/kg, Pb 0.05 mg/kg and Zn 2.3 mg/kg). The heavy metal levels in Enyigba mine site decreased in the order Cd>Zn>Cu>Pb>As in the surface soil and Cd>Zn>Cu>Pb>As in the subsurface soil. The highest concentrations of heavy metals at mine sites were recorded at 100 m top (0-15 cm) soil with significant reduction in concentration levels as a result of increase in distance. The heavy metal concentrations (As 0.166 mg/kg, Cu 2.042 mg/kg, Pb 0.498 mg/kg and Zn 4.769 mg/kg) at mine site were within the acceptable limits in soil with the exception of cadmium (Cd 11.097 mg/kg). The heavy metal concentrations of the water bodies were all above the WHO standards (As 0.01 mg/l, Cd 0.3 mg/l, Cu 2 mg/l, Pb 0.01 mg/l and Zn 3 mg/l) though insignificant concentrations (below WHO regulatory standard for drinking water) of lead (Pb) was recorded in abandoned mine pit, Akpara Izzi stream and Ebonyi river. The ranking of the distribution of heavy metals in the surface waters is Zn>As>Cd>Cu>Pb. Though the concentrations of these metals in soils with the exception of cadmium were found to be low compared to WHO regulatory limits, contamination of soil with heavy metals even in traces is considered a serious environmental concern as these elements can persist in soil for a long time with chances of increasing their concentrations with time. Constant evaluation of soils and water bodies for heavy metal concentrations should be incorporated to be a vital component for effective land use planning for environmental stability and sustainability.

Keywords：*soil, mine sites, heavy metal contamination, Nigeria.*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Quantifying the Wind Speed Amplification Effect on Tailings Storage Facilities

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One of the first accounts of gold mining in South Africa was in 1868. Since then many gold deposits were discovered, and mined in South Africa. Today tailings storage facilities (TSFs) litter the landscape. These facilities can contain particles that are rich in pyrite as well as potentially toxic elements, such as uranium. Wind erosion of these fine grained mine wastes from TSFs have long been considered an environmental hazard in many countries. The erosion of particles from gold mine tailings can lead to the distribution of potentially toxic elements into ground and water resources as well as particles that can potentially cause silicosis and emit alpha radiation. The energy that wind, as a vector force, can exert on fine grained solid mine waste can be substantial and far exceed the minimum energy required for the movement of particles. When the wind energy, as defined by wind speed, turbulence, surface roughness, vortexes, fluid viscosity and other factors, exceeds the minimum energy required for the movement of particles, erosion takes place. The erosion of particles by wind can be in the form of creep, saltation or suspension and is a function of the relative wind energy.

It has long been known to experts, in the field of tailings dam rehabilitation, that the wind speed increases with height on a TSF. Due to the greater erosive power of greater wind speed, it was imperative to quantify the wind speed amplification effect on TSFs. Few studies have attempted to quantify the aforementioned phenomenon. In addition, the effects of surface covers on the near surface wind speed and the wind amplification effect was investigated. Grass cover and wind barriers on TSFs have proven effective in decreasing wind erosion by decreasing the wind speed. The extent to which the wind speed is decreased was quantified within this study, lending validity to such rehabilitation options.
The quantification of the wind speed amplification effect was performed using R.M. Young wind monitors, equipped with Campbell Scientific data loggers and installed at a height of 2.2 meters above the ground/tailings surface. The wind monitors were installed at 20 meter intervals on the slope of a 40 meter high TSF. Wind speed measurements were recorded concurrently by all the loggers in 5 minute intervals throughout a day, thereby enabling analysis of individual wind speed measurements. The data analyses lead to the validation of the wind speed amplification effect on the TSF. A wind speed amplification factor of 1.5 was measured for each 20 meter gain in elevation, relative to the ground surface, with a total wind speed amplification factor of 2.4 for the 40 meter high facility.

A similar study, to the aforementioned, was performed on a TSF with grass and wind barrier nets on the slope where the measurements were conducted. The analysis of the data illustrated an overall amplification factor of 1.3, with varying degrees of amplification on the slope in-between the lowest and highest wind monitoring units. A study was then performed to quantify the effect of surface covers on the near surface wind speed. Interpretation of the results illustrated that the wind speed was decreased by 39.98% directly above the grass, whilst the wind speed directly behind the net was decreased by 53.42%.

Considering the validity of the wind speed amplification effect on TSFs and the greater erosive power of the higher wind speed, it is evident that effective wind erosion remediation options have to be implemented on these facilities. Extrapolating the results from the decreased wind speed and combined with the results from the decreased amplification factors in the presence of surface covers, validity to such remediation options are obtained.

Keywords：*wind, wind speed amplification, tailings storage facilities*

P3-468

[C3.5-3] Management and Reclamation of Mining Site Soils

Inter-Populational Variation on the Accumulation of Hazardous Elements and Nutrients in Cistus Monspeliensis L. Growing in Portuguese Iberian Pyrite Belt Mine Areas

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Cistus monspeliensis L. is one of the species of the genus Cistus identified in some mining areas from Portuguese Iberian Pyrite Belt (PIPB), however the knowledge about this species and the possible inter-populational variation on the chemical elements accumulation is scarce. This study aimed to compare the accumulation and translocation of some toxic elements (Al, As, Pb, Sb and V) and nutrients (Ca, Cu, Fe, K, Mg, Mn, Ni and Zn) in C. monspeliensis populations growing in Chança, Lousal and São Domingos (PIPB). Nowadays, these mines are abandoned however the type and period of mining activity originate different contamination levels in each area.

Several sampling areas were selected in order to include representative soils of each mine where the studied species grow. These soils were classified as Spolic Technosol Toxic (developed on different mine wastes and mixtures of mine wastes and host rocks) for Chança (n=6) and São Domingos (n=6), and Leptosol (developed on schists and greywackes) influenced by adjacent tailings and acid mine drainage in Lousal (n=4). Composite samples of soils from C. monspeliensis radicular system environment, roots and shoots were collected. Soil characteristics (pH, NPK and organic C) and multielemental concentration of soils (total and available fraction) and plants were determined.

Plants grow, without visible symptoms of deficiency or toxicity, in soils with a large heterogeneity in their characteristics. Values of soil pH varied between 3.5 and 6.1 and soil fertility range was great (0.6-2.9 g Ntotal/kg; < 13.6 mg Pextractable/kg; 44.0-199.4 mg Kextractable/kg; 9.0-51.8 g Corganic/kg). In general, soil fertility in Chança mining area was slightly higher, compared to the soils of the other mine areas. São Domingos soils showed great total concentrations (g/kg) of As (0.7-3.0), Pb (0.7-9.2) and Sb (0.06-0.5), but Al concentrations reached high values in Lousal (87-119 g/kg). Toxic elements concentrations in total fraction of Chança soils were low (g/kg, As: 0.02-0.1; Pb: 0.04-0.2 and Sb: 0.03-0.09) but Al values were close to those in São Domingos (g/kg; Chança: 46.7-82.4; São Domingos: 24.8-85.7). Independently of the mining area, the total soil concentrations of each nutrient and V were in the same range. Nevertheless, São Domingos soils presented the smallest Mn total concentrations (0.06-0.6 g/kg) while Lousal soils had the highest Zn total concentrations (0.2-0.9 g/kg). Available fractions of the chemical elements (extracted with aqueous solution of diluted organic acids which simulate the rizosphere conditions) were < 6 % of the total concentrations of the same elements, except for Ca.

Chemical elements concentrations in roots and shoots were higher than the available soil concentrations of the same elements and were dependent on the mine area. Cistus monspeliensis showed great translocation capacity of almost all the chemical elements from roots to shoots. However, Pb and V were retained in roots only in São Domingos and Chança populations. Lousal and São Domingos plants were Mn and Zn accumulators (1 < soil-plant transfer coefficient = Shoot element concentration/total soil element concentration < 10). In the three populations, toxic elements (Al, As, Pb, Sb and V) showed a low to very low soil-plant transfer coefficient (0.001 < soil-plant transfer coefficient < 0.1). The calculation of the biological absorption coefficient (shoots element concentration/available soil element concentration) showed that this species have high elemental absorption efficiency. In the plant shoots of the three populations, concentrations of Mn and Mo were considered phytotoxic and deficient, respectively. In São Domingos area, the concentrations of As, Fe and Zn in plant shoots were also above the phytotoxic values for plants as well as the Zn in plant shoots from Lousal area. The concentrations of the other elements (toxic and nutrients) in shoots were normal and/or sufficient for plants development. In general, variability inter- and intra-populational of C. monspeliensis, concerning the studied chemical elements concentrations, was observed.

Keywords：*Sao Domingos mine , Lousal mine, Zinc accumulation*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Content of Potentially Toxic Elements in Dumpsite Soils after Brown Coal Mining as Affected by the Reclamation Method

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Large-scale open-cast mining of brown coal is a commonly used method of mining which leads to the subsequent formation of permanent dumps of sterile rock. An effort is concentrated on landscape reclamation and revitalisation of these sites in the northern parts of the Czech Republic. In order to make either agricultural or forest exploitation possible, it is necessary to reclaim the dumpsite earths. They are usually sterile rocks, often very clayey, with no or very low organic matter content and sometimes also with unfavourable soil reaction. One reclamation measure consists in soil covering with natural topsoil. It should increase mainly the organic matter content and improve nutrients status. Physical properties, particularly soil structure, are often improved. Moreover, topsoiling should increase biodiversity of the newly created soils. The aim of this paper is to assess the effect of topsoiling and other reclamation practices on the content of selected potentially toxic elements (PTE), particularly Cd, Cu, Pb and Zn, in several areas of the north-western part of the Czech Republic.

The contents of studied PTE were in most cases under the limit values valid for agricultural soils in the Czech Republic. In some cases, such as for Pb, they were very low compared to the limit values. It can thus be concluded that the content of studied PTE currently does not present a significant problem on the reclaimed areas. The effect of atmospheric deposition is rather small in these areas and the content of potentially toxic elements is conditioned mainly by soil parent material. In contrast, the content of some PTE, especially Cd and Pb, in adjacent natural soils is often higher than the content in the dumpsite soils as they were exposed to atmospheric deposition for a long time. Consequently, when topsoiling with material from natural humic horizons is used as a reclamation method, the content of PTE can be slightly higher than in the soils with no topsoil cover. Nevertheless, as the contents of the PTE are still under the tolerable limits even in the soils with topsoil cover, and other soil properties are usually improved, topsoiling can be generally recommended as a reclamation method when revitalisation and further agricultural exploitation of the reclaimed soils is required soon.

Keywords：*Soil reclamation; coal mining dumpsites; potentially toxic elements; topsoil cover; soil pollution*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Comparative Restoration Potential and Soil Carbon Sequestration Efficiency of Certain Indigenous and Exotic Woody Species Planted on Coal Mine Habitats in a Dry Tropical Environment, India

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Accumulation of significant C stock in redeveloping soils of mine spoil depends upon the quality and rapidity of biodiversity reconstruction in a short span of time. Developing young forests on any particular degraded ecosystems play a significant role in mitigating the effect of global climate change. But, restructuring of vegetation on such degraded ecosystems is not an easy task. It needs careful scientific consideration prior applying restoration principles.

Present study was conducted on a degraded ecosystem in a dry tropical region of India where mining is one of the serious problem. Mining operation not only degrade the forest cover even degrade the soil composition. Thus, degraded soils have poor ability to provide essential nutrients (C, N and P) for vegetation development because soil-plant relationships and nutrient circuit in the soil medium has been damaged. Hence, soil restoration is a really challenging ecological problem; moreover, their recovery by natural succession is very slow. Therefore, biological soil restoration by establishing desirable plant species is cost-effective and more stable technique than physical and chemical rehabilitation procedure.

We selected eighteen plantation sites as a total in different ecological models (mono- and mixed culture) for assessing restoration potential and efficiency of soil carbon sequestration on coal mine spoil for this study. Fourteen plantation stands selected as mono-cultured and four (1: Albizia lebbeck + Acacia catechu, 2: Azadirachta indica + Phyllanthes emblica, 3: Dalbergia sissoo + Tectona grandis and 4: Dendrocalamus strictus + Tectona grandis) were selected as mixed cultured. Of which, eight woody species were indigenous and hard, and in which, four of them (Albizia lebbeck, Pongamia pinnata, Dalbergia sissoo, Albizia procera) were leguminous tree and short stature in size; and four (Azadirachta indica, Tectona grandis, Dendrocalamus strictus and Shorea robusta) were non-leguminous. While remaining four woody species (Acacia auriculiformis, Casuarina equisetifolia, Eucalyptus hybrid and Gravillea pteridifolia) were exotic in nature. The objective of the present study was to assess restoration potential and their role in soil carbon sequestration by examining several soil and vegetational parameters with respective time.

Results indicated that influence of planted species in terms of restoration potential, accumulation of soil organic C and their sequestration in below-ground component was more pronounced for origin and ecological models with increasing plantation age. In comparison to mono-culture planted stands, mixed culture either legume or non-legume combination showed a strong tendency for restoration qualities. Among planted species, Soil carbon sequestration efficiency was significantly varied with plantation age confirming continuous accretion of carbon in soil which may in-turn more strong enhancement of biological fertility and stable soil ecosystem development that will make a fertile ecosystem in a short range of time.

Keywords：*Ecological restoration; coal mine spoil; biomass; NPP; Indigenous plantations; Carbon sequestration;*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Smectite Formation in Mine Tail Soils Affects Macroporosity, Hydrological Properties, and Pollutants Flow

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Mining activities take a direct impact on the environment, particularly when this activity is focused on metal-ore exploitation. Abandoned metal mine areas contain different types of residues from ore-processing operations that are typically characterized by high concentrations of heavy metals. One consequence is the generation of acid-mine drainage, caused by the oxidation and hydrolysis of metal sulphides.

Mine tail soils have been studied below several points of view, but not on how crack formation affects their properties and functioning, before irreversible hardening. The Cartagena-La Union mining district is one of the more ancient Spanish mining regions. This region is placed at the south-eastern part of Spain, and contains one of the largest lead and zinc ore deposits in South Europe, which was exploited for Ag, Pb, Zn, Cu and Fe from the Phoenician and Carthaginian times. The aim of this research work was to characterize the pedogenesis occurred in mine tailings of different age and properties, and to highlight the mineralogical and physical changes.

Soil profile morphology was studied in the field likewise the surficial pattern of cracks, shear strength, bulk density, and erosion. Laboratory analysis were conducted to characterize physical, chemical, elemental, mineralogical, and hydrological differences between the soil mass in the macro aggregates and in the fissures. Macroporosity was studied through image analysis of thin sections of undisturbed soil samples. Clay and fine clay fraction were extracted and quantified from each soil sample, then, X-Ray Diffraction (XRD) onto oriented slides (magnesium and potassium saturated, glycolated and heating to 550 ºC) was performed. Each XRD pattern was decomposed from peaks.

Studied soils resulted strongly polluted, especially as for Zn, Pb, Cd, Cl, Mn, and Ni and were classified as Stagnic Spolic Technosol (Anthrotoxic, Episiltic), Stagnic Spolic Technosol (Calcaric, Ecotoxic, Episiltic), Stagnic Spolic Technosol (Calcaric, Anthrotoxic, Episiltic), and Petroferric Spolic Technosol (Anthrotoxic). Crack formation significantly affected shear strength, bulk density, macroporosity, saturated hydraulic conductivity, and element distribution. Gully and tunnel erosion was also driven by crack formation.

The mineralogy of the clay fraction revealed that after more than thirty years since the closure of the mines, some pedogenetic processes have been taking place. Clay mineralogy indicated that smectites are forming as a result of altering the primary chlorites under acidic conditions, giving to these soils vertic properties. An evolution occurred within these clays after oxidation of metal sulphides. It provoked a high amount of acid mine drainage that acidified the substrate; thereby generating clays with vertic properties that finally affected the evolution of these soils.

Therefore, it seems clear that the mineralogical change played an important role in the formation of cracks, being a good indicator of soil evolution. Crack formation deeply affected soil features and behavior, namely hydrological properties and flow of pollutants, which in turn condition environmental health and possible soil stabilization and reclamation strategies.

Keywords：*pedogenesis, WRB, pollution, reclamation, Spain*

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[C3.5-3] Management and Reclamation of Mining Site Soils

The Potential and Risks of Biosolids Application in Opencast Mine Restoration

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The restoration of opencast mines can greatly benefit from the direct (or immediate) transfer of topsoil, followed by plant regeneration from the seedbank, or the careful collection and direct transfer of vegetation along with the associated topsoil, which allows existing plants to survive. However, in most opencast mines, large quantities of soils must be stockpiled (sometimes for long periods) due to logistical limitations. This process causes anaerobic conditions and decreases soil fertility, in addition to bulk soil volume loss over time. It has therefore been proposed that such soil is amended with nutrients and/or organic matter to support plant growth and increase soil quantity when used in restored areas. One very promising solution currently undergoing trials in New Zealand coalmines is the application of biosolids. This municipal waste material represents a very economical and continuous source of organic matter that can be mixed with or spread on stockpiled soil during the restoration process. Due to sterilisation by heat-treatment, biosolids contain very low levels of bacteria and present no direct health concerns. Chemically, however, they can contain varying concentrations of trace elements, heavy metals and micronutrients that, while may be beneficial in low concentrations, may impact on soil fauna and soil food webs when present in high concentrations. Therefore, the application of biosolids in mine restoration areas and its implications for soil fauna needs to be investigated before large-scale applications are implemented.

We designed two pot trial experiments to investigate the potential impact of biosolids application on plant growth, soil fauna survival and growth as well as biomagnification of potentially toxic elements in the food web. The first was an agricultural experiment where European earthworms and oilseed rape were exposed to low rates of biosolids as recommended for use in agriculture. The second experiment replicated a mine restoration process where native New Zealand earthworms and a New Zealand native grass (red tussock) were exposed to high rates of biosolids as currently applied in restoration trials. For both experiments, plants were harvested and pots destructively searched for earthworms after five months.

The application of biosolids substantially increased plant production in both experiments. European earthworm biomass was enhanced by the addition of low levels of biosolids in the agricultural treatment, but earthworm tissue samples showed elevated levels of copper. Because earthworms are predated by a wide range of vertebrate and invertebrate predators, there is a potential risk of biomagnification of copper in the food web. In the mine restoration experiment, none of the earthworms exposed to biosolids could be found at the end of the experiment. These had either died or exited the pots. Although our results suggest that biosolids could be applied effectively to improve plant growth in a restoration context, it is important to consider potential subsequent effects of prey-loss and metal accumulation in foodwebs, and the ecological impacts therein. In addition, the application rate needs to be chosen appropriately to limit direct negative impacts on soil fauna.

Keywords：*Earthworms, New Zealand, Restoration, Stockpiling, Pot experiment*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Geochemical Mapping of Polluted Soils and Environmental Risk Assessment: A Comparison Case Study in the Province of Huelva (spain) and the Zambales Mountain Range (luzon Island, the Philippines)

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The soil is one of the environmental systems which could be most affected by the dispersion of pollutant, also because of the close relationship with the atmosphere and meteoric waters. The distribution and type of contamination depends closely on the climate, precipitations, drainage, vegetation, litology and human activities. As a matter of fact, soil contamination due to heavy metals and metalloids, such as As, Cd, Cr, Cu, Ni, Pb and Zn, represents the source of a severe potential hazard for the ecosystem equilibrium and the health of living beings.

This study is carried out in two abandoned mining zones near to populated areas, which underwent similar exploitation history, but in very different climatic and environmental conditions. The aim of the research is to analyze the influence of precipitation amounts, soil thickness, drainage density and vegetation cover on pollutant distribution. The first zone is close to Huelva, in the Rio Tinto mining district and belongs to the Iberic Pyritic Belt of the southwest Iberian peninsula. This mining site is characterized by a Mediterranean climate with low precipitation (490 mm/year) and low vegetation cover. The second case study is the Zambales Mountain Range, a mining district in the Luzon Island of the Philippines dominated by a tropical weather with forests and intense rainfalls (2350 mm/year).

The wide spectrum of climatic variables in the case studies requires to develop a single flexible methodology for the mapping and monitoring of the environmental degradation in both semi-arid and tropical environments, allowing comparative studies. The methodological approach comprises remote sensing, Geographic Information System (GIS), spatial statistical analysis, field sampling and ICP and isotopic geochemical analysis.

The presentation illustrates the first stage of the project. The processing of multispectral (Aster) and hyperspectral (Hyperion) images, in comparison with available geological and geochemical data, is used to search for spectral indicators of specific pollutant or anomalies in the vegetation cover related to soil contamination. Then, digital elevation models (DEMs) are used to delineate the drainage and superficial flow and to find potential correlations with the remobilization and dispersion of the pollutant in the soils, sediments and water bodies.

These results allow a first comparison between the case studies, and delineate the different behavior of pollutants dispersion in the two climatic end-members. Also the remote sensing and GIS analysis form the basis to plan the future soil and sediment sampling campaign, according to the specific characteristics of the areas. The field, ICP and isotopic data will be integrated in a GIS database for spatial geostatistical analysis. Those analysis will be complemented with the lead isotopic signature of human hair samples collected from the people who lives close to the mining zones, in order to identify the origin of the pollutants and the influence of the contamination on the living beings.

Keywords：*Remote sensing, Lead isotopic analysis, ICP analysis, Geostatistical analysis, Human hair sampling*

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[C3.5-3] Management and Reclamation of Mining Site Soils

General Characteristics of Organic Matter in Reclaimed Soils

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The aim of this study is to determine the special characteristics of the organic matter in reclaimed soils after open coal-mining activities in the region of Pernik (Bulgaria). Soil organic matter, pH, total N, CEC and particle size distribution of 7 profile layers have been determined. The data showed high and very high (6 to 16%) organic carbon content in the superficial layers. A significantly high part of the organic carbon, in fact, is coal carbon, that does not participate in the "carbon cycle". The real "humus" carbon in these soils is mainly formed by the newly organic matter compounds. Both of these humus types, the inherited and the newly formed, posses the specific characteristic of the studied reclaimed area of "ecologically balanced humus, which is rich in N"; its soil organic matter is of 'humic' type, with medium sized and of medium density humic acids molecules, with small amount of fulvic acids and no aggressive fulvic acids.

Keywords：*coal-mining activities, Bulgaria, humic acids*

P3-475

[C3.5-3] Management and Reclamation of Mining Site Soils

Speciation and Bioavailability of Metals and Metalloids in Managing Health Risks of Mine Wastes for Rehabilitation

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Environmental chemistry and toxicology are key tools for understanding metal and metalloid in environmental systems and its effects on biota, including human. This paper provides an overview of the rationale of using bioaccessibility to predict metal and metalloid bioavailability for risk assessment of rehabilitated mined land and its application to develop site specific guidelines. Bioavailability (in-vivo) is defined as the proportion of total concentration that is biologically available for absorption into an organism and may be determined from in-vivo experiments using animal models. Bioaccessibility (in-vitro) is the proportion of metal and metalloid that can be absorbed by an organism and is generally a more conservative approach to estimate bioavailability of contaminated wastes such as from mining. Mining, smelting of non-ferrous metals and burning of fossil fuels are the major sources for anthropogenic metal and metalloid pollution. Base metal mineralogy such as in sulfides and is most commonly a source of metals and metalloids. This paper aims to: (i) review the significance of speciation and bioavailability of metals and metalloids in managing health risks for mine site rehabilitation and show how mine site rehabilitation with metals and metalloids can be better managed.

The International Council on Mining and Minerals developed ten principles for sustainable development in the mining and minerals industry. These principles have been adopted in Australia to promote rigorous mine closure programs before mining completion and identify quantitative indicators of rehabilitation success. In particular, Principle 4 of the ICMM's ten principles is about, 'implementing risk management strategies based on valid data and sound science'. To avoid health risks to communities from mining activities, good prediction and planning is required, together with well-designed monitoring to detect adverse trends.

The National Environment Protection Measures (NEPMs) give guidelines for soil contamination from arsenic in Australia. If the health-based investigation level (HIL) is exceeded, a further Tier II risk assessment of the site needs to be undertaken. In the absence of site specific data for metals and metalloids, the NEPMs may not provide accurate close out criteria for mined land. Information about the bioavailability of arsenic in contaminated soil can provide this key because, in the absence of site specific data, bioavailability is usually assumed to be 100% for risk assessment purposes. Commonly, elevated arsenic and other metal concentrations in contaminated soils that exceed the HIL values could have adverse health implications.

A review of currently available bioaccessibility methods and limitations give general guidance in the NEPM for determining their use and application in contaminant site assessment of arsenic to give prediction of bioavailability. Absolute bioavailability is

measured via animal uptake but is expensive and time consuming. A more practical approach uses in-vitro PBET (physiologically based extraction test) to determine the bioaccessibility of individual soils. Comparison of in-vivo bioavailability measurement using animal (rat) uptake provides a means to validate the in-vitro bioaccessibility measurement. A risk assessment may therefore be conducted on a metal and metalloid survey of surface soils representing different categories of mine wastes by employing the following approaches: (i) in-vivo bioavailability measurement of composite wastes using rats; and (ii) the in-vitro PBET (physiologically based extraction test) determination of bioaccessibility of individual soils.

This paper has provides an overview of the rationale and application of using bioaccessibility to predict arsenic and metal bioavailability for risk assessment of rehabilitated mined land and its application to develop site specific guidelines. Arsenic and metal residues from mining may arise from historical activities or current mining projects and can be managed by using a risk assessment framework. The PBET in-vitro bioaccessibility model was used for the assessment of metal and metalloid bioaccessibility and validated for its potential to predict ABA of mine wastes derived from rat in-vivo experiments. The alternative in-vitro approach, can replace animal in-vivo experiments, which simulates human uptake of metals and metalloids.

Keywords：*Environmental chemistry toxicology metals and metalloids speciation, bioavailability, bioaccessibili*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Plant Microbe Associations for Reclamation of Oil Sand Mining Sites in Canada

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Canada's vast oil reserves are in the form of oil sands, a mixture of sand, water, clay and bitumen. Mining of oil sands impacts large tracts of land, but industry is committed to reclaim all disturbed land to an ecologically healthy state in response to governmental regulations and societal concerns. To achieve this end point will require innovation and development of new technology. One approach is application of phytotechnologies; a form of ecological engineering that depends on natural, synergistic relationships among plants, microorganisms and the environment. Our research is focused on assessing the utility of plants and associated microorganisms for reclamation of oil sand mining sites under prevailing Canadian environmental conditions and associated regulatory oversight. Our focus is bacterial and fungal root endophytes that help plants grow in stressed environments and potentially help degrade polyaromatic hydrocarbons. Field sites in Alberta, Canada are established to monitor plant-microbe associations on reclaimed oil sand mining sites. The results of this work indicate that to fully exploit and use plant-microbe associations we need to gain a better understanding of: (i) the pool of plant reclamation species found in Canada; (ii) how plant-microbe associations operates under unique Canadian climatic conditions; (iii) the mechanisms employed by plant-microbe associations to restore impacted sites; and (iv) the agronomic requirements needed to maximize plant-microbe associations as an efficient and cost-effective clean-up technology. The focus of this presentation is on field performance data demonstrating the potential and appropriate uses of the newly emerging phytotechnologies across a range of impacted sites.

Keywords：*oil sands, plant-microbes, root endophytes, reclamation*

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[C3.5-3] Management and Reclamation of Mining Site Soils

Characterization of Soils around an Old Abandoned Smelter at Jang Hang, Korea

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Soils of an abandoned smelter at Jang Hang, Korea have been the subject of interest because of carcinogenic heavy metal contaminants found in the soils. Although many researchers have studied contaminants in the soils during many years, physiochemical and mineralogical properties of soil particles having contaminants are not clearly understood yet. Using the combination of macro and microscopic analysis, in this study, we studied physiochemical and mineralogical properties of soils having toxic contaminates around the abandoned smelter at Jang Hang, Korea. Samples collected within 1 km radius of the chimney as a point source from the abandon smelter were analyzed by ICP-AES, XRD, FE-SEM, and sequential extraction. The highest total arsenic (As) and lead (Pb) concentrations are 425.6 ppm and 710.3 ppm, respectively. Concentrations of those metals increases with decreasing particles size of soil samples. From the sequential extraction, arsenic is mainly accounted by a residual type (> 90 %), whereas the most proportion of lead (~80 %) is found to be associated with Fe/Mn oxides. In SEM analysis, 'rod-shaped' Fe + Cu silicate particles having As were observed in a scale of tens of ㎛, with the shape of craters on the surface. From experiments of 1N HCl extraction, Pb in the contaminated soils is leachable up to 91 % whereas the extraction efficiency for As shows relatively low (< 26 %). From these results, it is suggested that contaminants for As could not be associated with particles of Pb contaminates in soils around the abandoned smelter at Jang Hang, Korea.

Keywords：*heavy metal, mineralogical properties, arsenic, lead, rod-shaped silicates*

P3-478

[C3.6-2] Salinity Management When Irrigating with Marginal Quality Waters

Soil Water Retention and Water Use Efficiency of Cotton under Plastic Mulched Drip Irrigation in Soils of Different Salinities in the Tarim River Basin

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The Tarim River basin, the area of largest Chinese cotton production, is getting increased attention because of serious environmental problems, including water shortages and water over use. Based on two experimental stations (Korla and Aksu), soil chemical and physical properties, soil water content, soil matric potential, and soil osmotic potential, cotton yield and water use efficiency under plastic mulched drip irrigation in soils of four different salinities (1.7, 1.8, 3.5, 3.7 mS cm^{-1} in 1:5 soil and water solution in top 30 cm soil respectively) in the Tarim River Basin were measured. Results indicated that soil water content varied from 15-69% in 80 soil depth underneath during cotton season from May to September in 2012 in the four different saline soils; matric suction power reached both the highest point (76 kPa) and the lowest point (1 kPa) at 25cm soil depth in the low saline soil compared to the other soils; soil water suction was highest (4397 kPa) in 25cm soil depth in high saline soil and the lowest point (675 kPa) was in the lowest saline soil in 45 cm soil depth. Soils with the soil water content (around 30%); lower soil water suction (below 2000 kPa) and lower soil matric suction (below 30 kPa) had the highest water use efficiency and highest yield. Higher water content below 30cm soil profile in high saline soil could not reduce the soil salinity harm and led to lowest water use efficiency and yield. The saline soil increased the yield through the low matric potential induced by the soil texture of good soil porosity. In field management the soil texture, matric and osmotic potential should all be considered for water use efficiency.

Keywords：*soil water retention, saline soil, soil matric suction, soil water suction, water use efficiency, drip irrigation, Tarim River basin*

P3-479

[C3.6-2] Salinity Management When Irrigating with Marginal Quality Waters

Modeling Sorghum Response to Irrigation Water Salinity at Early Growth Stage

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Plant response to salinity varies at different growth stages. Information on plant response to salinity at various growth stages can be used in managing saline waters for irrigation. This study was conducted to quantitatively assess response of Sorghum (Sorghum bicolor L. Moench) to salinity at seedling stage. Consequently, an extensive experiment conducted in natural saline sandy loam soil including non-saline water (EC=0.3 dS/m) and five natural saline water treatments (4, 6, 8, 10, and 12 dS/m). The reason for selecting natural sources of saline water and a saline soil was to minimize deviations from natural conditions under which sorghum grows. The seeds were planted and seedles counted at 24 hours time intervals. The Maas and Hoffman, Van Genuchten and Hoffman, Dirksen et al., and Homaee et al. models were used to predict relative seedlings at different salinity levels. The obtained results indicated that salinity threshold value EC* was 1.0 dS/m at seedling stage and the seedling rate reduced to 50 percent at 11 dS/m of soil salinity. All evaluated models were overestimated EC* value. The calculated statistics indicated that the nonlinear salinity models were more applicable than the linear model. Among those, the Homaee et al. model provided better predictions at seedling stage.

Keywords：*irrigation; salinity; sorghum; seedling; threshold value*

P3-480

[C3.6-2] Salinity Management When Irrigating with Marginal Quality Waters

Interactive Effects of Nacl Salinity and Waterlogging on Availability of Copper, Iron, Manganese and Zinc in Two Different Soils

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Waterlogging and salinity are wide spread problems in irrigated as well as in nonirrigated areas and threatening the sustainabilty of agricultural production. Waterlogging is the presence of excess water in the root zone of plants resulting in poor gas exchange and eventually anaerobic conditions. Soil salinisation is the process of accumulation of excess salts in the root zone. Micronutrients mobility and solubility in soils are of environmental significance due to their potential deficiency and toxicity to plants, humans and animals. Many factors and variables govern micronutrients behaviour in soils in complex ways. Two of these factors are soil waterlogging and salinization that influence on micronutrients availability to plants. The objective of this study was to determine the effects of waterlogging and salinity on availability of copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) in two different soils from Iran.

A factorial experiment based on completely randomized design with two replications including duration of soil waterlogging at six levels (0, 1, 3, 7, 15, 30 days), soil saturate extract salinity at three levels (0.11, 4, 8 dS/m) and soil type at two levels (one alkaline loamy sand soil and one acidic clay soil) was carried out under laboratory conditions. The NaCl salt solutions were added to soils and mixed throughly to achieve the desired salinity levels. Then the soils were waterlogged and during the waterlogging period, the water level was maintained three cm above the soil surface. At the end of waterlogging periods, the DTPA-extractable Cu, Fe, Mn and Zn was measured Lindsay and Norvell (1978) method at submerged conditions. The concentrations of Cu, Fe, Mn and Zn in the extracts were determined with a Shimadzu atomic absorption spectrophotometer. The statistical analysis of data was carried out with MSTATC software.

The results showed that the main and interactive effects of waterlogging and salinity on the DTPA extractable Zn, Fe, Cu and Mn were significant. The DTPA extractable Mn was increased by increasing the duration of soil waterlogging in non-saline conditions (0.11 dS/m) in both soils but was decreased in saline conditions (4 and 8 dS/m) and amount of decrease in acidic clay soil was greater than alkaline loamy sand soil. In loamy sand soil, by increasing the duration of soil waterlogging, the DTPA extractable Fe was increased in non-saline conditions but in saline conditions it was decreased after an initial increase. In acidic clay soil, the DTPA extractable Fe was increased by increasing the duration of soil waterlogging. By increasing the duration of soil waterlogging, the DTPA extractable Cu and Zn in both soils and most treatments were significantly decreased after an initial increase and the amount of decrease in acidic clay soil was greater than alkaline loamy sand soil. The DTPA extractable Mn, Zn, Cu and Fe concentrations had different trends during soil waterlogging periods.

The DTPA extractable Cu and Fe in both soils, and the DTPA extractable Mn in acidic clay soil were significantly decreased with increasing soil salinity level, while the DTPA extractable Mn in loamy sand soil was increased with increasing soil salinity level at early stages of waterlogging and then decreased. The effect of NaCl salinity level on the DTPA extractable Zn was dependent on the soil type and the duration of soil waterlogging. There were significant regression equations between the duration of soil waterlogging and concentrations of the DTPA extractable Cu, Fe, Mn, and Zn in both soils. These models can be used for estimation of the DTPA extractable Cu, Fe, Mn, and Zn concentrations at different waterlogging periods. By increasing the NaCl salinity level, the pH of soil solution and the rate of Fe and Mn reduction decreased during the waterlogging periods.

Keywords：*Availability, Micronutrients, Salinity, Soil, Waterlogging*

P3-481

[C3.6-2] Salinity Management When Irrigating with Marginal Quality Waters

Impact Study on the Application of Vinasse to Cambisol and Vertic Luvisol in Ethiopia

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To study an impact on the application of vinasse to Cambisol and vertic Luvisol in Ethiopia, we used HP1 an hydrogeochemical models to assess the medium-term risks of the use of that agricultural practice by a Sugar Factory. The three water input scenarios tested play a major role in soil function and simulated soil changes after a vinasse input. There is always drainage in all three types of soil; it varies from slight (50 mm/yr) to fairly substantial (1000 mm/yr). However, the latter value is related to a scenario (i) that does not take rainfall into account in irrigation management and (ii) that ignores losses of water before it reaches the soil. Overall the conditions seem optimal, strictly from the water supply standpoint, for limiting the risk of salinization. Under the initial conditions, the irrigation water used was not heavily loaded with salts (ca. 4.5 mS/cm) and the soil exchange complex was 80% saturated with calcium because of the calcareous origin of the parent rock. The behaviour of the three soils is fairly similar overall. The input of vinasse, at a dose equivalent to 340 kg/ha of potassium, causes a significant increase in the concentrations of chemical elements in the soil solution but also greater leaching of these chemical elements out of the soil profile. Over time, the distribution of cations in the CEC does not change very much and appears to settle on noncritical values. Sodium, then potassium, partially replaces magnesium and calcium in the CEC, but ultimately the change is slight. The percentage of calcium in the CEC never falls below 75%. Saturation indices determine whether the physico-chemical conditions are such that minerals (halite, calcite, gypsum, etc.) will precipitate out and cause salinization. Our simulations show that when vinasse inputs are done at a normal dose (equivalent to 340 kg/ha of potassium), the risk of precipitation of minerals is nil, especially when water inputs are properly calculated (low drainage). However, when the inputs are doubled (equivalent to 580 kg/ha of potassium), several minerals are near supersaturation and therefore liable to precipitate out. The volumes of water supplied are also immaterial, since when drainage is slight, anhydrite and gypsum are the substances liable to precipitate out, and when it is greater, K-jarosite will. Therefore, whatever the water input scenario tested, we recommend against vinasse inputs at a dose equivalent to 580 kg/ha of potassium. On the other hand, for all three types of soil, vinasse inputs at a dose equivalent to 340 kg/ha of potassium present no medium-term risk of soil salinization. Moreover, at these same doses, no parameter (chemical composition, breakdown of elements in the CEC, SI, etc.) tends toward a critical threshold.

Keywords：*vinasse, spreading , HP1 , hydrogeochemical models*

P3-482

[C3.6-2] Salinity Management When Irrigating with Marginal Quality Waters

Effect of Drip Irrigation on Corn (zea Mays) Growth in Reclaimed Tidal Saline Soil

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Soluble salts are dominant form at reclaimed tidal saline soil, which can be improved by leaching of soluble salts out of water with excessive irrigation water. The objective of this study was to evaluate the effect of irrigation on corn (Zea mays) growth at reclaimed tidal saline soil. Field experiment was conducted at Saemangeum reclaimed tidal land (35°46′N, 126°37′E) in Korea and the dominant soil series at this experimental site was Munpo series (coarse loamy, mixed, nonacid, Mesic, Typic, Fluvaquents). Corn was planted with 30 kg per ha seeding rate. During the growing season, three different irrigation rates were applied as following; (1) unirrigated (Control), (2) sufficient irrigation, (3) minimum irrigation. Soil electrical conductivity was significantly decreased with increasing irrigation rates. Soluble salt content was significantly decreased with irrigation, but soluble and exchangeable potassium content in soil was not changed by irrigation. Soluble and exchangeable cations were statistically decreased with irrigation, but the depression of soluble salt was greater (59 % vs. 11%) than that of exchangeable cations. Electrical conductivity was decreased with soil depth, which indicating that salt was leached out with vertical water flow. Corn development was significant with irrigation and the length of stem, panicle number, and stem thickness was statistically greater compared to the control. Although the germination rate was more than 95% in all treatment, withering rate was great, which was significantly decreased (35% vs. 90%) with irrigation due to its high soil salinity level. Our results indicated that soluble salt control is critical at reclaimed tidal saline soil and irrigation could be one of the management options to alleviate salt damages at reclaimed tidal saline soil in Korea.

Keywords：*Reclaimed tidal land, irrigation, soil salinity, corn (Zea mays)*

P3-483

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Peak Soil- Exploring Relationships between Soil Quality and the Nutritional Density of Crops

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Much has been written about the possibility that declining soil quality is leading to a steady decline in the nutritional value of fruits, vegetables, forages, and grains. The decline is soil quality is attributed to a variety of factors including simple depletion of plant nutrients to excessive use of fertilizers and even genetically modified crops. Nutritional value is determined by the concentrations of minerals, vitamins, protein, amino acids, anti-oxidants, and many other constituents, in the edible portions of plants. This literature review will explore the complicated relationships between soil quality and indicators of nutritional quality in various crops. Two general approaches exist for addressing the issue: Surveys of nutritional components of crops when comparisons can be made over time, and individual studies where relevant comparisons exist. Credible surveys do suggest that concentrations of Ca, P, Fe, Mg, Cu, Na, K, protein, riboflavin, and ascorbic acid may have declined in fruits, vegetables, and grain over time. However, the extent to which soil quality played a role is difficult to determine given that cultivars, changes in use of fertilizers, changes in agricultural practices, increased use of irrigation, and even increasing atmospheric CO2 concentrations can all influence plant composition. In general, nutritional quality is not considered during plant breeding where the focus lies on yield, insect and disease resistance, or other quality attributes. The addition of fertilizers providing the basic plant nutrients likely increases the concentrations of those mineral elements in the crop. However, the effect of such additions on constituents such as vitamins, anti-oxidants, anthocyanins, etc., is less clear. Further, fertilizer additions that cause large increases in crop yield may lead to the dilution of various constituents in the edible portions of the plant. Conversely, low yield may increase the concentration of various constituents. Crop yields have increased dramatically in the past 50 years and simple mass balance would suggest soil depletion for any element not replaced through fertilization. If these elements are limiting yield then yields may decline while the composition of the crop remains relatively constant. If these elements are not limiting yield then their concentrations in the crop may decline with time. Fortunately, the list of essential elements for plants and humans largely overlap, directly or indirectly. Iodine is one human essential element that is not considered to be essential for plants. However, plant essential elements are generally not added to soils unless a yield increase is anticipated as a result, and in many areas of the world fertilizer availability is limited for many reasons. Commercial fertilizers provide a relatively narrow range of elements to soil , predominantly N, P, K, Ca, Mg, and S for the major plant nutrients, and micronutrients when necessary, most often Cu, Zn, Mn, Cu, and Fe. Manures, composts, biosolids, or other C-rich materials supply a wider range of elements to soils and are thought to be more beneficial to overall indicators of soil quality. The extent to which a possible decline in the nutritional value of crops has a negative influence on human health is not known. Clearly in some developing countries significant human health effects from vitamin, Fe, I, and other mineral deficiencies exist and can be related to diet and/or soil characteristics. In many areas of the world, the fortification of food with vitamins and minerals and consumption of dietary supplements would offset possible declines in the nutritional quality food due to reductions in soil quality. Further, changes in dietary preferences and food availability make it difficult to elucidate the influence of soil quality on per capita nutrient intake. Per capita consumption of thiamin, riboflavin, niacin, Fe, folate, carotene, Ca, P, Fe, Zn, Se, and vitamins C, E, and B12 were higher in 2004 compared to 1909 in the United States while consumption of K was lower. These differences were attributed to mandated fortification programs for some foods and changes in the proportions of fruit, vegetables, dairy products, fats, oils, grain products, meats, and legumes in the diet rather than changes in soil quality or composition.

Keywords：*soil quality, nutrition, minerals diet*

P3-484

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Experiences with Developing and Implementing Watershed Scale Projects to Improve Water Quality in East Tennessee, USA

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Since 2001, the University of Tennessee (UT) Extension has been successful in developing and implementing two large-scale watershed projects in the ridge and valley region of East Tennessee. With support from numerous federal and state agencies, these projects these projects have supported graduate students, Extension personnel and funds to identify and model sources of non-point pollution for rural and urban sources, develop watershed restoration plans, implement best management practices (BMPs) and monitor changes in water quality.

UT Extension's educational efforts to identify and promote ways of reducing non-point source pollution have resulted in the adoption of many different types of BMPs by landowners in the Pond Creek and Oostanaula watersheds. Agricultural BMPs that have been established include providing cattle with alternative sources of water, fencing cattle out of streams, providing improved access to streams, growing cover crops, repairing and protecting heavy use areas and applying manures and other fertilizers based on crop nutrient needs. To date over $2 million in external grant funds have been obtained to support our efforts in Pond Creek and Oostanaula Creek.

Keywords：*Watershed management, water quality, soil erosion, non-point source pollution*

P3-485

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Exploring Relevance of Agro Input Dealers in Dissemination and Communication of Soil Fertility Management Knowledge: The Case of Siaya and Trans Nzoia Counties, Kenya

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Lack of access to necessary agro-inputs contributes to low agricultural productivity and slows the overall economic growth and development in most parts of sub Saharan Africa (SSA). Agro-input dealers make inputs more easily accessible to rural-based smallholder farmers. This study assessed the role played by agro-input dealers in disseminating and communicating integrated soil fertility management (ISFM) practices and information to smallholder farmers. The study was conducted in Siaya and Trans Nzoia counties in Kenya, and looked at agro-input dealers' awareness of ISFM practices, the communication channels used to access agricultural information and support services that agro-input dealers provide to farmers. The study interviewed 144 agro-input dealers randomly selected across the study area. The field surveys were conducted where agro input dealers were the main respondents. The result from logit regression model estimates showed that gender, age, educational level, experience in agro-input business and visit by extension staff significantly influenced the agro-input dealers' awareness of ISFM technologies. Factor analysis of the communication channels that agro-input dealers used to access agricultural information indicated that community based (Cosmopolite interpersonal) channels of communication were the most preferred communication channels among the agro-input dealer network in two study areas. Apart from selling inputs, the interviewed agro input dealers also provided additional support services to farmers. The three most important services provided to farmers were information on agronomic practices for seeds, pesticides and fertilizers. There was general limitation in capacity of the agro dealers especially when it came to providing credit facilities to farmers thus the need for enhancing agro dealers access to credit facilities. The study underscores the important role played by community based channels of communication in the ISFM knowledge dissemination. The study findings suggest the need to improve the provision of extension services to agro-input dealers to enable them effectively communicate information about ISFM technologies to farmers. Such initiatives on capacity building should take into consideration gender of the agro-input dealers.

Keywords：*ISFM, Agro-input dealers, smallholder farmers, knowledge, communication, dissemination*

P3-486

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Soil Zinc Deficiency and its Impact on Human Health in India: An Overview

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Zinc (Zn) is by far the most important micronutrient in soil fertility management when judged in terms of its deficiency in Indian soils. More than 90% of Zn in soils occurs as insoluble Zn and is unavailable to plants. Zinc deficiency is common in about half of the Indian soils which will increase to 63% soils by 2025 leading to low crop yield and zinc malnutrition in human beings. Hence, Zinc deficiency in India should be considered as "national zinc nutrition menace in all soils and crops" (Singh, 2009)

Zinc deficiency in soils does not only reduce crop productivity, but it also leads to low-zinc food causing human malnutrition. The problem is global, however, it is more acute in India as billions of people suffers from zinc malnutrition, also known as "hidden hunger" that is caused by lack of sufficient zinc in diet. There are negative health effects of zinc malnutrition. Zinc deficiency causes stunting, reduced fertility, impairment in physical development, immune system and brain function. Zinc is second most abundant trace elements in the human body after iron. Research has shown that the regions in the world with zinc deficient soils are also characterized by widespread zinc deficiency in humans. There is a highly significant correlation between zinc deficiency in soils and crops and zinc deficiency in humans (Cakmak, 2008). Lack of a clinical syndrome of zinc deficiency has delayed its recognition as a public health problem. To date, serum zinc is the only biochemical indicator of zinc status for populations.

When soils are deficient in zinc, the grain concentrations of crops grown in those soils are lower. People eating crops grown in zinc-deficient soils receive less zinc from their diets and are therefore at risk of zinc deficiency. Various field test conducted in India indicate that wheat grown on soils containing less than 0.6 ppm DTPA-extractable zinc (Singh, 2009) respond positively to zinc fertilization at a rate of 5 kg Zn/ha.

Improving the zinc nutritional status of food crops by agronomic biofortification is a creative approach for fighting zinc malnutrition in humans. A direct application of zinc fertilizer under field conditions is highly effective and very practical way to maximize uptake and accumulation of zinc in food grains. In the case of increases in grain zinc concentrations, foliar zinc application are more effective than the soil zinc applications.

Among the different strategies to reduce Zn malnutrition in human populations, the agronomic bio-fortifications is considered most sustainable and cost effective approach to enhance the zinc concentrations in grains of food crops and to address zinc deficiency in soils-plants-humans chain. There are reports that farmers involved in rice wheat cropping system have the tendency to go for unbalanced fertilization and do not apply zinc fertilizers even in low zinc status fields (Singh, 2011). Of late, it is predicted that as high as 25-30 per cent Zn content in rice and wheat will gradually decline with rising concentrations of atmospheric CO2 for the middle of this century.

Zinc deficiency in soil is having a 'serious' impact on human health and crop nutrition. Currently, there is no standard method of relating zinc deficiency in soils and plants to their suboptimal levels in humans. Therefore, a serious attempt is required to be made to develop innovative new diagnostic test to diagnose Zn- malnutrition in human beings by soils and /or plant/tissue/human hair analysis.

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Keywords：*Agronomic Biofortification, Deficient Soil, Human Health, India, Zinc*

P3-487

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Education and Social Awareness in the City of Sao Paulo-Brazil

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In the city Sao Paulo - Brazil live over eleven million inhabitants in urban areas widely . This population barely know the soil where they step and do not have the opportunity to make this discovery because of soil sealing . The University of Sao Paulo has a space for culture and leisure visitors who have recieved the need to know more about the soil . This space consists of experiments on the soil , where visitors can interact and touch the soil , as well as see a soil profile in a natural park . In general , visitors are students who go with their teachers to make an excursion didactic and always happy with the findings on the soil. We present experiments that demonstrate that the soil has various colors , has magnetism , electrical charge , can be acidic or basic , has a varied fauna , and other important features. This initiative has contributed to the teaching of soil between the students and the general public .

Keywords：*education and social awareness for soil science, soil for children, discovering soil*

P3-488

[C4.4-1] Education and Social Awareness for Soil Science in General Public

"Library of Rocks": An Important Tool for the Learning of Soils

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This paper presents the results obtained by the Laboratory of the Educational Technology Degree in Geography from the IF-Baiano, Campus Santa Ines, which has developed innovative strategies for learning soils, among them the "Library of Rocks'. The "Library of Rocks' is a collection of minerals and rocks, which can be used for different purposes, however in the case presented subsidizes the development of teaching and, subsequently, research and extension. The "Library of Rocks' has been used in internal classes of Higher Education, presenting important results in the learning of concepts and geological processes fundamental to understanding of soils. The evaluation procedure and the information obtained from the reports of the students showed that the learning process has been successful developed. In the reports were identified core ideas, which showed the importance of the process developed for the understanding of environmental concepts and processes fundamental to understand the soils and citizenship were identified.

Keywords: *Teaching soils, Library of Rocks, Learning, Citizenship*

P3-489

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Process for Soils Museum Preparation

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Soil museum is important for soil resources learning, both for conservation and agriculture utilization. Although in a country has many kind of soils but soil scientists have conducted a systematic soil classification system. To learning many kind of soils in the field in short time is difficult or impossible. So soil sample collection from various landform and made as soil monolith then show as a soil museum is useful visual aid in teaching or learning soil science. From the experience of soil museums in Thailand the process for soils museum preparation has 8 steps. 1) Determining the location for soils museum, size and main theme of soils museum. 2) Prepare soil samples in the form of soil monolith, soil block or soil clod. The soil samples should be main soil series in the country, problem soils, soil properties, soil organism. Select the highlight soils sample. Prepare the explanation text and figure. The step of preparing the soil samples will take long time. 3) Design the step of show soil samples and the walk ways in soil museum. This step should be work together between designer and soil scientist. In case of few budget shouldn't select designs to show with electronic tools . 4) Construction , new building or renew from old rooms. 5) Place the soil samples and set the explanation. 6) Setting lighting and sound. 7) Set the explainer. 8) Set the system for evaluation.

Keywords：*Soil museum, Soil monolith*

P3-490

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Behavior of Farmers under Climate Change in Eastern Algeria

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The objectives of the study are to identify the different types of agricultural practices in eastern region of Algeria under climate change.

A global analysis of rainfall gradient in relation to some soil criteria shows the change in behavior of farmers in their choice of farming. Agriculture in semi-arid conditions is subjected to chronic instability due to natural hazards, so that development in these areas becomes a problematic task, the reorientation of development policies must take into account the temporal variability of farmer's trends and threats that arise and compromise the production activities.

Results from 42 variables were obtained from the questionnaires which characterize socio-economic and agricultural condition of the farms and the soil nature and its productivity. The main aims of the survey were the assessment of the farming practice transformation and building the local typology according to the economic performance of farming system.

Despite the arid nature of this region, farmers have learned to adapt their farming by level of soil productivity measured through crop stability in a given region.

The economic analysis of the study area shows a distinction between whole municipalities.

This is probably due to local conditions and farmers motivation to adapt their crops with chronic instability of the climate condition.

The result pointed to two different groups of economic performance (high and low); the first group is characterized by dynamic changes in agricultural practices : more farmers were able to find the right combination by introducing the most appropriate practices for the region and have an economic gain. The second municipality with low economic performance, shows that average less dynamic compared to the previous group.

Keywords：*Soil performance, farming practice transformation, climate change ,farmer trend*

P3-491

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Interactive Extension Techniques Effectively Engage Audiences Regarding Agriculture and Water Quality in Manitoba, Canada

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Water quality is a major concern to citizens of Manitoba, a province located in the geographic centre of Canada. In particular, the presence of excess phosphorus (P) leads to large algal blooms. Lake Winnipeg, the eleventh largest freshwater lake in the world, commands the greatest interest in this regard. Agriculture has received much attention as a source of P to surface water. Inherent conditions of climate, landscape and soil on the Canadian Prairies influence the nature and magnitude of the risk of P transfer from agricultural land to surface water. So too does farmer practice. These factors form the basis of extension messages devised by local government specialists. The intent is to raise awareness about the issue of surface water quality, improve understanding of water and phosphorus movement and explain the role of agriculture. It is critical to link the concern with agronomic practice to demonstrate relevance to growers and agronomists, and to instill a sense that actions can be undertaken to address the problem without economic penalty. In fact, profitability can be improved through adoption of Beneficial Management Practices (BMPs) that favour efficiency in fertilizer use.

Extension messages are delivered in an informative, interactive and inventive fashion through the use of props, illustrations, demonstrations and simulations. Frequently a learning station is developed to feature a particular subject. The design of the learning station is based on the assembly of samples and devices that fosters a flow of information from one aspect of the topic to the next, leading to a “what can done” conclusion.

One of the most elaborate and effective learning stations has been a combination of rainfall and snowmelt simulators used to explain water movement on the Canadian Prairies and implications for water quality. Agricultural practice is then overlain onto this context to explain what farmers can and can not do to mitigate the risk of phosphorus reaching surface water. It is important to convey the technical details in a balanced and positive way in order to avoid undue accusations in the case of a general audience and any defensiveness on the part of an agricultural audience.

At regularly scheduled and special events, extension agents seek to engage a wide range of audiences: farmers, agronomists, teachers, primary and secondary students, college and university students, as well as the public at large. The flagship event for agronomists, with an attendance of 350-400, is the annual Crop Diagnostic School. The reach of this event is huge. For instance, the sixty-one per cent of 2013 participants who completed evaluations stated that they directly or indirectly influence approximately five million hectares (thirteen million acres).

Extension techniques and events will be illustrated and described. The water movement learning station will be featured prominently. Figures and descriptions regarding example events will be presented.

Keywords：*water, phosphorus, agriculture, extension, agronimists, farmers, students, public*

P3-492

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Understanding Soils: Inspiring the New Generation towards Agricultural and Environmental Sustainability. A Workshop for School Students in Oman

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A training workshop was conducted to communicate with 300 school students with wide range of ages, centered on 12-14 yr olds. The main organizer of the workshop was the Students Society of the department of Soils, Water, & Agricultural Engineering at Sultan Qaboos University, in cooperation with the Ministry of Education, Oman. The primary goal of the workshop was to inspire the community and to build a public interest awareness of the new generation on the importance of soils. Specific objectives of the workshop were to: (i) Show the role of soils as a critical Earth system that interacts with the four major systems including lithosphere, biosphere, atmosphere, and hydrosphere, and (ii) Demonstrate the multi-functions of soils on daily life. The workshop consisted of three major components chosen to fascinate and expands the imagination of school students about soils which included (i) theoretical aspects, (ii) a practical and interactive part, and (iii) skills acquisition. For component (i), students were enriched with concepts relevant to the physical, chemical, and biological properties of soils as related to agriculture and environment. The soil concepts were demonstrated to students using techniques such a documentary movie, brochures, posters, and competition in writing a short assay about soil and environment. Component (ii) consisted of interactive and real-time scientific models and experiments addressing the full spectrum of issues that concern contemporary soil scientist like soil degradation due to erosion, role of soil in supporting the plant growth, contamination of soil and water and others. With the skill acquisition components, students were allowed to have a direct contact with soil to gain dexterity in as estimating soil texture with the feel method, using the Munsell© soil color chart, measuring soil pH and EC, identification and observation of soil bacteria and fungi under the microscope, etc.

Questionnaires distributed and later analyzed and interviews with the students indicated that they were captivated by the many hidden peculiarities and properties of soil. Survey showed that the students were inspired by the broad context and functions of soil and the workshop has broadened their imagination and potentially had effectively alter their preconceived perception of soils. Students also pointed that the way the workshop was designed was effective and made them spontaneously involved with the whole experience.

Keywords：*Soil education, Soil science, School students, Community awareness, Soil Workshop, Inspiration*

P3-493

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Improving Soils Knowledge through an Intelligent Platform for Knowledge Transfer and Data Management in Agriculture

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Information isn't knowledge unless it's accessed and understood. Hence, the information-age, where technologies like the World Wide Web have made information readily available, is not the knowledge-age. The breadth and choice of information and source often leads intended users to become overwhelmed. In agriculture, scientific advance is well ahead of landholder implementation and is not always aligned with landholder requirement. Agricultural extension requires modernisation and 'real-time' methods of data collection and dissemination. Additionally, the general public are increasingly disconnected with their food origin and the required resources such as soils and water. This paper conceptualises a technological framework that could be implemented on a national scale in order to increase the efficacy of agricultural extension and public understanding of natural resource requirement in agriculture. By discussing the applicability of social media, smart-phone applications, intelligent information sources, electronic search engines, and educational theory, a conceptual framework for intelligent knowledge transfer and data management is presented. The framework draws upon the success of social media and web based information management sites, such as Facebook, Wikipedia and Google, to apply similar technological advances to education and extension in the agricultural industry. Importantly the framework is based on benefit to the user (i.e. what's in it for me?) in order to encourage further use, public awareness and enhance delivery of agriculturally based information.

Keywords：*extension, education, data management, knowledge transfer*

P3-494

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Influencers of Food Security and Food Dietary Diversity in Rural Semi - Arid Communities

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Objective: The aim of this study was to investigate the food availability, food choices and nutritional adequacy of household food in the study area.

Methods: Both primary and secondary data were used in this study. The primary data was collected by using a pre-tested questionnaire administered to selected farmers in the study area and focus group discussion methods. A probability sampling method (that is, pure or simple random sampling technique) was used to select the respondents. From a total population of 3,236 small-scale irrigators in Kaabong District, 147 respondents who happened to be irrigation farmers were randomly selected while 43 dry-land farmers were selected adjacent to the selected irrigators.

Results: This study revealed that the type of carbohydrate food eaten most is the Sorghum which is eaten seven times in a week by a large majority of the respondents (about 60%) out of 190 respondents, while very few eat other carbohydrate foods and only less than 1% Millet few times in a week. This could be because Sorghum is the staple food eaten in the Kaabong district. The study revealed that household food security depends on a nutritionally adequate and safe food supply at the household level and for each individual; a fair degree of stability in the food availability to the household both during the year and from year to year; and access of each family member to sufficient food to meet nutritional requirements. There is no significant difference in the type of food eaten between the irrigation and dry-land farmer households. Social factors and cultural practices in most countries have a very great influence on what people eat, on how they prepare food, their feeding practices and type of food they prefer. The likelihood of food security increases when farmers increase agricultural output and have access to a piece of land on the irrigation project. Therefore, with concerted support from government, and all stakeholders, food security can be enhanced at the household levels. Also, education and extension training are essential for farmers so that they are able to adopt new technologies. The study suggests that households that need to be targeted for food aid are those with large families, and those without access to irrigation projects. Also, to be included are those families with few assets, and those without access to agricultural land and implements.

Keywords：*Food security, food dietary diversity, rural semi Arid*

P3-495

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Reconnecting the Public with Soils and Agriculture in Manitoba, Canada is Achieved through the Use of Interactive Extension Techniques

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Basic knowledge of agriculture and soils must be extended to an increasingly urbanized public to reconnect people with food production and the resources essential to it. Employing interactive techniques with visual elements is very effective in engaging audiences on a subject that has become unfamiliar and complex. Soils extension staff with the Province of Manitoba have devised learning stations to deliver concise and stimulating lessons in a range of subjects.

The main audiences range from primary to secondary to post-secondary students, as well as school teachers and college instructors. The long-term, train-the-trainer plan is to equip outreach staff, of partners such as universities and colleges, to deliver lessons themselves. This capacity building will expand the complement of extension agents, ease logistics and increase the total audience reached with vital extension messages.

Soil development is explained using a 'Recipe for a Soil' learning station. The soil forming factors of climate, biology, topography, parent materials and time are first described with visuals such as samples of granite, shale and limestone as well as soil monoliths and the carbonate fizz test. Students learn that there are many different types of soil (over one thousand in Manitoba alone) with slightly or greatly different “recipes” involved in their creation. Then soil properties are addressed, with hand-texturing being one of the activities for students to undertake. However, soil colour is the focus and a segue to the main attraction. Students are equipped with materials to assemble miniature soil monoliths that serve as take-home representations of soil horizonation. Manitoba’s provincial soil, the Newdale, is usually featured as the principal example and samples of its horizons often employed in the making of mini-monoliths.

'Plants Need to Eat, Too' was developed to educate students about the fact that nutrients are essential for life and that farmers must provide them in fertilizers in order to grow crops to feed the world. This learning station employs labelled samples of commercial fertilizers, “mystery” manures to be identified and crops commonly grown in Manitoba. The latter are displayed in bushel baskets and accompanied by the quantities of fertilizer required to grow that amount of crop.

'Feed or Fertilizer? Tracking Nutrients on a Beef Farm' illustrates two types of cattle management systems during the winter, intensive via confinement in a yard and extensive wintering in which animals are kept out of the yard on the land. Students are guided through the production cycle as nutrients either accumulate or become depleted in various parts of the farm. The lesson becomes more interesting when the practice of bale grazing, one of the feeding options for extensive wintering, is introduced via miniature paddocks, feed and animals. Implications for both production and environmental sustainability are addressed.

Throughout the lesson, tasks are assigned to keep attention and facilitate learning about management practices, nutrient dynamics and climatic/landscape processes.

Advanced soils training is offered at Envirothon, an annual environmental education competition for high school students. Participants not only learn but also develop skills in team work, problem solving and public speaking in a hands-on format. In the soils discipline, students acquire knowledge and training in soil development, soil classification, soil properties, landscape processes and soil management. Activities include hand-texturing, colour determination, carbonate testing and map reading.

All of these lessons and learning stations are modified to a higher technical level for deployment at farmer and agronomist-targeted events. This transition can be done through the use of soil and feed test reports, case studies and research results.

Lessons and learning stations will be described in text and photos, with numbers provided for representative events at which extension is conducted.

Keywords：*soils, nutrients, interactive, extension, hands-on, students, teachers, instructors*

P3-496

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Appy Days in Communicating Soil Science

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The importance of soil, and good soil management, is well known within some audiences in Australia. With a history of some significant soil problems—including soils low in nutrients and soils that are degraded, acidified or saline—soil management is a topic that occasionally rises to prominence in the awareness of Australians. However, the interest in soil among adults in urban areas is generally low, unless they are gardeners or food lovers.

In January 2012, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australia released its first official app for iPad. Called SoilMapp, this app taps into the best available soil information from Australia's national soil databases. Users can find out about the likely types of soil near them or explore across the country and access photos, maps and data to use in farming models.

The use of app technology has allowed new and existing users easy access to a wealth of existing resources Australian Soil Resource Information System (ASRIS) and ApSoil, the database behind the agricultural computer model: Agricultural Production Systems SIMulator (APSIM). The app provides people a way to access information on the go, wherever they are; they no longer need to be logged on to their computer.

As part of the development and launch of this app, a communication campaign was implemented using both traditional and social media, video and other mechanisms including face-to-face communication. This campaign also complemented other initiatives with a range of audiences, including promotion of World Soil Day.

This case study will:
• outline the experience of the CSIRO team involved in the final development, release and promotion of SoilMapp
• discuss the communication and branding objectives, activities, and resources required to engage particular audiences
• outline more generally how soil issues are covered in the media
• review the use of portable devices like smartphones and tables in Australia
• ask questions about and challenge the audience to consider how soil science and soil issues could be more effectively communicated to increase awareness.

Keywords：*communication, awareness, online, abstract, science, soil, media*

P3-497

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Educational Program with Agricultural Practice and Sensor Data Analysis for Primary School Students in Tokyo-Dr. Doroemon Project

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We propose an educational program “Dr. Doroemon Project” which includes thinking training through rice cultivation in the buckets by two kinds of method and data analysis for the 5-6th grade primary school students in Tokyo, Japan during the 2011-2013. “Doroemon” named after Doraemon who is one of the most popular characters all over the world. “Doro” means soil in Japanese. These days there are few chances Japanese students can learn soil science in regular curriculum. But it is possible to make an opportunity they can learn soil science in special curriculum, “Integrated Studies.” It exists separately from the regular subjects and the objective is growing up the following abilities, to think on their own, to make decisions and to solve problems. Each school can make an education program on its own flexibly. Fortunately some schools adopt agricultural practice to this subject but the ministry reported that some contents had not worked enough. Therefore we propose a new program which includes agricultural practice and enough opportunities to grow up these abilities through analyzing agricultural data. In this program the students grew the rice by SRI method as compared to conventional method in the bucket. SRI stands for the System of Rice Intensification. According to the SRI Guideline it usually can produce 20-50% more yield with less seeds, water and fertilizers. Rice cultivation in the bucket is popular method in Japanese school because of space-saving. After the harvest they analyzed three kinds of data such as yield data, soil moisture and soil temperature on the worksheet. We analyzed their findings about these three data to make out what they thought and discussed. Also we tried to find relation between how they do cultivation and what they thought and found. As a result this program could provide such opportunities, to compare and correlate multiple elements, express findings in objective and find cause and effect. Also we could find they were interested stronger in the cultivation method they adopted actually than that they didn’t. It suggested how they do cultivation has relation with their findings. In conclusion we would like to propose that “Dr. Doroemon Project” provided enough opportunities to think and discuss through analyzing agricultural data practice. Also agricultural practice has certain impact on their thinking.

Keywords：*education, sensor, primary school*

P3-498

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Open Society and Soil Inventory

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Towards the International Year of Soils 2015, we, soil scientists are obliged to develop and maintain human societies which achieve conviviality with nature and environment. One constraint should be noted: asymmetry of information. This phenomenon is widely recognized now. However, it is not until individual or community interprets and shares the meaning of information that the opportunity of action appears. Few deny the significance of soils to sustain global ecosystem. Social awareness about the importance of biodiversity has been raised in global environmental agenda, however, topics about soils seem to be left behind in such enthusiasm. There might be many reasons caused present situation surrounding us. The author would like to focus on the epistemological significance of human knowledge. The author proposes a semantic idea of soil inventory as the instrument in any dimensions stores information and meanings interpreted and shared in human society. This concept is yet fully recognized in the world because of asymmetry of discourse presupposition, i.e. quality and quantity of information about soils, epistemological common understanding on natural resources among communities in various scales. C.S. Peirce argued that the process of fixation of belief was scientific empiricism and pragmatism. He developed his pragmatic maxim within the context of relationship between the object and us, and introduce semiotic as epistemological assumption. The author will argue the possibility of construction of soil inventory in global community through incubating the thought of semiotic beyond a border. The process of soil inventory such as identification, characterization, classification, and valuation could be described as semiosis. In case of soil resources inventory, we usually conduct soil survey which identifies a unit of soil and delineates the border of it from surrounded neighbor units. Individual unit is designated certain characteristics which are derived from attribution of soil. Therefore when we obtain soil map as a result of classification, visualized topographical extent of unit appears as an interpretant which contains both intrinsic and anthropocentric value. Though there are many studies on Peirce's semiotic and pragmatism about computer science, molecular biology, and so on, few are available about fundamental soil resources. The author believes this study will produce a new thought which will be a breakthrough in the dialogue among the global society regarding sustainable soil resources management.

Keywords：*soil inventory, epistemology, pedology*

P3-499

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Interactive Soil Map of Russia

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The interactive soil map was developed from the small-scale (1:15M) soil map of Russia compiled at the Faculty of Geography (Moscow University) and published in the National Atlas of Russia (2004). In the original map, soils were named in a traditional way, and their areas basically correlated with natural zones and provinces. For the interactive map, soils were renamed in terms of the new soil classification, so that the units in both legends proved to be slightly different. Thus, 82 units of the initial map's legend became transformed into 113 units in the legend of the interactive map. Overall, the map includes 1971 soil polygons. This map is the first cartographic implementation of the substantive-genetic approach to soil classification. This implies important consequences for the assessment of soil resources. Instead of the traditional zonal approach (soils of tundra, soils of taiga, soils of deciduous forests, forest-steppe soils, steppe, semidesert and desert soils), the new approach suggests soil grouping by substantive-genetic orders: texture-differentiated soils (Luvisols, etc.), Al-Fe-humus soils (Podzols), Gley soils, Organic soils, Halomorphic soils, Humus-Accumulative soils, etc. Both approaches can be combined.

The GIS-project of the interactive map is based on QGIS (http://qgis.org) software. The database includes information on soil codes and soil names in the initial legend (id_old(interger), id_symb(integer)) and in the modified legend (id_new (integer), id_symb1(integer)) and on landuse code. By means of the Image Map Plugin module the interactive soil map was created in QGIS with a reference to the attribute id_new of the database field.

The legend to the interactive map is organized in accordance with the high (order) level of the new Russian soil classification system. Descriptive files contain information on soils of a given order followed by information on the particular legend's units belonging to this order. Each unit has a label, or "anchor" for finding (by clicking) the due part in the text is provided. The descriptions are arranged as follows: soil name is followed by the profile horizonation formula; then, diagnostic characteristics are given; major physical and chemical properties; geography and variants of the soil; location in the soil cover; land use and its limitations. Textual descriptions are supplied with miniature icons-references to full-screen pictures of soil profiles (with vertical rulers) and horizon symbols, typical landscapes, some particular details of morphology, and typical schemes of soil combinations (catenas) in landscape. Thus, the interactive map contains rich illustrative information.

The starting page in the browser window consists of two frames: the map frame and the left-side legend frame. They are independent from one another: information about soils can be obtained by clicking on it in the legend or on the map. The file of soil description is opened in a new window.

Additionally, we performed an assessment of the percentage of cropland for each polygons with the help of Google satellite imagery. On 14238196 sq. km (84% of Russia), this percentage is less than 10% (actually, tending to 0% on most of this territory); the areas with cropland percentages of 10-30, 30-60, and >60% occupy 5% of Russia each (928928, 884403, and 858439 sq. km, respectively) and are mainly found in the south of European Russia and West Siberia. These data are presented in a separate cartographic layer.

Further progress of the interactive process supposes the introduction of additional information on the soil properties and soil forming agents at the regional level.

This map it the first experience in this field of soil geography, and it has an informational and methodological importance. It can be used for teaching purposes and for popularizing soil science. The map (in Russian) is available at www.esoil.ru, and the English translation is under preparation.

Keywords: *interactive soil map, substantive-genetic classification, soil map, popularization of soil science*

P3-500

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Creating Awareness on Importance and Management of Soil by Rural Farmers in Nigeria: Role of Naerls Adopted Villages Project

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Adequate information about the soil is vital to ensure sustained use of this natural resource. However, access to such information by rural farmers in Nigeria is inefficient due to a variety of factors which include insufficient extension staff, poor infrastructure, limited coverage of electronic sources and dearth of information in the right format among others. The National Agricultural Extension and Research Liaison Services, (NAERLS), Ahmadu Bello University, Zaria, is an agricultural extension research institute that has the mandate to disseminate proven and relevant agricultural innovation to farmers in Nigeria. In order to ensure delivery of timely and relevant information to rural farmers, a strategy was developed to facilitate access to agricultural information by farmers in the rural areas. Part of the strategies employed by the institute involved setting up of information resource centres (IRCs) in villages purposively selected by the Institute as Adopted Villages across the country. Farmers were educated about the soil, its importance and how to manage it sustainably by strengthening their indigenous knowledge about the soils. The project was a success as farmers were better educated about soil and its sustainable use.

Keywords：*Soil, awareness, importance, rural farmers, sustainable management*

P3-501

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Presenting an International Educational Poster on World Soil Distribution

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A technical educational poster titled World Soil Distribution that graphically presents a guide to soil distribution relative to key soil forming factors is presented. It is proposed for publication under the auspices of the IUSS followed by widespread international release.

The main feature of the poster is two charts that graphically present the distribution ranges of many common soils according to the factors of climate, parent material and topography. These charts are surrounded by supporting information on the five key factors of soil formation. The soils referred to are those under the World Reference Base for Soil Resources (WRB) system, the key attributes of which are briefly described together with a correlation to Soil Taxonomy. Many soil and landscape photos are also included.

The poster is primarily intended as an educational tool, particularly for school and university students but also for many practicing soil and other environmental scientists. It is envisaged the poster may eventually be hung on the walls of many school classrooms, university laboratories and other organisation offices in many countries around the world. It should also be freely available on line for downloading as an image for viewing onscreen or as projected images.
The poster aims to convey some fundamental principles of soil formation and to illustrate how different environmental factors give rise to different soils. The poster should also serve to improve many people's general understanding and knowledge of major soil types of the world. Its primary aim, however, is to reveal the dynamic and intriguing nature of soils, and thereby potentially spark an interest in soil science and soils generally amongst students and also the wider community.

Keywords：*technical poster, education, soil formation, environmental factors, WRB soils*

P3-502

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Colours of the Earth

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In 2007 the painting box with the "Colours of the Earth" was designed by the Rural Development Division of the Lower Austrian Provincial Government with help of BIENE, an environmental NGO aiming to protect soil and to promote bio-energy. It should bring more soil awareness to people that are usually not aware of soil. Since 2010 this approach was repeated in several more European countries, namely Czech Republic, Slovak Republic and Hungary. Other countries within the Danube River Basin plan similar projects. Here we find an EU Strategy for the Danube Region and soil protection is a declared policy aim. Accordingly a soil awareness and protection network of the Danube Region (SONDAR, www.sondar.eu) was established to support this aim. More than 20 institutional members of SONDAR participate in four European Regional Projects during 2011 and 2014. Beside scientific topics, the "Colours of the Earth" is a work package in each project.

Every soil includes particular pigments that cover all varieties from brown, black, grey to red. According to findings present, the application of soil colours originates at the beginning of the Late Stone Age (Upper Paleolithic, 40,000 to 8,000 years BC) in Southern France and Northern Spain. The works of the Stone Age people have been conserved for thousands of years, hidden in caves. Mainly animals, men and signs were painted with colours made of earth pigments, the binding agents were birds' eggs, rubber from trees, fat, blood or animal dung.

The "Colours of the Earth" project includes five particular steps: i) the finding of suitable soils and the production of soil colours. Here soil scientists worked together with social institutions caring for people with special needs. ii) The branding of the soil colours as "Colours of the Earth" and the establishment of a trademark with a high symbolic value. A wooden box prepared from autochthonous local tree species, including particular octagonal glasses for eight or more soil colours is common for all projects related to "Colours of the Earth". iii) Local artists were incorporated to the projects. They are the tutors for courses where school teachers and other resource persons learn on how to prepare and use soil colours. iv) competitions with "Colours of the Earth" were organized and so far several thousands of art works were delivered to take part. The winners were selected by either a jury of artists and soil scientists or by an online voting process and awarded with prices, usually excursions to other regions. v) Local, regional and national politicians used the "Colours of the Earth" approach to campaign for soil and land use policies. The awarded paintings were exhibited in ministries, regional and local governments. So far more than 200 institutions became involved, more than 1.000 boxes with soil colours were produced, approximately 40.000 school children painted with those colours and close to 1.000.000.- online voting were counted (www.soilart.eu).

Keywords：*soil colours, soil awareness, Danube Region, SONDAR, school children, artists*

P3-503

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Soil Atlas of Latin America: An Innovative Tool for Policy Development and Awareness Raising

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Knowledge about the soils and its functions in the region is fundamental. Improving communication to civil society and raising awareness of the importance of soil are important tasks for science and development actions. The Soil Atlas of Latin America and the Caribbean (LAC), realized thanks a wide representation of the soil science community from over 19 Latin America and Caribbean countries, will represent to raise awareness on soil among civil society and the reinforcement of scientific collaboration between Europe and Latin America.

Keywords：*soil, atlas*

P3-504

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Generating Interest in Soil Science through Collegiate Soils Contests

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For more than 50 years in the United States, the National Collegiate Soils Contest (NCSC) has been bringing undergraduate students and professors in Agriculture, Soils, and Environmental Sciences together for a week-long intensive study of soils, landscapes, and land use. The event typically includes an orientation meeting, a coaches meeting, a banquet, and culminates in a contest which crowns individual, group, and overall champions. Much work and preparation goes into hosting the contest, which rotates between seven different regions in the United States. Host institutions prepare a handbook which contains contest rules and materials that students use during the contest. Typically 15-20 practice and five contest sites are selected and described by contest officials. At each site, contestants describe a profile using field soil description techniques and then classify the soil to the subgroup level according to U.S. Soil Taxonomy rules. Additionally, students estimate various soil qualities and features such as water availability, hydraulic conductivity, and erosion potential; and interpret the soil and landscape for building sites and onsite wastewater treatment. A scoring system has been developed to evaluate the agreement between the contestant's description and that of the contest officials. This poster describes the modern National Soil contest and provide highlights from recent contests held in Platteville, WI and Doylestown, PA.

Keywords : *soil judging, teaching, undergraduate education*

P3-505

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Soil Scientists Communicate Research Findings during Annual Field Days: Best Practices for Public Presentations

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The United States Department of Agriculture provides a forum for community residents to understand how government employees' research is designed, executed and impacts the local area through presentations conducted during annual Field Days. Field Days showcase diverse research projects impacting the soils in geographic regions that can be replicated across the globe. This research study evaluated the effectiveness and usefulness of the presentations of 25 presenters during myriad Field Day presentations over a three year period. The presentations were digitally recorded and content analyzed for the components of effective presentations and constructive use of visualizations. The findings provide soil scientists with a guide on how to construct effective oral presentations and visualize content.

P3-506

[C4.4-1] Education and Social Awareness for Soil Science in General Public

Instruments to Raise Soil Awareness in Schools and Support National Soil Protection

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Raising awareness plays a major role in soil protection. This concerns knowledge exchange among experts as well as teaching students in schools or informing the general public.

The Environment Agency Austria (EAA) provides a number of tools developed in different projects.

A series of teaching materialshave been developed to raise awareness on soil protection among students aged 8 to 18.The offer includes workshops on soil protection, workshops on land take and living conditions as well as illustrations on soil functions and soil threats. In the soil protection workshops students may explore actively soil properties,soil formation, soil functions and soil organisms in a playful way like watching soil animals,. Key doing small physical experiments or playing soil games followed up with creative tasks.

Workshopsonland consumption,require the analysis of living conditions and land take in order to understand the own impact on land take and soil sealing. Additionally studentsare encouraged to communicate with their families about all issues raised during the course. Both workshops have been implemented successfully in Austrian schools.

Environmental illustrations with a focus on land and soil complete the soil awareness offer for schools. These illustrations aim at visualising complex issues such ascircular land use, soil functions or land take and flooding in an appealing and easily understandable format. The aim was to create content that fits the current state of (soil)knowledge and is appealing to laypersons.In order to make transnational use of the teaching material and the illustrations multi- language versions were produced.

The Soil Compass is a soil nature trail via www.It combines soil knowledge and interactive soil profiles showing a three dimensional video supported “outside experience” of subsurface life. It addresses the open public and municipalities to provide new soil profiles but can be used as teaching material as well.

The provision of a national internet platform, the Austrian Soil Platform (www.bodeninfo.net)
supports knowledge exchange among soil experts providing news, dates, meetings or projects as well as regulations and materials and administration of working groups. It also access to soil issues for everybody

To connect Austrian soil experts physically the Austrian Soil Forum is run for over ten years.

It supports soil and soil related experts to cooperate, create new ideas, find partners for projects, exchange knowledge, discuss current soil tasks or harmonise practice.

The conclusion is that awareness raising on soil among different target groups continuously has an effect to push the subject, even more if these groups cooperate and tools are adjusted. Supporting soil experts with information, organisation and good teamwork is as important as addressing actively the public and the whole education sector. As well it is shown that there is a market for workshops an education on soil particularly in schools.

Our aim is to make an attractive offer for soil scientists, environmental education in schools and the interested public and thus to support current soil protection strategies as well as to increase interest in soil and soil protection among tomorrows decision makers and land users.

P3-507

[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Learning Soil Classification through Virtual Learning Environment

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The objective in modern soil classification was a universal system of soil classification. After six decades of evolution, the objective has not yet been reached. Without a universal soil classification, Soil Taxonomy of USDA (USA) has been accepted as the soil classification system to be utilised for making and interpreting soil surveys in many countries without a national soil classification system as some South East Asian and Latin-American countries or Spain. Furthermore, this system has also been as a correlation system or common language for scientific publication. However, this system, with a morphogenetic approach, has become increasingly complex. The well-used of a soil classification is strongly responsible for the success of the process of soil knowledge transference. Consequently, the soil classification is frequently rejected by the students because of the alleged difficulty of the contents, specific language and complex architecture of the soil classification system. The present work was triggered by the need to develop new techniques of teaching to speed up the learning process and to experiment with new methods of teaching. In contrast to learning-before-doing, we propose to focus on learning-in-doing, a model where learners are increasingly involved in the authentic practices of communities through learning conversations and activities involving expert practitioners, educators and peers. For such, it is necessary to adopt virtual learning environment to new learning requirements regarding Soil Classification. Moodle has become very popular among educators around the world as a tool for creating online dynamics web sites for their students. This paper proposes e-teaching techniques introduced in Moodle virtual learning Environment in order to increase student motivation and interest in Soil Classification, connecting the scientific knowledge with the user needs. Such technologies can be used to facilitate the apprenticeship, long-term mentoring, and collaborative groups that learn through work on projects. The student interest to learn using e-project is clearly strong.

Keywords：*soil classification, moodle, Learning Management System*

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[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Soil Judging as an Instrument for Community-Building in the Discipline of Soil Science

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Soil judging contests, involving the description, classification and interpretation of soil profiles, and the description of soil landscapes, have long been part of the US collegiate 'soil science scene'. Since 1960, annual national contests have pitted the top undergraduate teams from seven regions of the US against each other, with the contest venue moving between regions over a seven-year cycle. With this long history has developed a very strong culture of field-based soil science, such that many of the Universities with strong agricultural curriculums in the US routinely participate in the (qualifying) regional and national contests. Only in the last few years have other countries started to adopt a similar concept of competitive soil judging; in 2010, the inaugural Canadian Soil Judging Contest was held in Saskatoon, while in 2012 the inaugural Australian Soil Judging Competition was held in Hobart. At the 20WCSS in Jeju, the inaugural International Soil Judging Competition will be held.

The benefits of participation in soil judging for both students and the broader discipline of soil science are numerous, have been apparent in the US for many years and are evident in the more recent competitions in other locations. For undergraduate students in particular, benefits of participation can be both personal and professional; the opportunity for travel, cultural awareness, improving self-confidence and building wider social networks are examples of personal benefits. While professionally, many students derive experience in soil description and interpretation (through training and competition), meet other academic soil scientists acting as coaches for other teams, are exposed to career opportunities, and in many cases improve their professional network for future employment. For the discipline of soil science, the main benefit of soil judging is that a cohort of undergraduate students from a range of degree programs are energized and enthused about soil science, and gain invaluable field experience that make them vastly better soil scientists. The camaraderie and enjoyment that such competitions engender leads us to suspect that soil judging must rank as one of the more effective recruitment tools the discipline of soil science has at its disposal, especially where undergraduates are wavering between different discipline areas of agricultural and environmental sciences.

Nevertheless, perhaps the greatest overall benefit of soil judging is the building of the soil science community, especially when the soil judging is 'bolted onto' a national or international soils meeting. The opportunity for soil judgers to mix with other soil science students and senior soil scientists in the field, to attend a meeting and hear of the prevailing issues and latest research findings, and to feel as though they are a legitimate part of a broad scientific community, are powerful ways to ensure that they become energetic early career participants in the soil science community. By supporting soil judging teams and celebrating their successes, the broader soil science community can significantly bolster its own strength into the future.

Keywords：*community, field learning, professional network*

P3-509

[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

The Value of Soil Science Information and Opportunities for Informing Policy Decisions

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Soil scientists have incredible opportunities to inform policy decisions outside the traditional areas for which soil scientists work. Over the last three years while working to provide science-based pest management policy decisions at the United States Department of Agriculture (USDA), the value of soil science has become incredibly clear. As a soil scientist, I review proposed rules and other foundational materials with a different set of eyes - noting the weaknesses of a soils-related discussion written by non-soil scientists or pointing out how soils information could better inform a decision. It has also been clear where soil scientists could provide leadership in informing the science particularly in areas where soil scientists are generally not engaged. For example, in a recent Science Advisory Panel on pollinators, a soil scientist was included with the hope that he/she could weigh in on the fate and transport of pesticides in/on soil in a risk assessment. The issue of pollinator health is incredibly important - understanding the science, including soil science, is keenly important. Another example is the finding alternative fumigants to methyl bromide which is being phased out under the Montreal Protocol. Soil texture and wetness are key characteristics that determine whether or not a fumigant will be effective. These are but two examples of where soil science information, and soil scientists who can interpret that information, can be of value in forming scientific decisions - which ultimately help to formulate policy. An understanding of the broad opportunities for soil scientists may help to attract a new generation to work in this critical discipline.

Keywords：*Soil science, policy, science*

P3-510

[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Introducing Soil and Plant Science: Undergraduates Learning through Experiences

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Problem based learning enables students to develop their knowledge and skills by working with real-world complex problems. But even when fundamental knowledge of a discipline is rudimentary, problem based learning can be used to introduce a discipline and provide an avenue for exploratory learning and developing critical thinking skills. Problem-based and exploratory learning often means that students will consider their discipline knowledge as well as inter-discipline knowledge, e.g. place soil science knowledge into context and integrate knowledge with other disciplines (agronomy). This approach can also encourage students to identify what they need to know and solve the problem--this is experiential. In a recent curriculum review by the Soil & Crop Sciences Department at Texas A&M University, future employees of departmental graduates pointed out that Plant and Soil Science graduates not only need good discipline knowledge, but just as importantly, need to know what knowledge is useful and apply that knowledge to solve problems.

To address the need for students to learn how to problem solve, develop quantitative skills, and develop both knowledge and skills in hands-on learning, a Gateway class titled, 'Problem Solving in Plant and Soil Systems' was created. Forty first to third year undergraduates in Plant and Soil Science and Turf Science majors enrolled in this unit. The teaching environment involves two, one-hour lecture time slots and one three-hour laboratory weekly. The lecture times are solely developed to support the laboratory, where student work in groups of five throughout the semester to design an experiment, harvest cotton lint in the field, collect soil samples, perform laboratory analysis of soils, read literature, write lab reports and ultimately present a scientific poster for a final grade. An important component of the class is that students are encouraged be creative and follow their curiosity when developing a hypothesis, but it must be testable. The class time revolved around three modules, plant physiology, soil properties, and precision agriculture technology such as proximal sensing. All three models are taught from a data analysis perspective and learning to use excel for data summary and analysis. Students are generally very uncomfortable the first half of the class in that they want to be told what they need to learn. Much of the teaching effort is toward developing analytical skills and helping students locate sources of information to answer their questions. At the end of the semester, students comment on how much they liked dealing with data they collected themselves, and being encouraged to use data and knowledge to solve real-world problems. They dislike that they are not provided with more directed readings and a more formal classroom structure. As an instructor of this type of class, the challenge is identifying where the students need help and addressing the need prior to an assessment point e.g. a homework, summary, or poster presentation.

Keywords：*experential learning, problem solving,*

P3-511

[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Terragenome-The Soil Metagenome Network

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The National Science Foundation recently funded a Research Coordination Network (RCN) to facilitate soil metagenomics studies. The RCN has sponsored workshops and sessions at a number of meetings this year, including a symposium at this year's SSSA meeting. This poster introduces the TerraGenome RCN to the soil science community and solicits its input about the activities of the network. We anticipate that TerraGenome will accomplish its purpose by holding periodic meetings to plan strategies and share information, coordinating sequencing and bioinformatics activities, hosting workshops to train students and scientists in metagenomic analysis, and generally enhancing communication and information sharing through a website and list-server. The most fundamental impact of TerraGenome will be to build and support a diverse community of researchers in the U.S. and around the world who have an interest in uncovering the taxonomic and functional diversity of soil microorganisms. Bringing together this community, with scientists representing several disciplines, will help to train students and postdoctoral associates to tackle an inherently interdisciplinary question. This is most clearly demonstrated from the workshops it will sponsor. The TerraGenome website will broadly disseminate the products of our Network activities, with a special effort to provide web-based tools for use by K-12 educators and students. Through its activities TerraGenome will help to provide the genetic foundation to better understand the diversity of microbial processes upon which the health and functioning of the planet is based. For example, the processes involved in cycling carbon, nitrogen, sulfur, and other elements are key determinants of plant and ecosystem productivity. Practically, this translates into producing food and fiber for humanity. Furthermore, the huge diversity of soil organisms represents a relatively untapped reservoir of potentially useful microbial enzymes and products, such as enzymes for cellulosic energy production, and antibiotics and other pharmaceuticals.

Keywords：*Metagenome, metatranscriptome, metaproteome, network*

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[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Alternatives for Mushroom Cultivation Casing Soil

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One of the most important stages of mushroom cultivation is casing in which soil covers the compost. One of the best covers for compost is peat. Casing soil should have high capacity for holding water, alkalinity, porous and light structure and fully decayed organic matter .Also it should not contain parasitic infections and germs. Since the suitable peat resources for mushroom are not found everywhere in the world and the sources are limited, some alternatives are introduced to be replaced with soil. These materials are used not only to reduce the cost of production, as the exchange rate and importing cost is high, but also to keep peat resources and preserve the environment. By this way global concern about the future of mushroom production prices and preserving the environment for future generations will plunge.

Gulser and Peksen studied about waste tea as a casing material in 2003. Riahi and Azizi in 2006 and Sharma et al in 1999 had researches on using SMC as the casing soil, that others had also studied on this material. Waste paper is one of the other materials which is introduced as an alternative for casing soil in mushroom production by Y. N Sassine in 2005. One of the other interesting ways to prevent using new peat is applying a plastic mesh on the compost and casing on that which is introduced by Farsi et al in 2011. Also a research is done in university of Pretoria in 2013, whereby pith from sugarcane bagasse can be utilized as a substitute for peat moss in the cultivation of mushrooms. But considering the hygienic aspects in spent material utilization is very important due to the dangerous diseases which can be transferred via waste material would cause more harm . Also, because of changing some of the soil characteristics, some treatments are essential to do on the spent materials to make it as the new one.

This review study is done to introduce some researches which are done not only to replace peat with cheaper materials but also to preserve environment from loosing peat resources. Also some treatments for enhancing the introduced materials to make better casing soil will be introduced. Mushroom cultivators can get ideas to see cheap or waste products of their farms periphery to reduce their cost of mushroom cultivation and rescue the peat resources from destruction.

Keywords：*Casing Soil, Mushroom, SMC, Bagasse, Mesh, Peat, Pith*

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[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Technical Soil Science Research Results in the Poster Format: Best Practices for Effective Communication

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A random sample of more than 1,000 poster presentations displayed at the European Geosciences Union annual conference over a three-year period were analyzed using content analysis technique. The results support that too much technical information is placed on posters and a majority of the conventions for effective poster presentations were violated. This situation can be addressed if an additional component in a soil science course is designed to cover how to consolidate technical information for poster presentation and how to make information usable and readable when creating a poster presentation.

P3-514

[C4.4-2] Widening the Soil Science Course to the Various Directions of Scientific and Humanistic Area

Soil Science in Religion, Arts, Society and History

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The Bible says that God let dry ground appear and commanded the land to produce all kinds of plants (fruit trees and grains), and then saw that it was good. Since the creation of the Earth, soil has shaped our world and the way we live in it in various ways, while preserving the diversity of all life on Earth. Soil has provided us humankind with most staple foods and shelters since ancient times, and therefore ancient civilization often worshipped the soil as a symbol of fecundity and richness, since soil has leveraged the outcome of almost every war or battle from ancient times by providing most of foods for our ordinary life and extraordinary times. Therefore, most part of our history can be regarded as a compilation of the official records of the wars and battles among the nations and races of humankind to occupy the land (more evidently soil's productivity and dwelling area). As the world's population increases, maintaining or improving soil's productivity and living standards without deteriorating nation's limited soil resources or assets is still a challenge of each nation even today as was in the past. Indeed, the more efficiently each nation tries to exploit the land to keep its current requirements, the more often modern economics and civilization force the nation to counter against a national food security crisis. As evidenced in the historical literature, soil has influenced the way of our living, human communities and societies in various ways. For instance, an individual or a group of persons of common concerns and interest living in modern society and culture became more nervous and indifferent to other people's thought and action than ever. With the advancement of digital technologies and devices, we humans became more and more exposed to the binary systems consisting of two numbers (zero and one, black and white, true and false, etc.). In addition, as civilization advances, soil surface becomes more paved with hard, repulsive materials such as asphalts and concretes. Those phenomena could explain how our modern society and communities become more repulsive, cliquish and ignorant of than ever. It is evidently true that soil science has contributed much into achieving maximum or sustainable agricultural productivity, and this achievement afforded more time to human society and changed the way of living in it. Therefore, people began to spend more time in enjoying and creating masterpieces in fine arts, music, literature and plays, in performing archaeological activities, or in developing science and technology. Such societal changes in the ways of living helped make our civilization more developed, but this advances in societal development in turn inadvertently deteriorated nature and the environment that surrounds human society. Our society in the future should be sustainable, and it is time for us to think of what and how we have to do to construct sustainable society. Because soil interacts extensively with human communities, this essay will provide the audience with a pleasant forum to discuss societal changes with knowledge in soil science.

P3-515

[WG1] Soil Monitoring for Mankind and Environment Safety

Creating Surface Soil Texture Map with Indicator Kriging Technique: A Case Study of Central Iran Soils

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Most of the techniques for mapping the distribution of categorical variables demand high level of knowledge and technical support. In current study to mapping about 8000 hectare of surface soil texture of HASSANABAD region in eastern part of Isfahan province in central Iran, we use a simple interpolation method of geostatistical techniques that called indicator kriging (IK).The indicator approach is used to describe the spatial variability of categorical soil data. The aim of this study is to run the indicator kriging technique to map the soil texture map as conditional probability. To execute the mapping process 120 points were sampled (0-30 cm) and analyzed to determine their soil texture. Iindicator variable is a binary variable that shows the existence of each soil texture in the study area with indicator 1 and the absence of each soil texture with indicator of 0. After transforming the absence (0) or existence (1) of each soil texture in sampled point, the experimental indicator variograms were computed for indicator data of soil texture in Ilwis GIS. Prediction of soil texture classes were done by ordinary kriging (OK). Finally six soil texture map for six identified soil texture in the study area was created.

The aim of this study is to run the indicator kriging technique to map the soil texture map as conditional probability

Keywords：*indicator kriging , soil texture map , geostatic , GIS*

P3-516

[WG1] Soil Monitoring for Mankind and Environment Safety

Regional Evaluation of Potential Landslide Earthquake and Wave Vibration Effect Based Relative Method (rem) and Geotechnical Mapping

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Mitigation of disasters especially landslides and earthquakes is one of the geological phenomenon that often occurs in Indonesia by looking at the appearance of geomorphological and geological dynamics. The method used in the evaluation of potential landslide areas, base on the study of literature, geotechnical mapping and study of REM (relative effect method).

Slope stability analysis and land description is one of the points of analysis in geotechnical mapping, it concerns the evaluation of potential landslide areas by the earthquake and wave vibrations. REM is a statistical method of evaluation of GIS in the determination of potential landslide areas, this method is used in order to determine the relative effect (RE) of each such unit of surface geology, slope morphometry, natural conditions, natural openings and natural cover in calculating the ratio of the unit. From these data can be generated interpretation and analysis of ground motion evaluation.

The result from this study one is zonation map based on the results of the evaluation using these methods. And from these data can be used as a reference in the floating of infrastructure and accessibility, especially for government development target areas in Indonesia.

Keywords：*REM, landslide and earthquakes, geothecnical mapping*

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[WG1] Soil Monitoring for Mankind and Environment Safety

Development of Land Use and Land Cover Areas of Nanggroe Aceh Darussalam Province around 10 Years after the Tsunami Disaster

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Banda Aceh is an area which is vulnerable to earthquake and tsunami
because it is located on the plate and fault of Sumatera Island and most of its area
lies along the coast.On December 26, 2004 an earthquake (9 on Richter scale) shook Indonesia . Its' epicenter was less than a 100 miles away from the northernmost part of the province of Aceh . As a result, the gigantic waves it caused turned into tsunami ensuing colossal damages to the coastal areas. Neither the media, nor the authorities warned citizens of upcoming earthquake and tsunami. Tsunami warning system simply did not exist in South Asia to alert people living in these areas. As a result, eleven countries were affected and thousands of people vanished into the ocean (around 300,000).

The impact of the earthquake and tsunami on Acehnese habitat was manifold: the villages were destroyed, previously arable lands got polluted by the seawater (causing salinization), fisheries were demolished, coral reefs and beaches washed away; roads, houses, hospitals, schools were wiped out.This study aims to determine the development of land use in the province of Nanggro Aceh Darussalam aerial observation after about 10 years tsunami.

Keywords：*Tsunami,Development,Land Use/Land Cover*

P3-518

[WG1] Soil Monitoring for Mankind and Environment Safety

Land Degradation in the Philippines Based on the Fao-Lada Land Use System Approach

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As signatory to the UN Convention to Combat Desertification, Land Degradation, and Drought (UNCCD), the Philippine National Action Plan, the main instrument of the Convention, has done historical analysis of land degradation in the Philippines, identified the forms, causal factors, extent and distribution of land degradation. The Food and Agriculture Organization (FAO) Land Degradation Assessment (LADA) Program was developed for drylands, and the Philippines as a monsoon country was approved to try the methodology. The Philippine FAO-LADA Project has three major components reflecting the three major outputs spelled out in the Terms of Reference: (1) Capacity development, (2) the development of the Philippine Land Use System (LUS) Map, and (3) Land degradation assessment based on comparative LUS analysis. The focus of this paper is on the second major output, the production of the Philippine Land Use System Map, Version 1.

Land use is defined as the sequence of operations undertaken with the purpose to obtain goods and services from the land. A nationally refined version of Land Use Systems (LUS) map and geospatial information dispensation was executed in ArcGIS 10 using the 2003 land cover data produced by the country's National Mapping Resource Information Authority (NAMRIA), initially with twenty-three classes. Spatial dataset on irrigated agricultural lands (NIA Irrigation Development, December 2010) was superimposed into the land cover separating the major land cover class of Agricultural land into Agricultural land, irrigated and Agricultural land, rainfed. Agricultural lands, rainfed with attributes of Other land, cultivated, annual crop were classified as Rainfed rice and corn while those with attributes of Other land, cultivated, perennial to Coconut. Sugarcane areas were derived from common soil types (BAS, undated) being devoted to sugarcane plantations and verified through geographic distribution of sugarcane area from BAS (2003). These sugarcane areas are also segregated from Agricultural lands, rainfed. The remaining areas that are not covered by the major rainfed crops were considered Diversified upland crops. The resulting areas for the major rainfed crops are now more consistent with the national statistics on crop production. For delineation of protected areas, the Forest class under ecosystem based on land cover that are also Protected class under major land cover was further delineated. Agroforestry areas from CBFM data were imposed and labelled as Forest, plantations. Although the LUS mapping units were polished and the LUS map, now with seventeen classes, is closing near to authenticity, the output is not yet definitive because other attributes need to be incorporated for further refinement. It will be further characterized by a number of biophysical and socio-economic attributes that are attached to the LUS units.

The 2003 Philippine Land Use System Map with 14 major mapping units were delineated. Since the terms of reference calls for a comparative land use system analysis and NAMRIA is yet to officially release the 2010 land cover map, the GIS-computed area was compared with official statistics released prior to 2003. The framework of analysis was based on DPSIR (Driving force - Pressure - State -Impact - Response) using the WOCAT-LADA Mapping Questionnaire. The output was field validated in three pilot local land degradation assessment areas in each of the major islands in the Philippines. Since the manual was developed for

drylands, expectedly, there were land degradation issues in a monsoon country that were not addressed such as intensive cropping without fallow, shifting cultivation, conversion of mangroves to fishponds, and urban migration. There were also issues relating to bodies of water such as overfeeding of fish and settlement of excess feeds in lake bottoms resulting to low biochemical oxygen demands, fish kills, and other related issues like excessive fertilization resulting in leaching of nutrients to water systems and consequent water hyacinth and algal blooms.

In conclusion, despite these limitations in the manual, LADA has excellent scientific basis to assess land degradation through set of indicators. Although originally developed for drylands, the methodology works for monsoon countries but we need to adjust the manual to cover additionally relevant issues. The Philippines should be able to comply with the UNCCD reporting requirements based on LADA methodology. And PhilLADA should be established to continue the project after this FAO project completion.

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[WG1] Soil Monitoring for Mankind and Environment Safety

Classification and Distribution of Iraqi Soils

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Since ancient days Iraq was known as the valley of the two rivers Mesopotamia. Its bountiful land, fresh water and varying climate contributed to the creation of agriculture since thousands of years. Iraq has soils which are markedly different from one another due to differences in soil forming factors .In general, the degree of soil development decreases from northern to southern Iraq as represented by the differences in morphological, physical, chemical and mineralogical properties. Most soils in Iraq are of secondary origin, consisting of materials transported from the place of weathering and accumulated somewhere else (Buringh, 1960).

The work of soil survey and classification in Iraq was started before 1950. At this point in time, the number and type of soil units in Iraq are incomplete due to the lack of semi-detailed or detailed surveys covering all of Iraq. Non-systematic work of soil survey has been the dominant type of work to date. Only 35% of Iraq is considered covered by a semi-detail survey. About more than 35% from the Iraqi area was covered by Semi-Detail soil survey work with 1:50 000 to 1:25 000 soil maps. There is no general soil map covering the whole country up to now ,using soil Taxonomy or other system. So the need for detail soil survey and developing soil map with large scale are very necessary . In order to develop general soil map for Iraq following USDA soil Taxonomy , 300 pedons covering the whole area of Iraq were collected from the previous works. The collected soil data were reclassified according to the key of soil classification ,2012 .Digitizing soil map at 1:500000scale was developed. The results indicated the presence of five soil orders arranged according to their dominance as following : Aridisols , Entisols , Inceptisols , Mollisols and Vertisols ,respectively . Twelve suborders belong to the dominant orders were recognized ,with twenty five great groups

Keywords：*soil classification , Soil Survey , Iraq*

P3-520

[WG1] Soil Monitoring for Mankind and Environment Safety

Long-Term of the Consecutively Monocultured Peanut Obviously Alters the Community Composition of Soil Nematodes in the Red Soil Region of Southern China

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Because of increasing land scarcity and as a consequence of agro-industrialisation, peanut is increasingly grown in repetition on the same land without any crop rotation. Such intensive peanut production is particularly widespread in the hilly red soil region of southern China. However, there are various problems associated with such consecutive monoculture, including a continuous decline in yield and quality and an increased susceptibility to disease. Soil free-living nematodes are the most abundant and species-rich metazoans in soils. Nematodes are useful indicators of soil quality because of their great diversity and participation in many functions at different levels of food webs in soil, relatively simple in separation and enumeration. Their populations, in contrast to those of bacteria, are stable in response to changes in moisture and temperature in soil. In the present study, the entire soil nematode communities of three fields where peanut had been consecutively mono-cultured for 3, 5, and 20 years respectively were compared at the genus level. Results showed that the genus composition, individual density of soil nematode in three fields were significant differences. Consecutively monoculture significantly increased the abundances of soil nematode with the prolonged years of peanut monoculture. The proportions of bacterial and fungal feeders gradually decreased, while plant parasites and omnivores and predators increasing with the prolonged years of peanut consecutively monoculture. The relative abundances of Mesorhabditis, Protorhabditis significantly decreased, and Prismatolainus, in bacterial feeders significantly increased with the prolonged years of peanut monoculture. Long-term monoculture significantly increased the relative abundances of Tylenchus, Pratylenchus in plant parasites. Consecutively monocultures had no significant effects on the biodiversity of soil nematodes, as estimated by the Shannon and Simpson indices. The current data demonstrated that the soil nematodes community was markedly affected by continuous peanut cropping, especially with regards to the functional trophic groups that were significantly influenced, which could be an important factor contributing to the obstacles of peanut continuous cropping.

Keywords：*Peanut continuous cropping, soil nematodes*

P3-521

[WG1] Soil Monitoring for Mankind and Environment Safety

Haiti Pilot Soil Survey Initiative

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USDA-NRCS is collaborating with Haiti Ministry of Agriculture, Natural Resources, and Rural Development (MARNDR) and Faculty of Agriculture and Veterinary Medicine (FAMV) to initiate a pilot soil survey of 3,000 Ha. The goal is to build capacity and establish partnerships to collect, organize, and disseminate soil information to enhance agriculture productivity, promote sustainable land use and improve short and long term socioeconomic and environmental condition. In 2012, a preliminary assessment of capabilities and resources was conducted and a stakeholders meeting helped identify partners, available resources, and expected outcomes.

A Cochran Fellowship Study Tour consisting of three phases was held in 2013. Phase I included a two day working session with National Leaders at the USDA/NRCS National Headquarters in DC. Participants met with leadership staff to learn how the US soil survey program is structured and managed. Phase II was held at the National Soil Survey Center and focused on methods for conducting a soil survey for both the Haitian Leaders and Specialists. Phase III was an additional week of in-depth training for the Haiti GIS, Database and Laboratory Specialists.

High resolution LiDAR data is available for the pilot area and provided the basis for detailed terrain modeling. Terrain attributes were generated to identify potential soil landscape regions. One of the outcomes from the training was that Haiti GIS Specialists were able to utilize digital soil mapping techniques to create a conceptual preliminary soil map.

Representative sampling sites have been identified. Field work will commence in 2014.

Funded by USAID and coordinated by USDA Foreign Agriculture Service.

Keywords：*Haiti, soil survey*

P3-522

[WG1] Soil Monitoring for Mankind and Environment Safety

Assessment of Soil Losses from Managed and Unmanaged Sites in A Subcatchment of Rawal Dam, Pakistan Using Fallout Radionuclides

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Soil degradation by water erosion, which is further responsible for sedimentation in the water conveyance systems and reservoirs, is a matter of growing concern in Pakistan. Conventional techniques for measuring erosion rates are time-consuming and need long data records. Caesium-137 (137Cs), a fallout isotope produced from atmospheric nuclear weapon tests, has become a well-established radiotracer of soil movement. To assess and validate the technique, as well as to compare the results with conventional methods the 137Cs technique was applied in a well managed sub-catchment, an unmanaged hill slope and a deforested area of the Rawal Watershed of Islamabad, Pakistan. The reference inventory of 137Cs, for an un-eroded site, was 3280 ± 138 Bq m-2. Based on this reference value, the net soil loss from the studied sub-catchment was estimated at 10.2 t ha-1 yr-1in just six months period. The results obtained by National Agricultural Research Centre (NARC) using conventional methods from a complete monitoring/ observation during the time period of 1990 - 1998 ranged from 0.3 to 28 t ha-1 yr-1, with an average value of 11.3 t ha-1 yr-1. Soil losses from two nearby deforested areas were 31.9 t ha-1 yr-1 and 21.4 t ha-1 yr-1 respectively. The net soil loss from an unmanaged hill slope in the same area was estimated at 37.7 t ha-1 yr-1. The results obtained using the 137Cs and the conventional techniques were thus very comparative and confirm that forest management is significantly reducing the erosion rates. However, the unmanaged hill slopes, overgrazing, deforestation are the real threat to the natural resource. The results proves the 137Cs technique to be less time consuming in the provision of information on soil loss and redistribution rates than direct measurement would have been and can be used to assess watershed management practices. The findings of the study can help policy makers understand the extent of erosion and locate target areas within a catchment that may need immediate action to reduce adverse erosion impacts in a timely manner.

Keywords：*soil erosion, redistribution, fallout radionulide, management practices, Rawal Watershed*

P3-523

[WG1] Soil Monitoring for Mankind and Environment Safety

Effects of Humic Acid in Remediation of Heavy Metals (pb And Cd) with Canola Plants (brassica Napus L.)

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The primary objective of this study was to investigate the effects of adding different rates of humic acid on the capacity of Brassica napus plants to take up from polluted soils with Pb and Cd under field conditions. Results indicated that soil pollution treatments significantly decreased seed, shoot, root and total dry matter yield. When evaluate the effects of different doses humic acid application on distribution of heavy metal uptake in aerial parts of the plant, statistically significant differences were obtained from in Pb and Cd collect ability to plant root, shoot and seed.

The root, shoot ve seed concentrations of Pb and Cd increased respectively by 108%, 145%, 145; 157%, 203%, 203% fold in the 2000 mg kg-1 HA-treated soils when compared with control plants.

The maximum of Pb and Cd phytoextraction potential (PP), bioaccumulation factor (BF) and rich factor (RF) were found with 2000 mg kg-1 HA treated soils when compared with control plants

Keywords：*Heavy metal, humic acid, phytoremediaiton, remediation factors*

P3-524

[WG1] Soil Monitoring for Mankind and Environment Safety

Soil Properties Prediction of the Main National Italian Soil Typologies by Means of Mid-Infrared Diffuse Reflectance Spectroscopy

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A set of 86 soil profiles, belonging to 13 national Italian soil typologies, were selected for the spectroscopy analysis. A total of 208 samples from the soil horizons was analysed by using Fourier transform infrared spectrometer (FTIR) with DRIFT detector for MIR region.

The samples selected for PLS calibration models were from the soil archive of CRA-ABP (Research Center for Agrobiology and Pedology, Firenze). Ten grams of soil samples <2 mm were grounded by a mill and sieved to <100 μm particle diameter. MIR-DRIFT spectra were processed for PLS calibration by Unscrambler X. The PLS calibration models were calculated to predict: sand, clay, total organic carbon, and inorganic carbon.

A subset of 132 soil horizon samples, belonging to 57 soil profiles, were used for the calibration models, and a test set of 76 soil horizon samples (29 profiles) were used to validate the models.

Different calibration strategies were used to establish the best calibration models for the prediction of the selected soil properties: a) random selection (set generated by a randomized experimental design method); b) selection based on a diversity index; c) selection based on a set of standardization samples. The different strategies, respect to the random selection, seem to have not driven to sensible improvements for prediction of the main properties of this set representing the main typologies of Italian soils. Prediction accuracy using random selection was: for sand, R2 = 0.83; RPD = 2.4; for clay R2 = 0.86; RPD = 2.8; for total organic carbon, R2 = 0.90; RPD = 3.1; and inorganic carbon R2 = 0.93; RPD = 3.1, respectively.

Keywords：*MID-DRIFT, PLS, Italian soils, Soil properties*

P3-525

[WG1] Soil Monitoring for Mankind and Environment Safety

Map Scale Effects on Soil Phosphorus Storage Estimation in the Uplands of Eastern China

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Phosphorus (P) plays a central role in maintaining soil fertility and protecting the ecological environment, but most of the P storage estimated at the regional scale has used a single soil map database, the differences of P estimation at multiple and optimal soil map scale remains unclear. In this study, six polygon soil databases of the northern Jiangsu Province, eastern China at map scales of 1:50,000 (P005), 1:250,000 (P025), 1:500,000 (P05), 1:1,000,000 (P1), 1:4,000,000 (P4), and 1:10,000,000 (P10) were utilized to support the P regional estimation of P storage and density. Results showed that total P storage in the top layer (0-20 cm) of the 3.93 M ha upland soil was 10.52 Tg, 10.07 Tg, 6.26 Tg, 6.02 Tg, 6.26 Tg, and 5.43 Tg based on P005, P025, P05, P1, P4, and P10 databases, respectively, in the northern Jiangsu Province, eastern China. Excluding the P4 soil map, P storages decreased as the map scale decreased. Taken the total P storage quantified with the P5 as the base, the assessment unit datasets at scale of P025 were the most preferable with a low relative deviation; by contrast, the assessment unit dataset at scale of P10 were the most inappropriate with a high relative deviation. As for soil group, the highest relative deviation of total P storage at different mapping scales was linked to the cinnamon soil, ranging from 11% to 610%. The most common soil in the area was fluvo-attic soil, which accounted for about 53-69% of the total area of upland soils and the relative deviation of total P storage at different mapping scales was reach to 20-40%. As for administrative area, excluding the P025 soil map, the relative deviation of total P storage in most counties was higher than 40% at different mapping scales. The results indicate that P simulation is strongly influenced by map scale. Therefore, it's necessary to using optimal soil map scale for better estimates P storage at the regional scale as the P estimation accuracy was considered.

Keywords：*Map scale - Upland soil - Phosphorus storage - Phosphorus density - Regional scale*

P3-526

[WG1] Soil Monitoring for Mankind and Environment Safety

Interpretation of Vegetation and Topographic Features Related to Soil Types in Amazon Forest: Comparison of Two Watersheds by the Use of Remote Sensing Data and Gis

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The region of Rio Negro basin extends over an area of about 580,212 km², which represents 11% of the total area of the Brazilian Amazon basin. This region is characterized by a great diversity of soil types, with dominance of Ferralsols and Acrisols associated to an evergreen dense rain forest, covering an area of strongly dissected plateau and residual hills. This region is located at the northwestern part of Brazil and is marked by its warm and humid conditions, a dense rain forest and a constant cloud cover, which makes difficult missions to collect field sample data as well as photogrammetric and remote sensing activities. The RADAMBRASIL project carried out in the Brazilian Amazon had the main propose of mapping vegetation, soils, geomorphology, geology and soil cover. The maps small scales (1:1000.0000) produced by this project were issued from RADAR-SAR remote sensing images and sample filed observations. These products were generated and delivered in the 70s decade. Since then, the only mapping effort at the Amazonian scale was a project carried out by the Brazilian Institute of Geography and Statistics (IBGE), which refined the RADAMBRASIL maps to the scale of 250:000 for the region of the Brazilian Amazon forest. The project developed by IBGE is an actualization of the RADAMBRASIL maps, based on novel remote sensing data but without refinement of the filed sample data set. In such a context, the objective of the present study was to describe and to map the geoenvironmental variables associated with the soil distribution in two watersheds of the Rio Negro basin, intending to compare the results with the ones obtained by RADAMBRASIL and IBGE. For this propose it was considered the lateral variation of the soil cover through the vegetation physiognomies, as well as geomorphological aspects related to the drainage network (Terrain Description Variables - TDV). The interpretation of these variables allowed the identification of general aspects related to the soil types. The studied watersheds are (1) the Bom Intento watershed (1169.88 km²), located at the central coordinates: 64°7'51.307'W, 2°46'39.509'S, in the region of Tefe city and (2) the Baniua watershed (424.49 km²), located at the central coordinates: 65°57'24.417'W, 0°3'29.839'S, in the region of Sao Gabriel da Cachoeira city. To map the topographic variables it was adopted a SRTM (Shutlle Radar Topographic Mission) DEM (Digital Elevation Model) from X band. Some terrain variables have been considered for statistical comparison between the two watersheds by the interpretation of the elevation-relief ratio or coefficient of dissection, steepness or roughness and topographic position index (TPI), as well as, hydrologic variables. The spectral signature of vegetation was analyzed and compared for the two watersheds by the interpretation of atmospherically calibrated Landsat 8 OLI composition and hyperspectral Hyperion (EO-1) scenes. According to RADAMBRASIL and IBGE the region of the Baniua is characterized by the occurrence of Acrisols and Ferralsols in top hills and hillsides, Gleysols in recent depositional areas, and Podzols in depressions and flat zones. Besides, according to these projects, the region of Bom Intento is predominately a flat area with some plateaus dominated by red Acrisols, Planosols and the flat depressions area occupied by Podzols. The results obtained in this study have shown that the IBGE and RADAMBRASIL maps of the Baniua watershed are in agreement with those observed in filed, with a similarity of 90%. Otherwise, the area of the Bom Intento watershed has been misclassified by previous studies (similarity: 40%). The filed truth allowed concluding that the waterlogged depressions area is dominated by Planosols. The topographic feature of the depressed area for the two watersheds are very similar with a widely spaced drainage network and absence of hills, given a flat surface in hillshade models. The aspect that can segment the depressed Podzols from the Planosols is the spectral signature of vegetation obtained in hyperspectral curves. Given this, it was concluded that the sandy areas of Podzols has a less capacity of retain water in surface than clayey areas of Planosols, which can be inferred by the spectral signature of vegetation due the water absorption features related with the flooded areas.
Acknowledgements: This work was funded by grants from Brazilian FAPESP

Keywords：*Amazon Forest, Podzol, Spectral Signature*

P3-527

[WG1] Soil Monitoring for Mankind and Environment Safety

Space-Time Digital Mapping of Gypsum Horizons Micromorphotipes in Arid Region (piedmont Plain of Turkestan Ridge (uzbekistan) as Example)

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The digital maps of soil salinity, gypsum, and gypsum pedofeatures in soils (gypsic calcisols, gypsisols, and solonchaks) of the Dzhizak experimental station (Uzbekistan) are compiled from the results of soil survey conducted during 1980 and 2008, using digital elevation model (DEM) and remote sensing data. The study area represents a part of the Golodnaya Steppe piedmont plain to the north of Turkestan ridge. The macro- and micromorphological descriptions of gypsic horizons made it possible to distinguish three different morphotypes. The morphological features of gypsic horizons were classified, and their distribution map was prepared using GIS tool. The spatial distribution of different morphotypes of gypsic horizons showed distinct correlations with the soil salinity, the groundwater level, and the character of soil water regime. It was established that the presence of different gypsic horizons should be taken into account in the new substantive-genetic classification of Russian soils at high taxonomic levels. Studies completed after 20 years, when the groundwater level dropped by about 1 m, confirmed that the gypsum content decreased in soils; however, the major morphotypes were preserved.

The micromorphological investigations demonstrated that certain changes took place in the microfabric of gypsum pedofeatures. Thus, fine dispersed crystals of gypsum disappeared from the soil profiles, and the number of pseudomorphic substitutions of calcite for gypsum crystals increased significantly attesting to the progressive calcification of soil profiles.

Keywords：*Digital mapping, Gypsicum, Micromorphology, Soil salinity, Uzbekistan*

P3-528

[WG1] Soil Monitoring for Mankind and Environment Safety

Efficiency of Sulfur Application on Soybean in Two Types of Oxisols in Southern Brazil

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Modern agricultural techniques have been increasing the yield of soybean (Glycine max L.) while also causing increasing removal of sulfur (S) from the soil. Besides this, the use of concentrated fertilizers with this element and inadequate soil management, with consequent formation of organic matter with low S concentrations, has been causing frequent symptoms if deficiency in the plats. To assess the effect of S on soybean yield and to establish critical levels of S-SO42- available in the soil, two experiments were conducted over a two-year period in the Parana State, Brazil, in fields containing Typic Haplorthox and Typic Eutrorthox soils, located in the municipalities of Ponta Grossa and Londrina, respectively. The experimental design was randomized blocks with five S rates (0, 25, 50, 75, and 100 kg ha-1) and four replicates. The source used was elementary S with 98% purity. The maximum estimated yields on average for the two years were obtained with application of 49.9 and 63.0 kg ha-1 in the Typic Haplorthox and Typic Eutrorthox soils, for an overall average of 56.4 kg ha-1, with S-SO42- concentrations in the 0-20 cm depth of 16.9, 19.3 and 17.1 mg kg-1, respectively, values higher than the 10 mg kg-1 indicated as the adequate concentration for soybean plant. In turn, at the 21-40 cm depth, the S concentrations were 49.5, 74.2 and 56.4 kg ha-1. The efficiency of the fertilization diminished with increasing S rates, in both soil types, while the greatest yield efficiency was obtained in the plants grown in the Typic Haplorthox soil.

Keywords：*Glycine max, yield, available S; critical S concentration*

P3-529

[WG1] Soil Monitoring for Mankind and Environment Safety

Comparison of Sample Preparation Methods for the Fluoride in Soil Material

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Fluoride is one of the target materials which preferentially deemed management necessary. The literature contains numerous examples of methods used to obtain fluoride from various solid materials. In Korean official method, ashing technique was applied with preliminary procedure to help release of fluoride from soil sample. However, ashing technique can be problem with contamination from impurities of the calcium oxide used to effect the solubilisation of the fluoride. This study was performed to research problems of analytical procedure and to improve analytical method of fluoride in soil samples. 84 samples of background level areas and 53 samples of potentially contaminated areas were included in whole samples. These samples were preprocessed by ashing using calcium oxide. Additionally, they were preprocessed by fusion using sodium hydroxide. Preprocessed samples were distilled with automatic distillation device and analyzed to colormetric method using zirconium oxychloride-SPANDS. And samples were measured with UV/VIS.

The average concentrations of 137 samples which were analyzed with ashing preliminary procedure were as follows: Background level area, 219.07 mg/kg; potentially contaminated area, 261.75 mg/kg; area 1(fields and paddies, school, park), 258.27 mg/kg; area 2(building site, forest land), 217.12 mg/kg; area 3(miscellaneous area, factory), 290.65 mg/kg. Fluoride concentration ranges of background level area and potentially contaminated area did not show a significant difference: Background level area, from 23.89 mg/kg to 599.94 mg/kg; potentially contaminated area, from 77 mg/kg to 758.12 mg/kg. Additionally when Fluoride concentration of fusion preprocessing method is compared with the method preprocessing by ashing using calcium oxide, fusion preprocessing method was overestimated in low concentration range.

Keywords：*Fluoride, Ashing, Fusion, Korea*

P3-530

[WG1] WRB - Lessons Learned from the Development of the Third Edition 2014

Update of the Wrb Soil Classes in the 250k Soil Database of Finland: Expression of Soil Moisture Regime in Mineral Soils

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In the cool and humid climate prevailing in Finland, wetness of the soil is a permanent constraints to agriculture. As much as 86% of agricultural land is artificially drained, and only 14% of the fields mostly coarse-textured soils - can be cultivated without a man-made drainage system. However, this self-evident soil characteristic has not been expressed in the WRB [1] names of Finnish soils in the Soil Geographical Database of Europe (SGDE) at scale 1:1000 000, or in the Soil Database in Finland at scale 1:250 000 [2], derived from the map of quaternary deposits. Until today, most agricultural clay soils of Finland have been classified as Vertic Cambisols, and the medium-textured soils as Eutric/Dystric Cambisols, none of these names expressing the inherent wetness. However, according to US Soil Taxonomy, the same soils have been classified as Aquepts or Aquic subgroups of Inceptisols [3]. The large area of Histosols (29% of the area of Finland in SGDE) also suggests soil wetness and poor drainage.
In Norway, intensive soil classification according to the WRB system has been going on in the field for more than 10 years. There the most common agricultural soils are Stagnosols and Planosols, which as the reference group level express the stagnic colour pattern and wetness of the soil, and Luvisols ja Albeluvisols, where the wetness is expressed with the prefixes gleyic and stagnic. Considering the nearly similar geological history and climatic conditions in Southern Norway and Southern Finland, a hypothesis can be made that the same soils occur in both countries. To test this hypothesis, a soil excursion was arranged in Finland in 2012 to investigate the major agricultural soils of Southern Finland and to harmonize soil classifications in the two countries.
Almost all investigated soils of Finland had a stagnic colour pattern. Most clay soils were classified as Stagnosols, in the lowest positions also as Gleysols. Stagnic colour pattern was most common also in soils with sandy top soils and clayey subsoils, these being classified as Planosols. Many clay soils exhibited clay eluviation. Because in the WRB system Stagnosols key out before Luvisols, most clayey soils of Finland should be classified as Luvic Stagnosols. Albeluvic tonguing was evident, but owing to the limitations in data of the database of quaternary deposits, it is not possible to delineate Albeluvisols in this soil database. Fine silt soils were very poorly developed, falling into Stagnig Regosls instead of their earlier classification as Eutric/Dystric Cambisols. Now Cambisols are restricted to medium-textured glacial tills or fine sands. According to earlier surveys, more coarse-textured soils, mostly under forest vegetation, are dominated by Histic, Gleyic and Haplic Podzols. After the revisions listed above, the Soil Database of Finland at scale 1:250,000 much better expresses the essential soil characteristics of the country, the names reflecting the moisture regime attributable to the humid climate.

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Keywords：*Soil moisture regime, harmonization, humid climate*

P3-531

[WG1] WRB - Lessons Learned from the Development of the Third Edition 2014

Converting Legacy Soil Map of Turkey into the World Reference Base (wrb) tor Soil Resources- Case Study: Gaziantep, Turkey

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In Europe soil mapping was done according to different National Classification Systems and Turkey as a candidate country need to correlate and harmonize soil maps for EU policies. Existing soil map was completed in 1960 and classified according to old American soil classification system. Due to the converting soil legacy profile data into WRB needed to develop a method to convert the legend of the Soil Map of Turkey into the WRB (WRB-2007). This study assessed how this can be used for a small scale map (1:25000) at national level and the detailed information of Turkish mapping units often have no correspondence in WRB - particularly in terms of particle-size distribution, pF, color and drainage. The test was carried out in Gaziantep as case study area on a 1:5000 scale (the original maps) 70 profiles described .with analytical data of about 230 horizons. Conversion leaded to maps with more information, and also better readable in an international language.

Keywords：*Soil Mapping, Legacy Soil Map, Soil Information System, World Reference Base (WRB)*

P3-532

[WG1] WRB - Lessons Learned from the Development of the Third Edition 2014

Specific Features of Pedogenesis in Thermokarst Depressions (alases) of the Permafrost Zone and the Place of Alas Soils in the World Reference Base for Soil Resources

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Large territories within the permafrost zone are represented by Pleistocene plains composed of the ice complex deposits. Changes in their thermal conditions in the Holocene have resulted in degradation of ground ice and active thermokarst development with the formation of thermokarst depressions (alases). Changes in the surface topography have caused strong transformation of the initial soil cover on the plains.

The development of alases and their functioning lead to evolutionary changes in the permafrost environment that can be referred to as the alas process (Desyatkin, 1991, 1993). It includes several elementary processes: thermokarst (formation of young thermokarst depressions), water cycles (periodic formation and disappearance of lakes in the depressions), thermal abrasion and thermal denudation leading to expansion and deepening of the depressions, formation of taliks, changes in the relief during growth and degradation of pingo mounds, and migration of intermittent lakes within the depressions. Alas process destroys the initial plains with ground ice and transforms the deposits in the depressions into specific layered parent materials that have no analogues elsewhere.

Alas process in thermokarst depressions specifies two alternating stages of soil formation: the hydromorphic subaqueous stage and the xeromorphic proper pedogenetic stage. A more detailed subdivision includes the following development phases: lake phase (subaqueous), marsh phase (superaqueous or hydromorphic), meadow phase (semihydromorphic or mesomorphic), and steppe phase (xeromorphic). The lake phase is further subdivided into half-phases of the full lake and the shrinking lake differing in their geochemistry: during the former, the parent material is enriched with organic matter of limnic origin (sapropel); during the latter, the accumulation of peat mass on the surface of bottom sediments is developed. Both processes contribute to the high organic matter content in the parent material that becomes exposed to the surface after drying of the lake.

After each cycle of the lake drying, water-saturated talik developed under the lake is subjected to freezing with the formation of ice-core heave mounds (hydrolaccoliths, pingos, or bulgunnyakhs) changing the relief within the depression. As a result, during the next wet period, the lake is formed in other place. In the course of lake migration within the depression, new portions of the bottom undergo the subaqueous stage with considerable transformation of the parent material. The development of new lakes is also accompanied by active thermal abrasion of their shores with ground ice; mineral products of the abrasion cover the surface of the organic lake and marsh sediments.

Multiple alternation of hydromorphic and xeromorphic stages in the same alas during millennia leads to the formation of polycyclic layered parent materials. Their heterogeneous layering disturbs the classical horizonation (A-B-C) of the soil profiles. The profiles of alas soils usually have surface and buried organic horizons of limnic and marsh geneses. Such horizons are designated as LD (lacustrine deposits) horizons. They consist of peaty sapropel deposits; in some cases, they are rich in carbonates and contain

heavy-textured mineral admixture. The number of LD horizons in a soil profile shows how many cycles of the hydromorphic development have taken place in this soil. The thickness of LD horizons indicates the duration of the hydromorphic stage.

Thus, alas deposits are specific parent materials that greatly affect the morphology of alas soils. These soils usually contain surface or buried organic horizons of marsh (T) and lake (LD) origins. Syngenetic differentiation of the profile is a distinctive feature of alas soils. Taking into account the specificity of their genesis and morphology, we suggest that a separate reference soil group-Alassols -can be distinguished in the WRB.

The WRB system already suggests separation of three reference soil groups that are actually based on the specificity of parent materials. These are Fluvisols, Histosols, and Andosols. The morphology and origin of alas soils strongly differ from those of 'classical' Fluvisols and Histosols. The specific conditions of their formation do not allow us to place them in the group of Stagnosols. A decision to establish a new group of alas soils (Alassols) seems to be reasonable taking into account the widespread distribution of such soils in permafrost areas with the ground ice complex in the Subarctic and Boreal zones of Asia, some parts of North America, etc.

P3-533

[WG1] WRB - Lessons Learned from the Development of the Third Edition 2014

World Distribution of Wrb Reference Soil Groupspresented on New Educational Poster

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The world distribution patterns of Reference Soil Groups (RSGs) of theWorld Reference Base for soil resources (WRB) are presented in a new educational poster. The poster was prepared under the auspices of the IUSS WRB Working Group and is proposed for international release at the 20th WCSS.

Two central charts presentthe distribution ranges of RSGs in relation to the soil forming factors of climate, (mineral) parent material and topography. The ranges were derived from an examination of data on 4380 soil profiles from 123 countries from the ISRIC WISE Global dataset, plus a detailed literature review. Only 23 of the 32 RSGs are depicted on the charts, as the formation of the other nine RSGs are primarily controlled by other soil forming factors (eg, Anthrosols, Leptosolsand Histosols). Validation of the results with 100 random soil profiles indicated a success rate of 85% in predicting the possible occurrence of a particular RSG, but usually as only one of a number of possibilities. The broad attributes and land management features of each RSG and their approximate correlation with Soil Taxonomy are also presented on the poster.

The poster is primarily intended as an educational tool, to convey fundamental principles of soil formation and to illustrate how different environmental factors give rise to different soil groups. It may contribute to gettingWRB better known as a comprehensiveclassification system within the soil science and wider environmental scientific community. It may also provide a useful tool for soil scientists, and other environmental scientists, to gain a first approximation of likely RSGs that may be encountered in most locations around the globe.

Keywords：*Educational poster, WRB reference soil groups, Distribution, Correlation, Soil Taxonomy*

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[WG1] WRB - Lessons Learned from the Development of the Third Edition 2014

Estimates of the Rates and Processes of Development of Texture Profiles in Some Australian Soils - Implications for the Definition of an Agric Horizon

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The development of texture contrast soils in south eastern Australia is widespread. The rate of development of the texture profiles is examined using a set of soils from the Lower Macquarie Valley in Central NSW within south eastern Australiawith current rainfalls of 450 to 550 mm average annual rainfall and some published data from the alluvial terraces on the coastal plains of south eastern Australia with rainfalls of 650 to more than 1000 mm average annual rainfall. The alluvial sediments of the Lower Macquarie Valley were laid down in a wave of fluvial activity dating from the late Pliocene to the current time to form a riverine plain. Linear bands of alluvial sediments of different age occur across the landscape. The alluvial sediments were mapped into geological formations of approximately equal age groupings. The ages of the sediments strongly influence the features of the soils. The oldest alluvial sediments occur in the Trangie Formation and are 1.6 million to 150 000 years old and the youngest are less than 5000 years old and are associated with the current Macquarie River. The development of the soils on a series of river terraces on the coastal plains of south eastern Australia was studied in a series of published research papers. The development of texture contrast profiles is shown to require the continuous application of pedological processes for periods more than 10, 000 years in more permeable soils. In the less permeable soil in lower rainfall areas on the backplains of the Lower Macquarie Valley, texture contrast soils do not develop and soils remain Vertosols. Observations indicate that texture contrast soils can arise as a result of a number of processes. The WRB criteria for an Agric horizon through time are applied as well as a statistical measure of the texture profile anisotropy.

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[WG1] WRB - Lessons Learned from the Development of the Third Edition 2014

New Qualifier in Wrb Based on Brazilian Soils with High Iron Contents

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The Brazilian Soil Classification System (SiBCS) separates at the subgroup level classes with very high iron contents, identified as Perferrics (Fe_2O_3 equal or higher than 360 g kg^{-1} by sulfuric acid extraction, referred as total iron) and Ferrics (Fe_2O_3 extracted by sulfuric acid solution from 180 to 360 g kg^{-1}). These criteria were based on the study of Curi and Franzmeier (1987) and are used in the Latosols, Nitosols and Cambisols orders. The main parent materials of these soils are itabirite (a hematite-quartz metamorphic rock) and basalt. According to WRB 2006 (IUSS Working Group WRB, 2006), they are Ferralsols or Nitisols with the Rhodic qualifier. The Rhodic qualifiers only refers to the color and is not directly related to the iron content. Thus, new qualifiers were proposed during the revision of WRB, identified as Ferritic and Hyperferritic, for soils having a layer, equal or thicker than 30 cm and starting within 100 cm of the soil surface, with Fe extracted by dithionite-citrate-bicarbonate (DCB) in the fine earth fraction equal or higher than 10 % and 30 %, respectively, and not forming part of a petroplinthic, pisoplinthic or plinthic horizon. The application of these criteria to Brazilian soils, available in the ESALQ - USP database (http://www.esalq.usp.br/gerd/), resulted in a total of 491 observations with high iron content (total iron). However, the information is based on the total iron in the fine earth fraction, and a pedotransfer function has to be developed to predict the dithionite-extractable iron from this data. Some soil properties related to the high iron contents are parent material, CEC, clay texture, and color (hue and chroma), this last valid for Rhodic Ferralsols and Rhodic Nitisols. A map of soils with high iron and a histogram of the distribution, probability maps, variance and purity map were prepared with the Brazilian data available. More data is necessary to model the relationship between dithionite-extractable Fe and total Fe; however, the preliminary results validate the proposal of the new qualifiers in the WRB.

Keywords：*Ferralsols; Nitisols; Soil classification*

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[WG1] WRB - Lessons Learned from the Development of the Third Edition 2014

Genesis and Variability of Anthrosols in the Campine Area of Belgium

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Often reffered to as the 'Terra Preta' of Europe, Anthrosols are a fascinating soil type. These man-made soils reflect centuries of farmer's efforts to boost soil fertility in the sandy soils on wich they depended, changing them to soils with deep, brown, antropogenic horizons rich in organic matter. Although most practices related to Anthrosol formation have been abandoned in
Within the Anthrosol reference group, the source material used as manures or bedding varied significantly as did the original soilscapes that were subjected to antropogenic soil forming processes. Moreover, differences in agricultural practices and land-use history add more complexity. Hence, considerable variability exists in soils that belong to the Anthrosol reference group. Despite their relevance, little has been documented on the range of morphological and chemical properties encountered in this group. This study describes the morphological and chemical variability of Plaggic and Terric Anthrosols in the Flemish region, and relates these differences to Antrhosol formation and land-use history. Moreover, the effects of recent land-use changes and reforestation on the properties of Plaggic and Terric Anthrosols are illustrated.

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[WG1] WRB - Lessons Learned from the Development of the Third Edition 2014

Digging Deeper in Soil Classification: Could Buried Palaeosols be Adequately Represented in the World Reference Base System?

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Despite ongoing discussion, there is a strong need for a well-defined, widely usable classification for buried palaeosols that can accurately represent the main palaeosol characteristics. Although most soil classification systems are not primarily indented to classify buried palaeosols, the vast array of ill-defined terms and concepts used today is confusing and existing soil types and qualifiers are often used in a simplified or adapted way without proper definition. Several adapted systems, based on either Soil Taxonomy or WRB, have been proposed in literature, documenting properties that are most likely to remain stable over time. Such adapted systems have the disadvantage that they emphasize on only a small number of profile characteristics, while palaeosols often are complex and polygenetic. Moreover, using an existing system in a modified way may add to the confusion. Proposing a completely new system for buried palaeosols is not advantageous either, as the main goal of any classification system, i.e. to provide a reference to a large a number of soil scientists, is not attained.

Rather than developing a separate system, the authors evaluate the use of WRB 2014 without major alterations. For palaeosols buried deeper than 2m, they propose to consider the upper boundary of the palaeosol as the 'soil surface' and add the word 'Buried'. RSGs and qualifiers can then be used unaltered to represent an array of major palaeosol characteristics, making this approach particularly suitable to classify welded or polygenetic palaeosol-complexes. The use of WRB 2014 is assessed for a range of benchmark palaeosols, covering both deep-seated palaeosols and palaeosols close to the surface, dating from the Jurassic to Late Pleistocene. These case studies establish a proof-of-concept that WRB could straightforwardly be extended to include palaeosol classifications. Not all definitions used in WRB 2014 can be indisputably applied to palaeosols, but small adaptations in future versions could easily solve this problem.

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[WG1] WRB - Lessons Learned from the Development of the Third Edition 2014

Symbols for Diagnostic Horizons: Experience of the Russian Soil Classification System and Proposals for Wrb

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In modern soil taxonomies, soils are classified by identifying the diagnostic horizons, properties and materials, or by the combination of diagnostic horizons. Thus, in the recent Russian classification system (2004, 2008) a definite taxonomic significance is ascribed to diagnostic horizons and genetic properties, and an intricate set of symbols is introduced as an essential part of the system. Symbols for horizons and properties are used both for a morphological description and for a brief presentation of soil profile ("profile formula") for classification purposes. For example, the soil profile with the following sequence of diagnostic horizons: AY (grey-humus or soddy) - EL (eluvial) - BEL (eluvial-illuvial interface) - BT (textural) - BC (transitional) - C (parent material) is classified at the type level as "soddy-podzolic soil" being a member of the next level (order) - "Texturally differentiated soils".

There are special symbols for designating soil horizons and some of their characteristics recommended by the FAO Guidelines for Soil Description (2006). However, they are weakly related to the diagnostic horizons and properties of the international soil classification system - WRB (World Reference Base for Soil Resources, 2006, 2007) although both diagnostic elements, horizons and properties, identified in the course of morphological description of the soil, are the core of the WRB system. As a result, there is a gap between the common soil profile description and the identification of diagnostic horizons in WRB.

Our proposals are the following. First, diagnostic horizons in WRB should have symbols derived of their names; they may be composed of three capital letters. For example, MOL - mollic, CLC - calcic, GYP - gypsic, AQU - anthraquic, HST - histic, etc. Second, the common morphological description according to the FAO guidelines should be combined with recognizing the diagnostic horizons. Some important soil horizons, especially the upper ones do not perform any diagnostic functions in WRB (with few exceptions: mollic and histic). Therefore, the profile formula will comprise common symbols for non-diagnostic horizons and proposed symbols (written in boldface caps) for the diagnostic ones. The horizon symbols may be complemented by lower case letters for subordinate characteristics in the description, for which the "codes of qualifiers" (ANNEX 2 in WRB issue) may be the best alternative. For example, the profile formula for an Albic Luvisol - analogue of the above-mentioned soddy-podzolic soil may be: A - ALB - EB - ARG - BC - C. If it has such subordinate characteristics as stagnic and fragic, the profile formula becomes more complicated (A - ALB - EBg - ARG - BCf - C), and these characteristics may be taxonomically recorded as "suffixes" or "prefixes".

The proposal is aimed at harmonization of the system of symbols for its actual application as an objective for the WRB Working Group.

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[WG1] WRB - Lessons Learned from the Development of the Third Edition 2014

Application of Wrb 2014 (fao) in the Greenhouse Gas Emissions Inventory for the Biennal Report in Land Use and Forestry of Mexico

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Mexico regularly updates and provides to the Conference of the Parties (COP) the National Inventory of anthropogenic emissions with the sources and absorption by sinks of all greenhouse gases (GHG) not controlled by the Montreal Protocol. Calculations for emissions of GHG are performed for six categories defined by the Intergovernmental Panel on Climate Change (IPCC), of which two categories are related to the emission or removal of carbon dioxide, methane and nitrous oxide in soil: agriculture (Category 4) and land use-land use change and forestry (Category 5). The calculation of GHG emissions or removals in the soil requires a precise and ordered knowledge about the magnitude, dynamics and distribution of biochemical and thermodynamic processes involved. This level of knowledge of the soil is closely related to the conceptual advance of classification systems. The FAO Legend, with less than 40 qualifiers, was useful at the time to generate basic information on potential carbon sources and sinks in the soil (Tier 1). The WRB 2014 is useful to develop an intermediate level of assessment on potential GHG emission-removals in the soil (Tier 2) because it efficiently groups the genetic similarities and morphological properties of the more representative soil groups of a country and spatially represents them much better than the traditional FAO approach. The WRB 2014 contains various qualifiers and diagnostic criteria directly related to carbon production (e.g., humic, folic, histic, melanic, aridic, yermic, mollic) and at least two related to methane production (e.g., gleyic properties and reducing conditions). Through the diagnostic criteria of WRB 2014 it has been possible to segment the values of organic carbon in Mexico's soil profiles for each relationship established between soil and vegetation, and therefore calculate the potential emission-removal of GHG on the soil, with a more efficient cartography. Mexico currently has carbon measurements for all soil groups and for 88% of the most representative soil qualifiers of the country. The next step is to combine targeted sampling systems (soil profiles-WRB 2014 Protocol) to the systematic sampling systems (soil drillings-CONAFOR Protocol) in addition to representative monitoring points. With this information Mexico can also quantify the spatial variability of GHG, especially carbon dioxide (CO_2) and their corresponding uncertainties at detailed scales (Tier 3). In order to improve the estimates in the emission-removal of methane (CH_4) and nitrous oxide (N_2O) of soils, we suggest updating the guidelines outlined in the Good Practice Guidance and Uncertainty Management of the IPCC, and complement the sampling protocol conducted by the Comision Nacional Forestal (CONAFOR) in their National Forest and Soils Inventory (INFyS) in Mexico.

Keywords：*PNUD, CONAFOR, WRB, GHG, MEXICO*

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[WG1] WRB - Lessons Learned from the Development of the Third Edition 2014

Suggestion for Modification of the Setting of Salt Affected Soils in the New Wrb Classification Key

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Soils may satisfy the criteria of one or more taxa on the first or lower levels of classification as well, thus priority should be given to the one that is believed / proved to be more important in determining soil functions or limiting ecological services.

Salt affected soils in WRB are classified as Solonetz or Solonchak Reference Soil Groups. Solonetz soils are characterized by high content of exchangeable sodium and/or magnesium content that can restrict soil fertility either directly by Na toxicity, or indirectly by high pH, peptization, and deterioration of soil physical properties as structure and water management. In modern soil classification systems Solonetz soils are defined based on the presence of a natric horizon with criteria of texture, evidence of clay illuviation, structure, exchangeable Na percentage and thickness.

Solonchak soils have high concentration of soluble salts that limit plant growth by restricting water uptake and nutrient availability. Solonchaks are defined based on the presence of a salic horizon with criteria of electrical conductivity and thickness.

In the recent edition of WRB (WRB Working Group, 2006) Solonetz and Solonchaks are following Vertisols and Fluvisols in the "water influenced" set of the rationalized key.

After detailed literature review of properties of salt affected soils, and taxonomic distance studies based on the NASIS (USDA NRCS NASIS point database) and WISE (World Inventory of Soil Emission Potentials database 3.1) datasets we found that the properties of both Solonetz and Solonchaks determine more the function of soils than shrinking and swelling high clay content and stratification. Based on our results we propose to set the salt affected soils higher in the new edition of WRB classification key to precede the Vertisol and Fluvisol Reference Soil Groups.

Keywords：*Salt affected soils, WRB, classification key*

P3-541

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Ph and Lime Requirement of Soils on the Dike and on the Drained Pond Bottom of a Fish Pond on an Acid Sulfate Soils in Leyte, Philippines

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Some acid sulfate soils in Leyte have been used for fishponds. The water in the fishpond is retained using dikes. pH of soils of fishpond where dikes are composed of a narrow top and a wide low part was studied. The former is used as a pathway and as post to support the wide low part of the dike. The latter is used also as path by workers doing fertilizer application and harvesting of fish. Soil samples were taken from the top and low part of the dike .

Another fishpond was also studied where the dike is only composed of the top portion and where the bottom of the pond has been drained. Soil samples were taken from the dike and the drained pond bottom. pH was determined using a 1:2.5 (soil:water ratio) on all soil samples collected. Lime requirement using Veitch method was determined only on soils collected on fishpond with only the top portion of the dike, and on drained pond bottom.

On fishpond where the dikes are composed of a top and low parts, soils on top of the dike is more acidic than soils on the lower part of the dike. It is postulated that soils on top of the dike has been exposed to air for a long time so that more pyrite has been oxidized releasing a high amount of acidity. A high amount of jarosite was present on the surface of this dike. Soils on the lower part of the dike are submerged with water that leach the acids, and are also young, i.e. recently deposited, than the top of the dike and have less pyrite that had been oxidized, hence its pH is higher that the soils on the top part of the dike.

Soils on the dikes composed only of a top portion is more acidic than soils on the drained pond bottom. The top portion has been exposed to air for a much longer time than that of the drained pond bottom hence it is more acidic. Lime rate of 20 tons CaCO3 per hectare increase the pH of the soil from the dike from 2.7 to 3.4 at 6 weeks after application of the lime. Soils on the dike had been oxidized for a long time and so they have more reserve acidity. For soils on the drained pond bottom, application of 15-20 tons CaCO3/ hectare is needed to increase the pH from 3.66 to 6.29. Soils on the drained pond bottom has not been subjected much to oxidation, as shown by its high pH. Hence the amount of acidity that has been released is not much yet and can still be neutralized by lime.

P3-542

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Correction of Sulfate Soils

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The chlore and the sulfate in soils limite the progress in the paddy production in senegal. Some type of correction like gypse gives small result. But, if we combined the gypse and the organique matter the result is better. The quality (composition) of gypse is very important in the process of amendement (bonification). Usually, the gypse is the outcome in the process of fabrication of acid sulfure. It's possible to find in gypse composition's, other elements that prevent production of paddy. it's generaly the raison that some Producer prevent the use of gypse for amending sulfate soils.
in our experiment the organique matter mixed with the gypse give a result that interested senegalese Producers.

Keywords：*bonification, gypse, chlore,sulfate, combined*

P3-543

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Response of Aluminium Dissolved in Soil Solution and Drainage Water on the Waterlogging of Cultivated Boreal Acid Sulphate Soils

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The largest areas of acid sulphate soils (AS) in Europe are located on the coast of the Baltic Sea, where they were mostly formed by sedimentation on the bottom of the ancient Litorina Sea about 8,500 - 4,000 BP. After the latest glaciation the isostatic land uplift has exposed new land from the sea. Exclusively in Finland 130,000 ha of this kind of soils have sulphuric horizons or sulphidic materials within 1.5 m of soil surface. Artificial drainage is prerequisite for their cultivation and when drained and limed, they are very productive. Unfortunately efficient drainage also speeds up the oxidation of sulphidic material and causes environmental hazards which cannot be mitigated by agricultural liming. Environmental hazards are related to the high acidity and high aluminium concentrations in the discharge water, causing chronic and acute toxicity problems for aqueous ecosystems.

A practical mitigation option is to prevent the oxidation of sulphidic material by partial waterlogging of subsoil. When this was attempted in field experiments by controlled drainage without introducing external water into the soil, the improvement of water quality was limited because effective evapotranspiration in dry summers often lowered the groundwater level far below the drain pipes and exposed sulphidic horizons to oxygen. As the real benefits of maintaining partial waterlogging in boreal AS soils still remained to be tested, a lysimeter experiment was set up for the purpose between 2008 and 2010 [1]. In the lysimeter experiment (height 1 m, diameter 0.5 m), two water table treatments were established: the low water table treatment (LW) mimicked the normal drainage, but in the high water table treatment (HW), the whole AS soil was waterlogged to 0.2 m below the soil surface. In addition, a demonstration field was established in 2010 to study the controlled drainage with an option to pump additional water into the subsurface drains (CDP) and allow its comparison to other drainage options including normal subsurface drainage (ND) and controlled drainage (CD) [2]. A new technical solution, a plastic sheet to restrict horizontal groundwater flow to open ditches, made it possible to maintain high water table in real AS soil fields [3].

In this study, we compare the response of aluminium concentration to waterlogging on two different scales: in the pore water of lysimeter experiment and in the drainage water of field experiment. In the lysimeter study, waterlogging prevented the oxidation of sulphidic materials and decreased markedly mean Al concentrations in the pore water (ranging 0.5-3.9 mg/L) as compared to the initial concentrations (ranging 10.0-19.6 mg/L) and much more as compared to those in the LW lysimeters. The preliminary results from the field experiment (2010-2012) showed a similar but more slowly decreasing trend in Al concentrations as in the lysimeter experiment. Nevertheless, the Al concentrations in the discharge water (ranging at the beginning 8.3-21.4 mg/L) were 3.9 mg/L lower in CDP than in ND (mean difference, $P<0.001$, $N=20$). The aluminium concentrations were generally lower in CDP than in CD, but the differences were not statistically significant ($P>0.05$). Further field monitoring of discharge water quality will reveal the long-term effects of these management practices.

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Keywords：*acid sulphate soil, aluminium, water management, drainage*

P3-544

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Sulfidic Sediments and Acid Sulfate Soils in Sweden

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In Sweden sulfidic postglacial sediments and acid sulfate soils (AS-soils) occur in areas that were previously covered by marine or brackish water and that have been subjected to post-glacial isostatic rebound. The sulfidic sediments were to a large extent deposited at relatively large water depths on the floor of the Baltic Sea. Today the sulfidic deposits are present in lowland areas, most frequently along the coast of northern Sweden, which has been subjected to a large isostatic land uplift.

It is often possible to identify the sulfidic sediments and AS-soils in the field. The AS-soils are typically characterized by long vertical cracks that are coated with iron hydroxides, sometimes together with the yellow mineral jarosite, and the pH is commonly below 4. In northern Sweden the sulfidic sediments often display a black color which is caused by a high content of iron monosulfides, whereas corresponding sediments further south, that are dominated by pyrite, consequently do not exhibit the black color.

AS-soils have been shown to affect the waters in many streams along the coast of northern Sweden, which is manifested by periodically low pH levels and high concentrations of certain elements (e.g. aluminum) in the stream waters. Even though large amounts of trace elements are leached from the AS-soils, the total contents of trace elements are not higher in the sulfidic sediments than in other fine grained deposits in Sweden. The intense leaching of certain elements is however due to the strong weathering caused by the acid conditions of oxidized AS-soils.

AS-soils have mainly developed in areas where the groundwater table has been artificially lowered by ditches to obtain arable land or to increase forest growth. The drainage area of streams that are affected by AS-soils are consequently influenced by a large proportion of land with sulfidic sediments, where the groundwater level has been artificially lowered. Areas with sulfidic sediments unaffected by ditches often constitute wetlands, which are covered by peat that typically restrain the oxidation of sulfide minerals.

An evaluation of the data collected in connection with the Geological Survey of Sweden's (SGU) geological mapping has shown that biogeochemical and geophysical data can successfully be used in combination with maps of unconsolidated deposits to roughly identify areas where AS-soils and sulfidic sediments occur. The distribution of silt and clay in areas uplifted during the last thousands of years corresponds roughly to areas with sulfidic sediments. A shoreline displacement model has been used to identify these recently uplifted areas. Biogeochemical data also indicate the presence of AS-soils. The characteristic discharge of leached metals from AS-soils is commonly reflected in the stream biogeochemistry of nearby water courses, e.g. elevated contents of nickel (Ni) and yttrium (Y) in sampled aquatic plant roots. Furthermore, measurements of the electric resistivity show that the sulfidic sediments are characterized by relatively low resistivity.

In 2012 and 2013, a study was conducted to improve the knowledge concerning the geographical distribution of sulfidic sediments and AS-soils in northern Sweden. The field work was focused on drainage areas where previous studies carried out by the County Administrative Board show a likely connection between AS-soils and poor water quality. Additional data collected from archives from e.g. road constructions also gave information on the presence of sulfidic sediments. For this study samples were collected in the field along the coast of northern Sweden. The pH was measured in the field and on selected samples after an incubation in laboratory. The elemental composition of 119 samples was also investigated by inductively coupled plasma mass spectrometry (ICP-MS), after 7M HNO_3 digestion. The results show that AS-soils has developed in the most recently uplifted areas with clay and silt, where the groundwater level has been artificially lowered. The AS-soils are often underlain by sulfidic sediments, which will oxidize if the groundwater level is lowered further. All data are used together with data from SGUs mapping, to produce a map that point out areas where AS-soils and sulfidic sediments most likely are present. Similar studies will be carried out over the next years to document the distribution of these types of deposits in southern Sweden.

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[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Some Aspects of Acidification of the Coastal Saline Soils in Poland

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Acid sulfate soils are formed in very specific geochemical conditions, mainly under the influence of seawater. Strong acidification caused by oxidation of iron sulfides affects both soil and water, and can damage the environment severely.

The occurrence of acid sulfate soils in north-western and northern Poland (over 20 sites) follows the spot pattern and includes a narrow littoral zone of the coast or areas of the delta plains. These soils are subject to salinization due to backwater effects and seasonal flooding from the Baltic Sea. The objective of this research was to characterize the properties of Polish acid sulfate soils in relation to their management and use.

The studied soils were developed from stratified deposits, poor in carbonates, which reflected the changing conditions of mineral and organic matter sedimentation. Sands with varying admixtures of silt and clay fractions dominated in the mineral sediments. The salinity and sodicity level varied widely (ECe 1-43 dS m-1; SAR 3-24). Those soils showed some properties typical for potential acid sulphate soils (PASS). Reaction of soil samples after two months of incubation was strongly acid (pH < 4). Whereas the mean differences between pH values measured under field conditions and after incubation had the highest values (ΔpH 1.6 ± 1.3 and 1.8 ± 1.3, respectively). It can be explained by sulfuric acid (VI) production due to the oxidation of sulfides.

The obtained results suggested that the analyzed soils are very sensitive to changes in redox conditions. Therefore, inadequate regulation of the groundwater level could lead to the soil degradation. Additionally, some toxic heavy metals becomes more mobile and available for plants in acidified environment. This is particularly important because those soils constitutes an integral part of the unique habitats protected within the Natura 2000 network, including the dominant Atlantic salt meadows (Glauco-Puccinellietalia, code 1330). The rare brackish marsh vegetation on the Baltic coast is also a refugium for rare bird species (e.g. Acrocephalus paludicola), including species listed in Annex 1 of the EU Birds Directive.

Keywords：*acid sulfate soils, Baltic Sea, coastal areas, Natura 2000 network*

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[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Geochemical Characteristics of Acid Sulfate Soils in Thailand

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This research investigated the geochemical characteristics of Thai acid sulfate soils (ASS). Twenty ASS profiles representing former, actual and potential ASS located in inland and coastal areas of Central Plain and Southeast Coast of Thailand were used. Soils were analyzed with ICP-OES (aqua regia digestion) and X-ray fluorescence (XRF). Principal component and classification analysis was used to interpret data. Results revealed that these soils vary greatly in geochemical properties. However, the factor diagram based on geochemical and textural data showed that the samples from Southeast Coast have a relatively coarse texture, whereas those from the Central Plain have a more clayey texture. The variations in chemical properties mostly reflect these differences in texture. Consequently, The data from each region separately analyzed using factor analysis for both regions showed that the attributes could be allocated into two affinity groups. The first group consists of Si and Zr. The second group is diffuse consisting of clay, Al, As, Ba, Bi, Ca, Cd, Ce, Co, Cr, Cu, Fe, Gd, K, La, Mg, Mn, Mo, Na, Nd, Ni, P, Pb, Rb, S, Sc, Sr, Th, Ti, V, Y, and Zn. Former, actual and potential AS soils in both regions have quite similar geochemical properties. Most coastal ASS have more Na, S and sand (Si,Zr) than do inland ASS. Topsoil from each profile is relatively organic rich, and topsoil samples contain higher amounts of rare earth elements which may have been applied in phosphatic fertilizers. Some coastal ASS in the Central Plain are more clayey than those in the Southeast Coast reflecting differences in regional sediment properties. This study has shown that texture of soil parent material has the strongest influence on the variation in geochemical characteristics of former, actual and potential ASS from coastal and inland areas of Thailand. The oxidation status is reflected in pH values but not in other properties.

Keywords：*Geochemistry, acid sulfate soils, former, actual, potential, Inland, Coastal*

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[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Management of Sulfide Induced Acidity in Peat Extraction (suhe)

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There are two common types of sulfide rich regions in Finland: sulfide-bearing marine sediments emerged from the former Baltic Sea due to postglacial isostatic land uplift, and coastal and inland black schist areas. Undisturbed sediments/tills are normally harmless. When excavated or drained, the oxidation of sulfides in contact with air produces extremely acidic soils with increased acidity and metal loadings flushing to the recipient streams. In this study we present results from a project (SuHE 2011-2014), that focus on peat extraction fields underlain by sulfide-bearing sediments, with the aims to (1) develop new methods for prediction and rapid detection of acidic discharge, (2) develop passive treatment methods for neutralization of continuously and occasionally acidic runoff, (3) characterize sulfur species and the corresponding acidity in different soil materials of different regions, and (4) evaluate the suitability of different land uses of these lands after peat extraction.

The soil characteristics of 15 peat extraction fields were investigated. Sulfide-bearing clayey-silty marine sediments with a very high potential acidity were commonly found below the peat layer. The sulfides existed mostly as pyrite (up to 3.5 %), but were occasionally also mixed with more reactive monosulfide. In contrast to previously well studied farmlands in Finland, oxidation of sulfidic sediments has been very limited in the peatlands, i.e. most of the acidity is still retained in undisturbed sediments. In several areas, particularly in black schist areas, the peat layer was also found to contain a high amount of sulfur (>1 %) with a corresponding high potential acidity. The till, which overlies the bedrock, is expected to be affected by black schists in certain areas, but sulfur concentrations and acidity were notably lower than in peat and sediments.

The runoff water from seven peat extraction areas was monitored within the frost-free period continuously by loggers for pH, EC and water height level. Moreover, EC and pH were also measured by using a field meter weekly or bi-weekly. Water samples were collected bi-weekly from outflow waters and among others sulfate, iron, acidity and DOC were determined. In the runoff water, sulfate concentrations varied substantially (0.6- 2400 mg/l) between the areas and pH varied generally from 3 to about 6.5. In 2012 ground water level pipes were installed in the peat extraction areas. Preliminary results indicate that ground water level and precipitation could be used to assess the occasional falls of pH (acidic discharge due to heavy rains after dry periods, when sulfidic minerals were oxidized) and need for neutralization of the runoff water in some of the investigated areas. When assessing the post-extraction uses of peatland the mineral content of soil, depth of peat, vegetation and pH in ponds and ditches were determined, and based on these results and other information the suitability of different land uses were evaluated.

Neutralization tests were performed in peat extraction areas in Finland during summer periods 2012 and 2013. For occasionally acidic sites, the tested tipping bucket system was found most effective. When filled with granulated Ca(OH)2, neutralization occurred temporally from pH 3-4 up to pH 10-11. The use of steel slag drain increased the water pH about 0.5-2 units from an initial pH of 3-6, but the limestone drain had problems. Container pilot and vertical fluidized bed pilot were tested for continuous neutralization. In all tests neutralization occurred, but the diversion well based container pilot filled with 1- 3 mm limestone crush was found most effective, i.e the pH of peat land runoff water increased with 1-2 units from an initial pH of 3-4. Neutralization occurred also temporary in vertical fluidized bed pilot filled with granulated Ca(OH)2, increasing pH from 3-4 up to 10-11. Due to mixing of material, fouling layer formation was minimized.

Partial funding to 'Impact Management of Sulphide-Soil-induced Acidity in Peat Extraction' (SuHE)-project comes from the European Regional Development Fund (ERDF) via the Centres for Economic Development, Transport and the Environment in North Ostrobothnia and Lapland. Other funding entities include the Council of Oulu Region, Vapo Oy, Turveruukki Oy, Nordkalk Oy Ab, Finnish Environment Institute, the University of Oulu, Finnish Forest Research Institute and Åbo Akademi.

Keywords：*Acid sulfate soils, Peat extraction, Neutralization,*

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[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Changes in Soil Chemical Properties of an Acid Sulfate Soil in Malaysia with Addition of Calcium Silicate under Submerged Condition

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Rice is a staple food for human being. The government of Malaysia realizes that it needs to increase the self-sufficiency level (SSL) in rice production from 73% to 86% for food security reason. Rice production can be increased by expanding the granary area planted with paddy and/or increase paddy yield per unit area. With minimal expansion in granary area due to scarcity of land and slow yield increase, rice production has fallen below demand as population continues to increase. This scenario allows farmers to utilize idle land (i.e. acid sulfate soil) to cultivate rice, hence increase their production on land that is predominantly unsuitable for crop cultivation. Expanding rice-growing areas into previously uncultivated areas is considered a last option and this must be done with great care. Cultivation practice must be sustainable to avoid negative environmental consequences, must be socially acceptable and benefits rice farmers and consumers.

In Peninsular Malaysia, most of acid sulfate soils are found in the coastal plains of the west coast. Acid sulfate soils are dominated by pyrite (FeS2). The characteristics of this soil are low in soil pH (< 3.5) and contain high amount of Al which would inhibit the root growth. In addition to that, the plant-available silicon in this soil is low. It is known that Si has enhanced the growth and development of several plant species including rice.

The objectives of this study were to evaluate the soil chemical properties of an acid sulfate soils in relation to calcium silicate application with different rate and time in submerged condition.

This experiment was conducted in Ladang 2, Universiti Putra Malaysia under rain shelter condition on January 26, 2013. The acid sulfate soils obtained from Merbok (Kedah, Malaysia) were treated with four rates (0, 1, 2 and 3 t ha-1) of calcium silicate under submerged condition for 120 days with 3 replications arranged in Completely Randomized Design (CRD). The soils were sampled and analyzed for every 30 days. Prior to submerging, the soil pH and exchangeable Al were 2.90 and 4.26 cmolc kg-1, respectively. From this study, it was noted that increment in calcium silicate increased the soil pH significantly among treatments and between the submerged periods. As the pH increased, the exchangeable Al in soil reduced significantly. At 60 days of submergence, the exchangeable Al of soil treated with 2 and 3 t ha-1 calcium silicates reduced below critical value of 2 cmolc kg-1 and kept reducing at 90 and 120 days of submergence, for both, untreated and treated soils. This indicates that the exchangeable Al is affected by the increase of calcium silicate in soil. Soil Si content is negatively correlated with the exchangeable Al. At first, Si in soil was deficient at 21.21 mg kg-1, because the critical value for Si deficiency is below 40 mg Si kg-1. After 90 days of submerged condition, Si content continuously increased to above the critical value as significant differences among the treated soil were observed up to 120 days. Besides that, calcium silicate increased the Ca content significantly among the treatments ranging from 1.68 to 4.94 cmolc kg-1 throughout the submerged period. On the other hand, exchangeable Mg did not show much of significant changes except at 60 and 90 days of submergence.

In the untreated soil, significant increment in soil pH, reducing exchangeable Al and Si content were also observed. At 90 days of submerged, the Si content of untreated soil increased to 59.81 mg kg-1. The increase of Si content for untreated soil may be due to hydrolysis of Si from soil under submerged condition.

Application of calcium silicate shows an ameliorative effect on acid sulfate soil as it increased the soil pH, reduced Al and increased Si content significantly with increment in rate of calcium silicate application. Prolonged period of submergence, show significant effects in increment of soil pH, alleviation of Al and increment in the Si content in the acid sulfate soil. Therefore, the suitable time to planting rice is after 30 days of submerged as the exchangeable Al and Si content was below and above the critical value, respectively during vegetative phase. These positive effects, in soil may improve farmers' rice yield.

Keywords：*Aluminum, Soil pH, Silicon, Rice*

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[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Coarse-Grained Low-Sulfur Acid Sulfate Soil Materials in Finland

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Traditionally, in Finland, it has been considered that acid sulfate (AS) soils consist mainly of fine-grained materials such as clay and silt sized particles. For this reason, areas covered by coarse-grained materials (sand sized fractions) have been overlooked in previous mappings of AS soils in Finland. However, after the national AS soil mapping in Finland started in 2009, it has been discovered that also areas hosting coarse-grained soils, previously regarded as non-AS soil areas, may locally comprise relatively vast areas of AS soils.

The main differences between fine-grained and coarse-grained AS soils is that the latter commonly have very low sulfur concentrations, typically between 0.01% – 0.1%, compared to c. 0.5% (Åström and Björklund, 1997) for the former AS soil type. Also the physical appearance differs significantly between fine-grained and coarse-grained AS soils. For instance, a typical fine-grained AS soil comprises a dark colored, often black, un-oxidized hypersulfidic (see Sullivan et al., 2010) parent material, whereas such colors are more or less absent in corresponding zones of coarse-grained AS soils. The absence of dark colors in the hypersulfidic parent material of coarse-grained AS soils is most likely due to lack of appreciable concentrations of iron monosulfides. Furthermore, preliminary studies indicate that a sulfuric horizon (pH < 4) is absent in a typical coarse-grained AS soil, the lowest field-pH measurements in the oxidized zone are generally around 4.5 – 4.7, thus making it difficult to use solely field-pH in order to identify coarse-grained AS soils. However, even though the sulfur concentration is low in coarse-grained AS soils, the pH drops significantly during incubation at room temperature.

Although the sulfur concentration is well below 0.1% (down to 0.01%) the pH may drop several pH-units, from field-pH values around 6 to well below 4 (below 3 is not uncommon), when incubated. This is mainly due to the poor buffering capacity of the coarse-grained material. In contrast, due to the stronger buffering capacity, fine-grained soil materials generally need to have a sulfur concentration above > 0.2% for the pH to drop below 4 upon incubation. For this reason, a sulfur limit of ≥ 0.2% has previously been used for defining Finnish sulfidic materials. Because of the recent discoveries of the coarse-grained AS soils with low sulfur contents, the Finnish definition of sulfidic material has recently been changed from ≥ 0.2% S to ≥ 0.01% S, thus adopting the guidelines set by the Acid Sulfate Soil Working Group in 2008 and published in Sullivan et al. (2010).

The metal discharge from coarse-grained AS soils is most likely much lower than that from fine-grained AS soils (cf. Deng et al., 1998). However, as indicated by the rapid drop in pH during incubation for coarse-grained AS soil materials, the buffering capacity is very poor in this type of AS soil. On a local scale, these soils are therefore of importance and their potential negative effects on the aquatic environment need to be considered.

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Keywords：*Acid sulfate soil, sulfide*

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[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Revised Acid Sulfate Soil Mapping Procedures Aand Classification in Finland

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Finland has the largest occurrences of Acid sulfate soils (ASS) in Europe. Sulfide-bearing sediments have been deposited in the sea between Finland and Sweden since the continental ice sheet melted about 10,000 ya. These sediments cover an area of c. 5 million ha below the upper shoreline of the ancient Litorina-sea, which due to rapid isostatic land uplift today is 40-100 meters above sea level. These soils are suitable for agriculture, but they require artificial drainage. Subsurface and forest drainage, peat-mining, dredging and construction activities expose thick layers of sulfide-bearing sediments to oxygen, eventually leading to leaching of acidity and metals and deterioration of streams, rivers and estuaries.

The harmful consequences of ASS in Finland have been known for decades and sporadic, local mapping projects were pursued from the 1950's to the 1990's using a wide variety of methods and criteria. Based on wide–spaced sampling, an estimate of 336,000 ha for the extent of agricultural ASS in Finland was made in the 1990's.

Fish kills in 2006–2007 and EU's Water Frame Directive (a legislative instrument to restore ground and surface waters in Europe to 'Good Status') brought about national co-operation and projects have commenced to localise ASS and develop methods to reduce their harmful effects. The Ministry of the Environment and the Ministry of Agriculture and Forestry (2011) formulated a National Strategy for ASS. ASS are also included in the Implementation of River Basin Management Plans 2010-2015 (Ministry of the Environment 2011). They recommended immediate ASS mapping using uniform and internationally valid methods.

Systematic mapping and classification of ASS started in 2009 with the Geological Survey of Finland (GTK) as responsible partner in co-operation with Abo Akademi University and University of Helsinki. Initially airborne geophysical data and other databases of GTK (soil, bedrock, peat-bottom sediment) and topographic data (including LIDAR) are used to delineate areas potential for ASS. This excludes about half of the area, while the other half is considered potential for ASS and is being mapped in the field. Profiles for lithological observations and sampling, as well as reconnaissance auger drillings are made to 3 meters depth at a density of 1 sample/2 km2. On the basis of observations, measurements and analyses, we classify the soils and make maps and reports available on GTK's web-pages. We have also made a definition of Finnish ASS, slightly differing from the ones of (WRB and Soil Taxonomy. This approach is a result of different characteristics and ways of formation, deep agricultural drainage in a Boreal environment and of observed/measured soil qualities leading to harmful environmental impacts.

Before and during the first years of mapping, ASS in Finland were considered to be fine-grained, gyttja-bearing sediments consisting of an oxidised horizon with pH <4.0 and a reduced sulfidic horizon having S >0.2%. During mapping, however, it became evident that also coarse-grained sediments can cause acidification even with S-contents as low as 0.01% when oxidised. This finding forced us to revise the mapping process, classification and definition for ASS in Finland. The modified classification of ASS by the ASS Working Group (Sullivan et al. 2010) proved very useful for this purpose. The most essential changes from earlier used to new descriptions are: Actual ASS to Sulfuric material; Potential ASS to Hypersulfidic material; Incubation 8-10 weeks to Incubation 9-19 weeks; S≥0.2% to S≥0.01%.

By the end of 2013 we have mapped about half of the potential ASS-area. There seem to be clearly more ASS in Finland than estimated earlier (336,000 ha). This is due to the denser and deeper (3 m) sampling, and inclusion of coarse-grained ASS materials will further increase the area.

Keywords：*Acid sulfate soils, mapping, classification, Finland*

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[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Evaluation of Laboratory Methods For Determining Lime Requirement of Philippine Acid Upland Soils

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Liming is one of the strategies to enhance productivity and increase yields of crops grown in acid soils. Accurate amount of lime to apply, however, is needed to attain optimum crop yields and avoid the risks of over-liming. This study was conducted to identify a method which can provide reliable estimates of lime needed to correct acidity of selected acid soils in the Philippines. Eleven methods were evaluated to raise the pH of soil to 6.5: Veitch incubation, CaCO3 incubation, Peech extraction, Barium Acetate extraction at pH 7, KCl extraction, Single Addition [Ca(OH)2] Titration (SAT), Soil Test Kit (STK), Shoemaker-McLean and Pratt single (SMP1) buffer, SMP double buffer (SMP2), Adams-Evans (AE) buffer, and Woodruff buffer. Results revealed that the appropriate laboratory method is influenced by the mineralogy, parent material, and physico-chemical characteristics of the soils. Peech extraction method provides better estimates of lime for Allophanic soils such as Tigaon series, which has high organic carbon (OC) and high extractable acidity (RA). Veitch Method is best suited to Kaolinitic Ultisols, Alaminos and Luisiana Series, due to their high exchangeable acidity (EA), high available Fe2+, and high RA. The buffer methods such as STK, SMP1, SMP2, and AE, were more suited for kaolinitic Alfisols with high Base Saturation (BS) and with moderate amounts of EA and Fe2+ but with relatively high RA content, such as Annam and Antipolo Series. Estimating LR from exchangeable Al3+ determined by KCl extraction method is best suited to soils with high BS and acidity that were mainly due to exchangeable Al3+, such as the Alfisol, Bolinao Series, and the Inceptisol, Bantay Series. These were also the soils that contain some montmorillonite and vermiculite minerals and had higher pH.

Keywords：*Lime requirement, soil acidity, upland soils*

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[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Spatial Modelling Techniques for Acid Sulfate Soil Mapping in Finland

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Acid sulfate (a.s.) soils constitute a major environmental problem in Finland, which has the largest occurrences in Europe (estimated in the order of 1000 km2 or more). These soils release a toxic combination of acidity and metals, causing severe ecological damage. Even small a.s. soil areas affect large water bodies, and mapping these hot spot areas is crucial for planning effective mitigation. A cooperation network conducted by the Geological Survey of Finland has been established in order to create a nationwide a.s. soil map. The mapping program started in 2009 and will be completed by 2015. Conventional mapping was deemed too laborious and time-consuming to map the large potential areas along the entire Finnish coast. On the other hand, spatial modelling techniques, applied on existing geostatistics and implemented within Geographical Information systems (GIS), allow us to overcome the limitations encountered within conventional mapping. Using diverse evidential datalayers (e.g. aerogeophysics, quaternary geology, DEM), these techniques enable the prediction of soil properties in areas with little or no available point data (i.e. physical samples, such as soil profiles or probing points).

Therefore, various spatial modelling techniques were assessed in order to generate probability maps for Finnish a.s. soils. Known a.s. soil occurrences could be utilized as training and/or validation points, as well as non-a.s. soil sites in some cases. The a.s. soil occurrences mostly corresponded to soil profiles containing sulfides within 3 m depth (i.e. when the profiles comprised an oxidized acidic layer as well as the underlying transition and reduced sulfidic horizons and/or when the pH decreased by 0.5 units to a value lower or equal to 4.0 after incubation). Weights-of-Evidence (WofE) was the first method tested on a catchment scale. WofE is an empirical, data-driven method based on Bayesian statistics. It requires the use of a large amount of positive points (i.e. known a.s. soil occurrences) covering the whole study area for the training and validation steps of the modelling. The condition of independence between the different evidential datalayers also required by WofE constitutes a significant limitation, especially when very few datalayers are available. Nevertheless, WofE could be applied to relatively densely sampled (about 1 point per 9 km2) catchment areas in Ostrobothnia (i.e. midwestern coastal Finland). Artificial Neural Networks (ANNs) are empirical, data-driven algorithms which attempt to emulate features of biological neural networks in order to address a range of difficult information processing, analysis and modelling problems. In particular, they constitute very good pattern recognition and classification tools with the ability to generalize from imprecise input data. An ANN called Radial Basis Functional Links Net (RBFLN) was applied to a small, relatively densely sampled (about 1 point per 9 km2) catchment area located in southwestern Finland, Sirppujoki. This method required the use of both positive and negative (i.e. known not-a.s. soil sites) points for the training and validation of the model. RBFLN appeared as a robust and reliable method for a.s. soil identification at a catchment scale and was particularly adapted to map areas with dense sampling. As a conceptual, knowledge-driven method, fuzzy logic (FL) adequately represents the imprecise and/or incomplete information contained within different datalayers. This technique allows us to create risk maps for large and scarcely sampled areas (about 1 point per 170 km2). The points, however, are only used for validation of the modelling. FL is particularly adapted to carry out a first assessment of scarcely sampled areas at a regional scale. It was applied to large areas along almost the entire Finnish coast.

Selecting the most appropriate spatial modelling method is highly dependent on different criteria: first, the scale of the study area (i.e. catchment or regional scale), then, the amount and type of available data (i.e. number of profiles and evidential datalayers) and finally, the quality of the available data, especially concerning the evidential datalayers (e.g. well-normalized aerogeophysical datalayers). In the future, Finnish a.s. soil mapping will benefit from the availability of higher quality data (e.g. Lidar data soon covering the whole country), more evidential datalayers (e.g. geochemistry data from water samples), but also from a more-refined modelling (adapted to water management, mitigation-orientated and taking into account the effects of climate change).

Keywords：*modelling, acid sulfate soils*

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[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Subsurface Chemication of Acid Sulfate Soils - Effects on Water Quality

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Upon drainage sulfide-bearing sediments oxidize and develop into acid sulfate (a.s.) soils (pH < 4) and large quantities of acidity and soluble toxic metals are released along the drainage channels to recipient waters with detrimental environmental consequences. Provided that oxygen is initially available, the acid and metal release from a.s. soils is catalyzed and largely controlled by the activity of acidophilic microorganisms (Wu et al. 2013). Being some of the most productive farmlands, there is an urgent need to find methods and agricultural practices by which these lands may be used in an environmentally sustainable way. Minimizing sulfide oxidation by preventing groundwater lowering, i.e. aeration of the sulfidic sediments, during summer droughts is the most obvious environmental measure that should be aimed for on farmland a.s. soils. Due to a well developed soil structure and strong evapotranspiration in the summer, this is challenging. Thus, in Finland controlled subsurface drainage has been used on some sites in order to counteract the groundwater recession. In addition, at the PRECIKEM experimental field in western Finland (Engblom et al., this volume), suspensions of ultra-fine grained (d50 = 2.5 μm) CaCO3 (c. 700 kg in 100 m3 of water) and Ca(OH)2 (c. 150 kg/100 m3) have been injected through subsurface drain pipes into the soil of four identical 1-hectare subfields. The aims of the treatments were to (1) neutralize the acidity and immobilize metals in the vicinity of the hydrologically active soil macropores and (2) to hamper the microbially mediated sulfide oxidation. In this study we present the preliminary results of the effects of the first large-scale subsurface treatments on the drainage water quality.

In the drainage waters of reference subfields (treated with 100 m3 water only) the pH was c. 4 and the acidity c. 5 mmol L-1, during flow events in autumn and spring. Concentrations of metals were extremely high, including those of Al (median 23 mg L-1), Ca (97 mg L-1), Cd (2.6 μg L-1), Co (172 μg L-1), Cu (18 μg L-1), Mn (5.4 mg L-1), Ni (324 μg L-1), SO4 (717 mg L-1), and Zn (693 μg L-1). In subfields treated with CaCO3 the corresponding pH the subsequent autumn and spring increased to c. 6 and the acidity was halved. The most remarkable change was found for the acid-sensitive Al that decreased with more than 95 %. The concentrations of Cd, Co, Mn, Ni and Zn were reduced more moderately (10-35 %). No significant decreases in the concentration of sulfate were observed, indicating that the short term reductions in metal concentrations are mainly related to the pH increase. Calcium concentrations were significantly higher (up to more than 100 %), i.e. some of the injected Ca is returned to the drains. Investigation of the drain pipes with a fiberscope revealed that some of the CaCO3 was also stored in the uppermost section of the drainpipes. Nevertheless, according to mass balance calculations, most of the suspension had been transported to the soil pores and retained there, probably relatively close to the subsurface drain pipes. With the Ca(OH)2 treatment, the effects on the water quality were small; most likely because the dose used was too small neutralize the existing acidity. In conclusion, the short term effects of

the subsurface treatment with ultra-fine grained CaCO3 are remarkably good but further monitoring of the water quality is needed in order to determine long term effects.

This work is part of the PRECIKEM project and funded by the European Agricultural Fund for Rural Development via the Rural Development Programme for Mainland Finland 2007-2013, administrated by the Centre for Economic Development, Transport and the Environment in Ostrobothnia, Finland. Co-funding and funding for investments have been provided by a number of private organizations and foundations. Support in constructing the field and material for experiments have been provided by companies KWH Pipe and Nordkalk.

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Keywords：*acid sulfate soil, mitigation, sulfur, metals, subsurface drainage*

P3-554

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Mitigation of Water Pollution by Ground Water Control on Cultivated Boreal Acid Sulfate Soils

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There exists 1000–2000 km2 of acid sulfate soils (ASS) at the coast of Finland that originate from the anoxic basins in the former Baltic Sea where sulfate reducing bacteria converted sulfate to sulfides in the bottom sediments. Some of these soils are drained and used for agricultural fields. Sub-surface drainage, in particular, exposes soil to oxygen, and sulfides are oxidized to sulfuric acid that makes the soil extremely acid (pH 2.5–4), and mobilizing high quantities of metals like Al, Cd, Co, Ni and Zn. To study means to alleviate these effects, a demonstration field (18.5 ha) with three different sub-surface drainage practices was established in Söderfjärden, near Vaasa in Western Finland in 2010. The treatments were: 1) normal subsurface drainage (ND), 2) elevated groundwater level via controlled drainage system (CD), and 3) a further controlled drainage system with additional pumping of water a few times during summer (CDP). A plastic sheet was installed into the depth of 0.3–1.8 m from the soil surface to prevent by-pass flow from the field and between the treatments [1]. We also studied the effect of the three different drainage systems on soil and water quality, emissions of nitrous oxide (N2O) from the soil and yields in 2010–2013.

In all three drainage systems the drainage water was very acid (pH 3.9–4.2) and contained high NO3-N concentrations (6.7-27 mg l-1). In 2013, the highest sulfate concentrations (590–950 mg l-1), acidity (2.2–3.3 mmol l-1) and electric conductivity (130–200 mS m-1) were measured in ND and the lowest in CDP (330–640 mg l-1, 1.5–2.7 mmol l-1 and 96–150 mS m-1, respectively). In the beginning of the study, the values were high and differences were not detected among treatments [3].

Fluxes of N2O were high from the ASS compared to mineral soils in general and high even compared to organic soils which are known as hotspots for this greenhouse gas. Different drainage systems had little effect on the emissions of nitrous oxide. The pH and content of mineral nitrogen in the plough layer were comparable to the levels of other mineral soils. However, the nitrogen content in the deeper layers was high as also observed in other studies [2]. This together with fluctuating ground water and low pH makes the deep soil layers a high source of nitrous oxide.

Grain yields of spring wheat (years 2011 and 2013) and barley (year 2012) were not affected by the drainage systems. Average yields of barley (5300-5700 kg ha-1) and spring wheat (5500-5900 and 5700-7000 kg ha-1 in year 2011 and 2013, respectively) were above the average yields in Finland. Large variations within the fields were observed in 2013, which was extremely wet growing season compared to two previous ones. Variation in yields within the fields was highest in CDP, followed by CD and ND. Lowest yields were obtained at the lower part of the fields (5100 vs. 7100 kg ha-1 in CDP). Such a variation was not observed in ND. Soil samples from each part of the fields were taken for soluble heavy metal analyses as a possible explanation for yield

variation.

These preliminary results suggest that oxidation of sulfides can be diminished by CD and CDP when these methods are combined with the plastic sheet in the lower edge of the field. Monitoring is continued to detect further effects of high water table on acidity, metal and nutrient losses as well as plant production.

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3Šimek M., Virtanen S., Krištůfek V., Simojoki A. & Yli-Halla M. 2011. Evidence of rich microbial communities in the subsoil of a boreal acid sulphate soil conducive to greenhouse gas emissions. Agric. Ecosyst. Environ. 140: 113–122.

Keywords：*acid sulfate soil, sub-surface drainage, heavy metals, acidity, greenhouse gas, yield*

P3-555

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Distribution, Dynamics and Management of Acid Sulfate Soil in Vegetable and Rice Cultivation in Brunei Darussalam

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The occurrence of potential acid sulfate (Sulfidic) soils in association with Clay (Aquerts) and Peat (Saprists) type of soils is common in majority of the lowland area in the country. This is due to geographic nature and location of the land surrounded by sea and formed by chemical and biological weathering process on sea deposit mainly sulfur and iron minerals. Development of such soils for crops cultivation was inevitable in the country for food production from food security perspective. These soils are being developed and used successfully for rice and vegetable cultivation without disturbing pyrite layer which is a main source of soil degradation. Survey studies showed that the presence of pyrite layer varies from 50-100 cm as subsurface layer under wet condition due to occurrence of continuous rainfall throughout the year protected from adverse impact of oxidation. But, there are some areas where pyrite layer was disturbed during development and cultivation, the soil becomes unproductive due to acidity (pH < 3.0) and salinity(>1.5 mS) through oxidation process and becomes actual acid sulfate soil and the effect was long lasting and could not be utilized for cultivation since liming has no beneficial effect to overcome the problem. Study showed that the acidity and salinity of the actual acid sulfate(Sulfuric) soil was continuous due to the process of drying and wetting under natural condition and soil physical structure was also spoiled due to the formation of jarosite mineral so that any plants including weeds could not able to grow. Realizing the consequences, these soils are being used for cultivation successfully with proper management practices by assessing the depth of pyrite layer and practicing ploughing operations and development of drainage facilities without disturbing the pyrite layer along with proper liming and fertilizer management practices for vegetable and commercial rice cultivation. In areas with deep peat soil having potential acid sulfate soils, zero cultivation method was practiced by growing traditional rice varieties.

P3-556

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Digital Soil Mapping of a Coastal Acid Sulfate Soil Landscape

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Coastal floodplains are commonly underlain by sulfidic sediments and coastal acid sulfate soil (CASS). Oxidation of sulfidic sediments leads to increases in acidity and mobilisation of trace metals resulting in an increase in the concentrations of conducting ions in sediment and pore water. Accurately mapping the distribution of CASS is essential for developing targeted management strategies. One approach is the use of Digital Soil Mapping (DSM) using ancillary information. We used EM38 measurements of the apparent soil electrical conductivity (ECa) in the horizontal (ECh) and vertical (ECv) modes in combination with a high resolution digital elevation model (DEM) to delineate the spatial distribution of CASS. We use a fuzzy k-means (FKM) algorithm to cluster the data. The fuzziness exponent, number of classes (k) and distance metric (i.e. Euclidean, Mahalanobis and diagonal) was varied to determine a set of parameters to identify CASS. The mean squared prediction error variance of the class mean was determined as a predictor for various soil properties (e.g. EC1:5 and pH) with k = 2–8. This analysis indicated that values of k = 3 and/or 4 were ideal for diagonal and Mahalanobis, respectively. The results suggest the DSM approach is amenable for further evaluation and on a larger scale and in order to refine CASS boundaries previously mapped using the traditional approach or to identify CASS areas that remain unmapped.

Keywords：*EM38, digital soil mapping, acid sulfate soil*

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[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Acidity Neutralization through Chemical Weathering of Clay Minerals in Inland Acid Sulfate Soils

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Inland wetlands occurring in many countries of the world provide favourable conditions for the formation of iron sulfide sediments due to the prevalence of long periods of inundation in the presence of organic rich materials, sulfate-rich saline waters and high microbial activity. The accumulation of sulfidic sediments in inland wetlands represents a potential for the generation of enormous amounts of sulfuric acid (H2SO4) upon exposure of these sediments to aerobic conditions. Phyllosilicate minerals are probably the only minerals that can provide long term acid neutralization through mechanisms of chemical weathering under these extremely acidic conditions (i.e. pH ≤ 4). The reaction of saline-acidic solutions with phyllosilicates is therefore, of considerable interest in understanding the acid neutralisation process. The aim of this study was to investigate the dissolution behaviour of a natural polymineralic clay sample under conditions of high salinity and high (SO42− based) acidity, mimicking the composition of inland ASS.

The clay sample used in this study was separated from a soil core collected from an inland wetland, (Bottle Bend (BB) lagoon) located adjacent to the Murray River in the south-west of New South Wales, Australia. The flow-through dissolution experiments were performed on < 2μm fraction of the BB clay. The specific surface area of the Na-saturated clay as estimated using a Quantachrome™ Autosorb 1 surface area analyser, was 104.5 m2/g. The mineralogy of the Na-saturated clay fraction of the BB sample was determined by X-ray diffraction (XRD) analysis of both basally and randomly oriented samples. Dissolution experiments were performed on a fixed clay mass of 0.1 g in background electrolyte solution of 0.01 or 0.25 M ionic strength (NaCl) with the pH adjusted to 1-4 using high purity H2SO4 and with the reactor temperature maintained at 25, 35 and 45°C. The output solution samples were analysed for Si, Al, K, Fe and Mg using colorimetric analytical methods and on ICP-AES. Geochemical speciation calculations were performed using the geochemical speciation program PHREEQC. The dissolved Al, Si or Fe concentration s(mol/L) at the steady state in each experiment, initial sample mass (g), specific surface area (m2/g) and fluid flow rate (L/s) were used to measure the dissolution rate Rj (mol m–2s–1) of the clay in each experiment.

The clay sample was dominated by smectite (40 %) with nearly equal amounts of kaolinite (26 %) and illite (27 %). The clay dissolution rates derived from steady state Si concentrations (RSi) decreased with increasing pH and decreasing temperature. The RSi values were also slightly higher at the lower ionic strength than at the higher ionic strength. The reaction order (n) obtained from the linear regression of the plot of RSi versus pH from 25°C experiments at both ionic strengths was 0.45. The RAl values for the two ionic strength systems were similar except for the pH 4 where a low Al concentration in the lower ionic strength solution throughout the experiments resulted in much lower RAl (-14.18 mol m-2s-1) compared to the higher ionic strength solution (-13.22 mol m-2s-1). The acid neutralisation capacity (ANC) of the natural clay was calculated from the cumulative amounts of neutralising cations released during the experimental period. In a flow-through reactor the ANC contribution from metal release (Al, K, Fe, Mg) can be calculated using the following equation:

In this equation ANC is in kg H2SO4/tonne clay/day, m is the mass of the sample (g) in the reaction vessel (i.e. ~ 0.1 g), 49 is the equivalent mass of H2SO4, F is the input flow rate (L/s), Cj is the concentration of the released cation (mole/l) and zj is the valence of the released cation (non-hydrolysed). According to these calculations, 1.11 kg H2SO4 was neutralised by one tonne of clay in one day at pH 1 and 0.25 M ionic strength of the solution at 25°C; whereas a minimum amount of acid neutralization was provided by clay dissolution at pH 4 and at 0.01 M ionic strength. The information on clay dissolution kinetics and acid neutralization capacity of clay minerals needs to be given considerable importance in devising rehabilitation schemes for acid sulfate soil systems.

Keywords：*Acidity, clay minerals, dissolution, neutralization, pH*

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[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Trends in Acid Sulfate Soil Research

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Acid sulfate soils have long been recognised as having important properties and behaviour in common. Previously this group of soil materials has been identified by names including argilla vitriolacea (Linnaeus, 1735), and colloquially as katteklei (i.e. cat clay) soils with the term cat implying "malign and mysterious qualities" (Dent & Pons, 1995). Such historic ad hoc classification implies that there has long been utility in grouping these soil materials together.

In the last four decades our knowledge of the processes and environmental consequences associated with acid sulfate soil materials has expanded considerably. For example, since the 1970s the volume of the literature on acid sulfate soils has continued to expand considerably in the general literature (using Google Scholar® search) from less than 10 articles per annum to >150 articles per annum for each of the past 5 years. Interestingly, the important impact of the International Acid Sulfate Soil Conferences conducted by the IUSS's Acid Sulfate Soil Working Group in stimulating interest in, and research on acid sulfate soil issues (as gauged by increased rates of publications) can been clearly observed in the annual acid sulfate soil-related publication figures. The growth over time in the peer-reviewed acid sulfate soil research publications (using Web of Knowledge® search) parallels that for the general literature increasing from a mean of ~1 publication per annum in the 1970s and 1980s, to between 20 and 40 per annum in the years since 2003.

Similarly, the nature of acid sulfate soil research has focussed on over the last 40 years has changed considerably. Initially the research focussed on understanding the formation, nature and distribution of these soil materials, the examination of acidification-related issues arising from their mismanagement, and on the management of acid sulfate soils to prevent and ameliorate acidification. Initially acid sulfate soils were considered to occur in areas affected by tidal or other marine influences, However in the last 20 years the range of 'type' locations where acid sulfate soils may be expected to occur now include: areas affected by tidal or other marine influences; exposed sulfidic regolith; dredged material from waterways; inland areas affected by salinity; subaqeous locations in waterways; upland coastal plains affected by aeolian marine salt deposition. Acid sulfate soil materials are even likely to be present in extra-terrestrial locations as shown by the recent scientific exploration of the surface of Mars showing the occurrence of jarosite.

The issues that were initially considered in acid sulfate soil research mainly related to acidification of waterways and soil and the effects of this acidification on crops & biota and the effects of Fe and Al. However, the range of issues examined in the last 20 years of acid sulfate soil research has expanded considerably to now include substantial contributions on the:

- mobilisation metals other than Al and Fe (e.g. Cu, Ni, Zn, Mn, etc)

- mobilisation of metalloids (e.g. As, etc)
- mobilisation of rare earth elements (e.g. La, Ce)
- mobilisation of nutrients (e.g. PO4)
- evolution of greenhouse gases (e.g. NOx)
- evolution of noxious gases (e.g. methyl sulfides, mercaptans)
- deoxygenation of waterways
- effects of sea level rise
- impacts on human health
- impacts on infrastructure
- impacts on the microbial ecology

Over the past 40 years acid sulfate soil research has greatly expanded our understanding of these special soil materials and their formation, their location, their properties and behaviour, the range of hazards they present to the environment. The range of management options available to meet the challenges that these soil materials pose has similarly increased.

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Keywords：*acid sulfate soil*

P3-559

[WG3] Understanding Acid Sulfate Soils: The Key to Their Proper Management

Acid Sulfate Soil Management Regulation and Guidance in Australia

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Acid sulfate soil materials have been widely recognized to present unique hazards if mismanaged. Here we examine different approaches implemented by various state and territory governments in Australia to minimize the impacts of disturbing acid sulfate soil materials during development. We examine current approaches and guidance provided across Australia, identifying similarities and differences between jurisidictions, and then examine where acid sulfate soil management regulation and guidance seem to be moving.

Planning instruments

The management of acid sulfate soil disturbance is commonly regulated through state-based planning instruments. These capture contemporary disturbance of acid sulfate soils during development activity. Acid sulfate soils are specifically mentioned within some jurisidiction's instruments such as in Western Australia, whereas in other jurisdictions such as Tasmania and South Australia, acid sulfate soils may, depending on their nature, be considered under general environmental protection acts or planning and approval acts.

Are disturbed sites containing acid sulfate soils contaminated sites?

Only in Western Australia, where they fall under the Contaminated Sites Act 2003.

Scope of the regulations

In all jurisdictions regulations only apply to new developments. Only in Western Australia, under the Contaminated Sites Act, in situ acid sulfate soil materials that have been previously disturbed and have elevated arsenic, aluminium and acidity in groundwater or soil above background concentrations, are considered contaminated land and must be managed as part of any future development.

Who assess Acid Sulfate Soil Assessment and Management Plans?

As acid sulfate soils are most commonly regulated through the planning process, in many states the responsibility for assessing Acid Sulfate Soil Management Plans (ASSMPs) falls to Local Government. Only in Western Australia, South Australia and Northern Territory are the majority of plans assessed by staff within state and territory departments. In some states the clear delineation of roles in this task is still under development. Recently in Queensland the state government has devolved its responsibility for assessing ASSMPs to local governments.

Level of detail required in Acid Sulfate Soil Assessment and Management Plans

For developments of comparable nature the level of detail required in ASSAMPs to gain consent, varies markedly between jurisdictions. Whereas the management aspects within ASSAMPs in some jurisdictions requires comprehensive detailing of strategies selected and their rationale, performance criteria, monitoring and reporting procedures, contingency procedures, coverage of dewatering practices (where applicable), verification testing procedures etc., such information is evidently not required to be provided in ASSAMPs in other jurisdictions to gain development consent.

Need for closure reports in Acid Sulfate Soil Assessment and Management Plans

Closure reports are only specifically required in Western Australia. These reports are submitted for clearance of any planning conditions placed on the development. Proponents need to confirm that the ASSMP was followed, provide validation of any neutralisation undertaken, and demonstrate the successful implementation of the management strategies.

Recommended laboratory analysis for assessment and management purposes.

Current recommendations vary from jurisdiction to jurisdiction, but most guidelines recommend the approaches detailed in the 2004 guidelines of Ahern, McElnea and Sullivan (2004) and use the Acid Base Approach with either the Chromium Reducible Sulfur suite or SPOCAS. The 2004 guidelines represent best management practice and have been endorsed by the National Council for Acid Sulfate Soil (NatCASS), the peak national advisory group on acid sulfate soil issues.

Where to?

As shown, there are considerable differences in how acid sulfate soils are assessed, managed and regulated across the country, and in particular in the level of effort required to gain development consent. The Australian Government is currently examining a national approach for technical guidance across a range of acid sulfate soil assessment and management issues. Such national guidance would need to be broad as differences in the physical and legislative landscapes in different jurisdictions will require jurisdiction specific approaches at the more detailed level. Despite these differences the appropriate management of acid sulfate soils needs to be ensured, and in this regard, national guidance would assist in setting national best practices for the management of acid sulfate soils.

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Keywords：*acid sulfate soil, management, regulation*

P3-560

[WG9] Steps made toward a Universal Soil Classification

Proposals for the Classification of Hydromorphic Soils in the Universal Soil Classification System

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Soil classification aims to make the soil environment more understandable, to aid in the recollection of soil information, and to aid in communicating this information. All of these create an environment for gaining knowledge. Knowledge in this regard refers to changing the actions of the individual.

The Universal Soil Classification System aims to develop single unified system for the classification and referencing (of national systems) of the world soils.

Hydromorphic soils are soils impacted on by water. This water can be reduced or not, but in all cases impact on the potential use of the soil. The water is available for evapotranspiration, especially in arid and semi-arid areas, but can also restrict root respiration, especially in humid areas.

This paper aims to review the diagnostics in various international systems for the classification of soils affected by oxygen deficiency, as an initial step in developing hydromorphic soil diagnostics for the Universal Soil Classification System. This includes sub-aquatic and tidal soils, oxy-acquic soils, and reduced soils (including groundwater saturation, stagnating water, reducing gasses, and human or natural relict reduced soils, but excludes organic-rich soils and soils with anthropogenic water saturation).

The World Reference Base for soil resources (WRB) applies differentiation at the highest (reference soil group) level. Soils affected by groundwater saturation are identified as Gleysols, those with iron accumulation under hydromorphic conditions as Plinthosols, those with stagnating water and an abrupt textural discontinuity as Planosols, those with stagnating water and a structural or moderate textural discontinuity as Stagnosols and those with stagnating water and albeluvic tonguing as Albeluvisols.

oil Taxonomy defines aquic, aridic, torric, udic, ustic, and xeric soil moisture regimes only at the second, Suborder, level. On the one hand this implies that water saturation is not a primary criterion, because it is not applied at the highest level, but on the other hand also that the moisture regime is utilised as criterion for all soil Orders.

Conclusions: This paper proposes the classification of hydromorphic soils based on the identification of horizons or layers. Qualitative morphological criteria such as redox accumulations and depletions, and stagnic and gleyic colour patterns are proposed as primary criteria, but should be backed up by quantitative criteria such as Eh & pH measurements, a,a' dipyridyl reaction, and piezometer measurements.

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Keywords：*classification, gleyed, reducing conditions, stagnic colour, water saturation*

P3-561

[WG9] Steps made toward a Universal Soil Classification

A New Global Soil Regions Map

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The Global Soil Regions map (Soil Survey Staff, 1999) has been widely used as a reference by students and educators to understand the world distribution of Soil Taxonomy orders and suborders. An updated version of the map is presented and is based on the Harmonized World Soil Database (HWSD) version 1.2 (FAO et al., 2012). The HWSD map improves on the original FAO World Soil map by incorporating larger scale maps for Europe, China and parts of Africa and Latin America.

Soil Taxonomy's integration of soil climate within the classification requires data on soil moisture regimes. A new soil climate map was developed using the www.WorldClim.org global raster data of mean air temperature and precipitation for the period 1950-2000 (Hijmans et. al., 2005). The Java Newhall Simulation Model (jNSM) (USDA-NRCS, 2011) was used to model soil moisture and temperature regimes from the WorldClim data (http://soils.usda.gov/technical/classification/jNSM/index.html).

A conversion table was developed to provide the best approximate Soil Taxonomy class for each possible combination of soil moisture regime and FAO soil unit class. The resulting map identifies Soil Taxonomy orders and suborders (Soil Survey Staff, 2010).

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Keywords：*Soil Taxonomy, climate*

P3-562

[WG9] Steps made toward a Universal Soil Classification

Diagnostics for the Classification of Tropical Soils

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The first modern soil classification systems were developed for the temperate regions of the globe. Although the soils of the tropics are not uniquely different from those of temperate regions, many fit the concept of being highly weathered and strongly leached. As soil classification systems have evolved to cater for these strongly leached soils, a range of diagnostic criteria have been utilised with varying degrees of success. The adoption of arbitrary soil attribute thresholds in classification systems sometimes results in a diversity of soils being included in one taxon or essentially similar soils being separated. We review the diagnostic criteria commonly used in the classification of strongly weathered, strongly leached soils and compare the approaches adopted in various national classification systems as well as those used internationally.

This review complements concurrent work in the interrogation of soil databases to identify discriminators and taxonomic relationships that can effectively capture and describe functional diversity in this important group of soils.

Keywords：*diagnostic criteria, taxanomic relationships*

P3-563

[WG9] Steps made toward a Universal Soil Classification

Soil Climate Regimes and the Global Application in Soil Taxonomy

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Soil climate has been an important component of the taxonomic structure of U.S. Soil Taxonomy since the release of the 7th Approximation and the first publication of Soil Taxonomy. Soil climate characteristics have been used to differentiate taxa from the Order (the highest level) down to the suborder, great group, subgroup, family, and soil series levels. The primary use of soil moisture regimes are at a high categorical level of orders (i.e. Aridisols) and suborders (i.e. Udtalfs). During the development of the Universal Soil Classification System, the soil climate and associated regimes were examined due to the high categorical level associated with soil moisture regime. The research question was focused on the applicability of soil moisture regimes to areas outside the United States.

Because measurements of soil climate are sparse, simulations of soil climate from atmospheric climate data have been important in the operations of U.S. soil survey historically. The Newhall Simulation Model (NSM) has been widely used to estimate soil climate from atmospheric climate data. The NSM model was historically a pedon based model, but has now been converted to a spatial model. The scope of this paper is to compare published soil climate maps using expert knowledge or assumed rules, with explicit geographic model output from an NSM model run using global gridded climate data, available water holding capacity of soils, and elevation data from shuttle radar topography mission (SRTM). Although this model produces results on a coarse resolution, the modeled climate maps will provide a direct application for assessing the regional soil moisture regimes, which is the most common application in US Soil Taxonomy.

In previous studies, we have used this application to evaluate the expert knowledge predications versus the NSM predictions for the conterminous USA. This research found that the NSM map and the expert knowledge 1994 map have a high level of agreement (74.6%), but differ in important ways. The highest level of agreement (96.8%) is in the Eastern Temperate Forests Ecoregion, while the lowest agreement (39.5%) is in the Southern Semiarid Highlands Ecoregion. Comparisons between the maps and historical climate station data showed a higher level of agreement between the NSM and the 30-year climate normal of both 1961-1990 and 1971-2000 periods (88.5% and 89.7%) than the agreement between the 1994 map and the 1961-1990 climate normal (75.6%). Because the NSM map is made entirely from model output and not from expert knowledge it is iterable, its assumptions are explicit and modifiable, and it can be updated when improved or new atmospheric, geographic, or soil data sets emerge. As such it represents a methodological improvement over the expert knowledge approach used to make the 1994 map.

The NSM mapping model was applied to the South American Continent and the African Continent. The moisture regimes were compared to mapped soils of the regions and land use. In the USA, soil moisture regimes closely match the ecoregions, soil properties and water limitations for production agriculture. These close relationships provide the information within the US Soil Taxonomy that gives users information regarding soil pedogeneis, use and variability. The results from the NSM maps in continents outside the USA do not provide the same level of information. This paper will discuss the role, application and categorical level of soil moisture regimes in the proposed Universal Soil Classification System.

Keywords：*Soil Taxonomy, Soil Moisture regimes, Soil Temperature Regimies*

P3-564

[WG9] Steps made toward a Universal Soil Classification

Harmonizing Humus-Enriched Soil Groups in Different Soil Classification Systems Using Taxonomic Distance

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The correlation and harmonization of different soil classification systems is beneficial for developing a global soil information system. The current efforts in soil classification are aimed at the development of the Universal Soil Classification system, which should make national soil data compatible. Numerical estimation of the similarities and dissimilarities between soil groups seems to be a promising and effective tool for comparison and correlation of soil taxa in different soil classification systems.

We performed the taxonomic distance calculations using centroids - calculated mean values for several soil properties for each soil group. The legacy data were derived from national and international databases. The difference in classification approaches and in laboratory methods generated the main challenge. Harmonization of these datasets required the use of existing and newly developed tools.

We compared selected soil groups of the Russian Soil Classification System (RSC), the United States Soil Taxonomy (ST) and the World Reference Base for Soil Resources (WRB). We evaluated the taxonomic distances between the humus-enriched soils (Chernozems and similar soils) of the RSC, the Great Groups (GGs) of the Mollisol order of the ST and corresponding Reference Soil Groups (RSGs) with similar properties of the WRB.

We successfully applied centroid-based approach for taxonomic distance calculation and correlation purposes for three international and domestic classification systems Russian soil classification, Soil Taxonomy and World Reference Base. This method was shown to work well: the obtained results were in a good correlation with expert-based knowledge, so the method could be a helpful tool for correlation analyses and could help in the understanding of the structure of each classification system.

We used a set of dominant identifiers for concept-based approach to examine selected soil classification units. We determined them as soil properties developed under certain conditions, which reflected the dominant soil forming factor and process. We harmonized all data bases thus the dominant identifiers could determine, characterize and differentiate all classification units included in the dataset.

The lack of quantitative definitions and limits of certain properties could lead to uncertainties in the results, because the concept-based approach for taxonomic distances calculation was based on coding of selected dominant identifiers.

If a database of good quality is available, we can base on the centroid based approach by calculating of centroid values from legacy laboratory data. The definitions of the centroids have to express the major numerically expressible differences related to pedogenetic factors, processes and properties, and hence have to correspond to the dominant identifiers of the studied taxa. Thus the quality of the results of this approach is strongly dependent on the availability and reliability of the input database and the used data. That is why all the researchers should be careful with laboratory methods they use and make their laboratory data as much complete as possible.

We suggest the presented and further developed numerical approaches to be applied in the efforts toward the development of the Universal Soil Classification System.

Keywords: *Universal Soil Classification System, Taxanomic relationship, Humus-enriched soils, Correlation, Russion soil classification, World Reference Base, Soil Taxonomy*

P3-565

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Organic Carbon and Nitrogen Storages in Permafrost-Affected Soils of Yedoma-Underlain Areas of the Lena River Delta

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The Lena River Delta (LRD) is located in northeast Siberia and extends over a soil covered area of around 21,500 km^2. It is the largest delta in the Arctic and likely holds more than half of the entire soil organic carbon (SOC) mass stored in the seven major deltas in the northern permafrost regions. LRD consists of several geomorphic units different in size as well as in physical and chemical soil properties. Recent studies showed that the spatially dominating Holocene units of the LRD (61 % of the area) store around 240 Tg of SOC and 12 Tg of nitrogen (N) within the first meter of ground. These units are a river terrace dominated by wet sedge polygons covered by a soil complex of Glacic Aquiturbels and Typic Historthels, and the active floodplains covered mainly by sand dominated soils as Psammentic Aquorthels and Typic Psammorthels. About 50 % of these reported storages are located in the perennially frozen ground below 50 cm soil depth and are excluded from intense biogeochemical exchange with the atmosphere today. However, these storages are likely to be mineralised in near future due to the projected temperature increases in this region.

A substantial part of the LRD (1,712 km^2) belongs to the so-called "Yedoma" or "Ice Complex" Region, which formed during the Late Pleistocene. This oldest unit of the LRD is characterised by extensive plains incised by thermo-erosional valleys and large thermokarst depressions. Such depressions are called Alases and cover around 20 % of the area. The modern soils covering the Pleistocene Yedoma deposits are influenced by wide ice-wedge polygon structures and consist of soil complexes of Glacic Aquiturbels and Ruptic Historthels. The widespread thermokarst depressions within the Yedoma deposits are covered by Ruptic Histoturbels and Ruptic Historthels, whereas the slopes are dominated by various Aquiturbels and Fluvaquentic Historthels.

Yedoma deposits in the LDR are known to store high amounts of SOC. However, within the LRD no detailed spatial studies on SOC and N in the soils overlying Yedoma and thermokarst depressions were carried out so far.

With this work we present our "investigation in progress" on soils in these landscape units of the LRD. Our first estimates, based on 69 soil pedons sampled in late summer in 2008, show that the mean SOC stocks for the upper 30 cm of soils on both geomorphic units were estimated at 13.0 kg m^{-2} ± 4.8 kg m^{-2} on the Yedoma surfaces and at 13.1 kg m^{-2} ± 3.8 kg m^{-2} in the Alases. The stocks of N were estimated at 0.69 kg m^{-2} ± 0.25 kg m^{-2} and at 0.70 kg m^{-2} ± 0.18 kg m^{-2} on the Yedoma surfaces and in the Alases, respectively.

The estimated SOC and N pools for the depth of 30 cm within the investigated part of the LRD add to 20.9 Tg and 1.1 Tg, respectively. The Yedoma surfaces (1,313 km^2 soil covered area) store 17.1 ± 6.3 Tg SOC and 0.9 ± 0.3 Tg N, whereas the Alases (287 km^2) store 3.8 ± 1.1 Tg SOC and 0.2 ± 0.05 Tg N within the investigated depth of 30 cm.

Further analyses of the soil core material collected in spring 2013 will provide SOC and N pool estimates for a depth of 100 cm and differentiate between the seasonally active layer and the perennially frozen ground. Furthermore, we will determine contents of water, ice and excess ice. With continuing advanced analyses of an available digital elevation model, slopes will be designated with their extents and inclinations as well as the expositions. They are of high importance due to varying depths of the seasonally active layer as well as varying solifluction processes depending on exposition. Furthermore, the planar extents of slopes derived from satellite imagery do not correspond to the actual slope soil surface area, which is vital for spatial SOC and N storage calculations as well as trace gas release estimates. The actual soil surface area of slopes will be calculated prior to result extrapolations.

Keywords: *Cryosols; Carbon; SOC; Nitrogen; Permafrost; Yedoma; Ice Complex;*

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[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Mineralogical "portraits" of Cryosols of Different Climates from Northern Eurasia

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The mineralogical characteristics are still very scarce for Cryosols and therefore the processes of phyllosilicate transformations in cold environment are poorly known. Several groups of Cryosols from Northern Eurasia were studied to assess the importance of pedogenesis and inheritance of clay mineralogy. They are: (i) Turbic Cryosols Reductaquic on loose marine sediments in arctic humid climate of Novaya Zemlya archipelago; (ii) Hyperskeletic Cryosols Reductaquic from ultrabasic rock (serpentinous dunite) in subarctic climate of the Polar Urals, (iii) Turbic Cryosols on loose sediments in cold semi-humid climate of the highlands of the Altai Mountains, (iv) Leptic Cryosols Oxyaquic on basic (dolerite from flood basalt complex or trap) rocks in cold continental climate of Central Siberian Plateau, and (v) Cambic Cryosols Siltic on predominantly calcareous loess-like sediments in ultra-continental climate of Central Yakutia plain.

The fine size fraction of clayish Cryosols of Novaya Zemlya archipelago is characterized by the presence of chlorite, mica(s) with biotite presence is most likely, mixed-layer clay(s) including smectitic clays, and kaolinite. The trends of decrease of chlorite and, especially smectitic clays in the upper part of profiles have become more pronounced simultaneously with acidification and gleyzation. The interesting scenario of pedogenesis is illustrated by Cryosols from serpentinous dunites from the tundra zone of the Polar Urals. The mineral association in profiles is the result of (i) disintegration of ultrabasic rock that is a potential source of inherited olivine, serpentine, talc, and chlorite and (ii) appearance of smectite(s) to be significantly decomposed in the upper horizons. Biochemical weathering seems to be the reason for selective decomposition of the most unstable minerals despite the pH-value in the soil being neutral to slightly alkaline. In Cryosols from the highlands of the Altai Mountains the inherited phyllosilicates are represented by mica(s) most probably by biotite and chlorite and the products of their transformation composed by mixed-layer clay(s) with low portion of vermiculite layers, and kaolinite. In the acidic upper parts of the profiles the value of amorphous phase increases whereas the one of chlorite and, especially biotite significantly decreases indicating the possibility of their dissolving/ destruction in permafrost affected soils. In case of skeletic Cryosols from Central Siberian Plateau the stability of inherited smectite(s) that is a predominant mineral(s) of fine size fraction depends on disintegration and weathering of the stones of hard rock (dolerite) that is most likely fast enough to keep sufficient amounts of smectite in the fine size fraction even in the acidic horizons of the profile. The interesting fact is that even in the Cambic Cryosol formed on the calcareous substrate in the ultra-continental climate of Central Yakutia plain the share of inherited smectitic clay reduced markedly in the upper acid horizons. Mentioned reduction can be explained by the introduction of non-exchangeable hydroxy-Al into the inter-lamellar space or partial dissolving of smectitic phase. Besides smectitic clays represented by mixed-layer illite-smectite and probably chlorite-smectite with high portion of smectitic layers that are dominated among clay minerals illite and chlorite, and traces of kaolinite are found. Moreover pedogenesis leads to increasing of a reduction in relative contents of both illite and chlorite in the upper acidic part of profiles.

So, those examples illustrate that even in permafrost-affected soils from Northern Eurasia, which is generally characterized by weakly developed pedogenesis the processes initiated mostly by acidification and gleyzation lead to changes of mineralogical composition in profiles. The results can be summarized as: (i) decrease of portion of the most sensitive to acidification smectitic clays due to decomposing / dissolving; (ii) decrease of portion of biotite and chlorite because of transformation to mixed-layer clays, and / or (iii) appearance of amorphous phase in upper part of profiles.

Basically, most of clay minerals in all studied Cryosols of Northern Eurasia are inherited from loose parent materials and / or occur in soil profiles because of intensive disintegration of skeletic material, if any. Thus, Cryosols in whole spectrum of climatic humidity in cold environment – from humid to semi-arid climates from Northern Eurasia are characterized both by inheritance of clay minerals from loose and hard parent materials and dissolution of phyllosilicates, mainly smectites, in upper horizons as a result of the pedogenesis.

Keywords：*Clay minerals; weathering of basic and ultrabasic rocks; loose sediments; acidification*

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[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Toposequence of Salt-Affected Soils from Northern Part of Seymour (marambio) Island, Antarctica

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The Seymour/Marambio island (ISM) is located in the northern sector of the Weddell sea, at the Antarctic Peninsular area, representing a transitional zone between Maritime and Continental Antarctica, with a subpolar, semiarid climate. The ISM is predominatly composed by marine sedimentary rocks of Cretaceus to Eocene age. We studied chemical, physical, mineralogical and morphological attributes, across a selected, representative toposequence. Also, pedogenetic processes and factors were discussed. For the soil study, nine profiles were described, collected and analysed, following a toposequence according to different parent materials and landforms. Samples were subjected to textural analysis, routine chemical analysis, chemical extractions by ammonium oxalate and CBD, as well as X ray diffraction. The geology exerts a control on soils and landforms. Permafrost is continuous and widespread, generally at depths of less than 100 cm, so tha Gelisols order (Soil Taxonomy), or Cryosols (WRB), are the dominant soils. Cryoturbation and organic matter accumulation were not observed. Soils were separated into two groups:: acid-sulphate soils and alkaline soils, unaffected by sulphates. The first are the best developed in the study area, meaning a significant physico-chemical and mineralogical alteration. Low pH and high Al saturation and potential acidity are typical. This accounts for primary mineral dissolution, and its absence in the clay fraction. Secondary minerals are those related to sulphide oxidation: soluble and insoluble sulphates, low crystalline Fe-hydroxides and little crystalline Fe phases. The peculiar yellowish colour of these soils are attributed to the presence of Fe-oxides and Jarosite. The presence of 2:1 clays (smectite and illite) in the clay fraction despite the acidity is due to low leaching. The alkaline soils, non affected by sulphates do not showed any marked weathering or transformation, with high pH, low potencial acidity and zero Al saturation. The main process is cryoclastic and haloclastic weathering. Primary minerals are present even in the clay fraction, corroborating its low weathering degree and chemical alteration. The landform is determinant for the chemical status of theses soils, by favoring or reducing leaching. Sulphurization and halomorphism are the dominant soil-forming processes in Seymour-Marambio island.

Keywords：*antarctica, soils, permafrost, aridic soil, cryosols*

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[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Impacts of Human Activity on Antarctic Soils: A Review

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Antarctic soils are vulnerable to disturbance due to their physical properties and naturally slow recovery rates due to low temperatures and, in some regions, low moisture contents. The most intense human activities in Antarctica, such as establishment of bases or research stations, are concentrated in ice-free areas.

The first recorded human interactions with Antarctica were sightings from three ships in 1820. Human activity in Antarctica became sustained during the 19th Century when whaling stations were established and in the "heroic era" (1895 – 1917) with exploratory expeditions such as those of Scott and Amundsen. The early visitors left structures and other equipment behind, thus establishing the first legacies of environmental impacts. Since the International Geophysical Year of 1957/58 there has been a sustained increase in human activity. In recent years there has been increased ship-based Antarctic tourism, with 46 000 tourists reported in the 2007/08 summer and 25 000 in the 2012/13 season.

The Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol) was signed in 1991 and designates Antarctica as "a natural reserve devoted to peace and science". The Madrid Protocol mandates the protection of Antarctic wilderness and aesthetic values and requires that before any activity is undertaken the possible environmental impacts are assessed.

Human impacts on the Antarctic terrestrial environment include; physical disturbance, spillage of foreign substances, and introduction of foreign organisms. Physical disturbances range from land disturbance during construction activities for roads and bases, though to formation of foot tracks and individual footprints in areas where humans have never previously walked. Accidental spills of hydrocarbon fuels and wastewaters have occurred and human waste was sometimes disposed of by discharge onto land. There is now evidence that alien vascular plants and other taxa can successfully colonise Antarctic soil ecosystems and there is increasing concern about potential for human activities to impact on soil microbial populations.

Where physical disturbance includes removal of the protective "active layer" the underlying permafrost will melt with resulting land surface subsidence and, in drier regions, accumulation of salt at the soil surface. The concentration of ice that occurs near the top of the permafrost had not re-established 30 years after disturbance near the Ross Sea region coast. Larger scale surface recontouring, such as bulldozing of tracks, or formation of vehicle or foot-tracks in loose materials may remain visible in the landscape for well over 50 years. Where surfaces are active, such as sand dunes or where liquid water is available seasonally, smaller scale impacts are obliterated within a few seasons. Visible recovery from footprints, scattered across the environment, was often greater than if the same amount of foot traffic was concentrated to form a foot-track.

Hydrocarbon spills have been shown to persist in the environment, with fuel perching on top of ice-cemented permafrost, for decades. Hydrocarbon degrading microbes are present in the Antarctic environment but, within the Ross Sea region, their effectiveness is limited by moisture and nutrient (N and P) availability.

Little is known about the response of Antarctic soil microbial communities to human disturbance or on what timescale responses can be detected. Studies of the long-term effects of trampling on soil fauna have shown increased mortality, lower abundances, and shifts in the dominant species of collembola with increasing trampling intensity and increasing soil compaction. Current knowledge of the drivers of bacterial ecology suggests that a disturbance of sufficient intensity to affect soil EC, pH, or moisture content is likely to cause a shift in bacterial community structure. More rigorous investigations incorporating DNA-RNA-based analyses and CO2 efflux studies could lead to a greater understanding of the effects of soil disturbance on biota.

Many of the most intense impacts on the Antarctic soil environment are legacies of past practice, and are concentrated in areas near bases. Visible disturbance collectively impacts only a small proportion of Antarctic terrestrial environment. With increasing environmental awareness, innovations such as ASMA (Antarctic Specially Managed Areas) and ASPA (Antarctic Specially Protected Areas) have been implemented. Thus, the standard of prevention of human impacts undertaken by many of the Antarctic programmes, such as those operating in the McMurdo Dry Valleys, is now more stringent than environmental management standards in most, if not all, other regions of the planet.

Keywords：*Cryosol Antarctic Permafrost human impacts*

P3-569

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Transformations of Cryolithozone Soil Cover under the Influence of Natural and Anthropogenic Factors

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Large areas of the world are occupied by the permafrost, the total area of cryolithozone on the planet is more than 180 million km2. The center of permafrost is located in Eastern Siberia and has a depth up to 500-700 m with grounds temperature of -3 up to -15°C and below. On the low and plains territories the body of permafrost contains huge reserves of underground ice. The cryolithozone as a product of the cold climate of the past eras, is kept due to severe climatic conditions of the present days.

Severe climatic conditions of cryolithozone create the specifics of the region environment, revealing a certain poverty of biodiversity, low productivity and weak sustainability of the ecosystem. In cryolithozone, all known factors of soil formation are modified by cryogenic processes and by the influence of the permafrost. For this reason, the soils here have complicated genesis. Specificity of permafrost soil formation gives special morphological structure for profile, composition and characteristics of soils. The diversity of cryolithozone soils is much more wider than in non-permafrost areas and the variety of soils is huge.

In harsh climatic conditions of Siberia and subarctic areas soils annually functioning for a short time period (2-3 months) and provide growth and development of plants giving primary product to sustain life in these severe areas. The depth of summer soils thawing varies from 0.1 to 4.3 m, it depends on many factors and generally increases from north to south. An abrupt increase of the active layer (AL) depth during the natural development of landscapes in Holocene led to the melting of ground ice and the formation of thermokarst landforms.

Present day climate warming at high latitudes, leads to disruption of equilibrium state of permafrost ecosystems. First of all, it affects the soils formed on the ice complex. Parameters of global climate change during the past 120-170 years can be seen in Central Yakutia According Yakutsk weather station data an average air temperature at the end of 19 and the first half of the 20th century amounted to -11.2°C, but at the beginning of 21st century it went up to -9.3°C. There was an elongation of warm season. Spring begins 10-15 days earlier and autumn ends 15-20 days later than it used to be in the mid-19th century. During the observation period there was an increase of precipitations. Changes in temperature conditions resulted in increased AL depth and also resulted in increase of ice complex grounds temperature for 1-2°C in the layer of annual amplitude. During a very short time period (1992-2000) the depth of permafrost surface on the tillage land with ice wedges increased from 1.8 m to 3.6 m and led to the local degradation of the ice complex. There are a lot of facts of such kinds. It points the following - if the natural processes of changing and development of landscape proceeded for hundreds and thousands of years, creating arable land by stubbing and deforestation, people can provoke thawing of underground ice and cause the formation of thermokarst lakes in a very short time.

In 2005-2009 increase of AL depth with previous precipitations amount led to catastrophic floods on the Kolyma-Indigirka lowland territory. As a result of additional water runoff from the melting permafrost layers to the basin of Alaseya river there were the lakes overflow. It promoted thermoerosion of the lakes banks and self-draining into the river, that caused severe floods in autumn and early winter period. All inhabited localities in the river basin during winter of 2007-2008 were flooded. Prolonged flooding of lowland ecosystems has led to complete degradation of vegetation and soil cover. In the micro and meso-subsidences there took place accumulation of fresh alluvium, while soils surface of elevated parts was flushed. On the coastal areas of the watershed there go processes of thermal erosion and destruction of grounds with ice complex, it has already destroyed up to 40-50% of the natural soil cover of forest areas, and also there has been an activation of the thermokarst on watershed areas.

Thus, global warming and human impacts cause local degradation of cryolithozone soils. With the present rate of climate change, this process can get acceleration exponentially.

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[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Soils Thermal Regime in Sporadic Permafrost Areas (Russia,Western Siberia)

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Global warming, recorded in recent decades in the north of Western Siberia, leads to a change in soils temperature regime, changing plant associations, gradual degradation of permafrost and changing landscape as a whole. For forecasting these changes is necessary to conduct regime native soil temperature observations.

Actual research is direct towards defining the climate-permafrost relation, including the effects of temperature forcing from climatic variation, local environmental factors such as snow and vegetation, and ground materials.

The research area is located in the north of Western Siberia (Nadym region, Russia) within the northern boundary of north taiga. It's zone of sporadic permafrost. Permafrost is absent under forest site and bogs, and exist under peatlands. We analyzed the soils thermal regime at three sites with different vegetation, topographic, geocryological conditions (all sites located an area of several acres): 1) the forest site, 2) the frozen peatland and 3) the relic frozen peatland. The forest site represents lichen-pine forest without permafrost in the soil profile. The soil was classified as Folic Podzols. The frozen peatland represents flat and slightly inclined main surfaces of peatlands with cloudberry sphagnum cover. The active layer is peaty horizon with underlying mineral stratum. Permafrost occurs below 60 cm. The following type of soil was identified as Turbic Cryosols. The relic frozen peatland is characterized with locally bare peat spots, sparse vegetation and permafrost from 40 cm in the peat layer. The soil is classified as Cryic Histosols.

The annual soil thermal regime was measured with Thermochron iButton™ data loggers located at different depths, respectively, 2, 5, 10, 20, 40 cm at each site. Air temperature was measured at the forest and peatland sites 1,0 m above the ground surface.

The three sites show significant differences of the mean annual ground surface temperature (MAGST), ranging from 1.6 (peatlands – site 1 and 2) to 2.9°C (forest site), but all of this values more 0°C. According to the literature the presence of permafrost in soil profile at these rates is problematic. So equilibrium in the climate-permafrost system is supported by the presence of peat horizons in the soils. Frozen soils in the study region is very susceptible to any effects.

The mean annual ground temperature (MAGT) at 20 cm (the main parameter for thermal regime identification in Russia) differs for the all sites. Coldest in our series is the Histosol (about -1.0°C), then Cryosol (about 0°C) and the warmest is Podzol (more than 2.0°C).

For relating climatic conditions to the ground thermal regime we use a transfer function ("N-factor") relating the thawing and freezing indices (degree-day totals above and below 0°C, respectively) in the air to the values at the ground surface. These measurements were used to analyze the influence of vegetation and snow cover on the ground thermal regime.

Freezing N-factor (snow cover effect) was applied for estimating thickness of snow cover on the sites due to the impossibility of such measurements in the field. Based on the range of this index values (0.2 – 0.4) snowpack throughout the territory thick. This is confirmed by a moderately low winter soils temperatures (-1.0 – -4.0° C) and low annual temperature range (□ 10 °C). The

maximum snow cover is observed for the forest site (Freezing N-factor = 0.19). For peatlands are typical smaller snow cover (Freezing N-factor about 0.4).

Thawing N-factor (plant vegetation effect) is 1.0 for the relic peatland, due to a complete absence of vegetation on most of its surface. Minimum values of thawing N-factor (0.87) marked on the forest site.

Thus the values of thawing and freezing N-factor indicate that the insulating effect of snow cover is much higher than of vegetation.

Cconclusions

Sporadic permafrost presence determines soil functioning in contrasting thermal regimes with a significant difference in its parameters.

Modern cryogenic soils temperature regime in research region shows the instability of climate-permafrost system and possible permafrost degradation, especially in case of peat horizons destruction.

With climate warming in the region, the greatest influence on the change in temperature of the permafrost and its borders will have changes in summer air temperatures.

Keywords：*Cryosols, global warming, soil temperature regime,N-factor, permafrost*

P3-571

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Humus Specificity of Shirmaher Oasis Soils (East Antarctica)

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Different date about organic substance of Antarctic soils (including composition of humus and humus formation plants) are in the literature. However they characterize not all geographical areas of this continent and not all variety of the soils formed in different ecological conditions under natural vegetation

One of the few studied territories in this aspect is the Shirmaher oasis.

he Shirmaher oasis located in the Central part of Queen Maud Land in 90 km from the Lazarev Sea is one of the coldest flat Antarctic oases

Soils formed under different vegetative associations on territory of the Shirmaher oasis are characterized by very small capacity, accumulative type of humus profile, fulvic orientation of humification process, absence of certain communication of group and fractional composition of humus with type of vegetative associations, a low share of humic acids, prevalence in them brown fraction, a wide ratio of carbon humic acids to carbon fulvic acids and also a high saturation of this humus component to nitrogen.

As a whole these characteristics are similar to soils of other areas of Antarctic regions.

At the same time the soils of the Shirmaher oasis are characterized by wide fluctuation of the total organic carbon quantity (from 9-14 % in organic horizons to 0,10-0,15 % - in mineral), prevalence brown humic acids, very low share of humic acids connected with calcium (no more than 2 %) and concerning high humic acid shares most strongly connected with clay minerals.

Humus acids most strongly connected with clay minerals can make to one third of total organic carbon that is typical for cryogenic soils of continental Eurasia different regions.

The hydrogen and carbon ratio in elemental composition of humic acids does not depend on vegetation type, fluctuates within 1.4-1.6 and corresponds to climatic characteristics of region. The preliminary data testifies about wider ratio O:C in humic acids of soils under alga community.

Humus specificity of soils caused by vegetative associations become apparent show at structure level of humic acids: a ratio of aliphatic and aromatic share, different position of a maximum and the first moment in luminescence spectra, and also distinction in a set of absorption strips and their position in infrared area of a spectrum.

Keywords：*humic acids, humus, Antarctic soils*

P3-572

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Cryogenic Transformation of Soil Solutions and the Formation of Salt Profiles in Solonchaks of Mongolia: Modeling Results and Interpretation

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Solonchaks of Mongolia are subjected to seasonal freezing. Evaporative concentration of the soil solutions in summer is accompanied by their cryogenic concentration in winter. The concentration of salts may exceed 300 g/L. Water with such a high salt content does not freeze at subzero temperatures and forms cryopegs. In parallel with the rise in the concentration of the soil solutions in winter, cryogenic transformation of their composition is developed.

Fotiev (2009) analyzed freezing of seawater and distinguished between three stages of the cryogenic transformation of marine cryopegs: (a) cooling of the brine without changes in its chemical composition (0 to -1.8ºC), solute concentration (-1.8 to -7.4ºC), and (3) desulfatization due to mirabilite precipitation (-7.4 to -22.5ºC).

Mongolian deserts have a continental type of salinization with the presence of significant amounts of sulfates. The content of sulfates in the Solonchaks may exceed the content of chlorides. Cryogenic transformation of such solutions may have its own specific features.

We studied soil solutions from Solonchaks of the Ekhiin-Gol Oasis in the Trans-Altai Gobi Desert of southwestern Mongolia at 1300 m asl. Annual precipitation is <50 mm. The mean July temperature is +28ºC, and the mean January temperature is -15ºC. The snow cover is absent, and the soils freeze down to 1.5 m; the topsoil temperature drops down to -25 to -30ºC. Various subtypes of Solonchaks predominate in the oasis. The degree of their salinization is very high, though the groundwater salinity is low or absent. The solonchaks are of the chloride or sulfate-chloride types of salinization with a significant content of gypsum. The salt crust at the surface is formed, whereas the lower soil horizons are nonsaline. The soil solutions were pressed out of the soil samples (Pankova, 1977) and analyzed by the same methods as soil water extracts.

Simulation of the transformation of the soil solutions at subzero temperatures was performed according to Pitzer's model (CRREL, USA) for a 7-component poly-ionic system (Na-K-Ca-Mg-Cl-SO4-H2O). A FREEZBRINE modification of the model was also used for calculating temperatures of the formation of the ionic composition of the cryopegs from their desulphurization curve (temperature dependence of the concentration of sulfate ions). The model was calibrated according to data by K.E. Giterman (1937). The system of (a) solution (23 components: cations, anions, and neutral molecules), (b) gases (8 components), and (c) solid phases (56 components) was analyzed. The possible presence of organic impurities and the development of sulfate reduction were not taken into account. Aluminosilicates were considered chemically inactive. The following interpretation of the results of the modeling can be given.

(1) At subzero temperatures, cryogenic transformation of soil solutions takes place in the solonchaks resulting in the appearance of 'phantom' minerals (hydrohalite) and precipitation of difficultly soluble salts (gypsum, calcite, dolomite, and, probably, magnesite) accumulating in the soils after the ice melting.

(2 The character of cryogenic transformation depends on the freezing temperature and on the composition and concentration of solutes. Four groups of soil solutions are distinguished: (a) brines (150-400 g/L) of salt-bearing horizons; at subzero temperatures, 'seasonal cryopegs' (nonfreezing solutions) are formed; hydrohalite precipitates at temperatures below -22ºC; (b) solutions of gypsiferous horizons (50-150 g/L) that remain unfrozen at temperatures down to -3 to -7º; weak precipitation of gypsum begins below the freezing point and sharply intensifies at temperatures below the hydrohalite crystallization temperature; (c) solutions in the lower soil horizons (5-50 g/L), whose behavior follows the scheme suggested by Fotiev for marine deposits; and (d) initial low-saline (<5 g/L) and fresh (<1 g/L) solutions, the freezing of which is accompanied by precipitation of calcite.

(3) Winter is an active rather than a passive period of the formation of the solonchaks of Mongolia. The specificity of salt distribution patterns in them is controlled not only by the evaporative concentration of the groundwater in summer but also by the cryogenic transformation of the soil solutions in winter.

Keywords：*solonchaks, cryopegs, cryogenic transformation of soil solutions*

P3-573

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Influence of Cryogenesis on Peatland Soils in the North of Western Siberia: Bare Peat Spots, Features and Functioning

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The considerable part of mire ecosystems in the territory of the Western Siberian plain develops in the conditions of permafrost. In these locations such mire complexes as peat plateau are widespread. There are unique peat plateau formations – peat spots, diagnosed by the extensive spots of bare peat, the vegetation on which is completely absent.

The purpose of the real work – to study features of formation and functioning of peat spots soils of northern peatlands. The area of researches is located in the north of Western Siberia (Nadym area, Tyumen region, Yamalo-Nenets Autonomous Okrug, 65°78'26'') in a zone of discontinuous permafrost. Most often, peat spots are located at the tops of peatlands, have an oval form, diameter ranges from 1 to 5 m, and their surface is covered with the overdried peat crust with a peculiar structure.

During researches of 2011-2012 more than 30 peat spots were studied. The following features were noted for them: thickness of peat profile is greater, peat spots are characterized by high degree of decomposition of organic matter.

During field works experimental sites were put on peat spots and on background areas with a vegetative cover adjoining spots. For these sites the data were obtained on annual dynamics of temperatures and seasonal dynamics of CO2 production, obtained by closed chamber method. It is established that on sites with bare surface emission of CO2 is much lower, than on sites under vegetation, (74 mgCO2/m2 per hour, 175 mgCO2/m2 per hour, respectively), at the same time concentration of CO2 at depths 10, 40 and 60cm has inverse correlation and is higher on the average for peat spots (0,18, 0,49, 055 % and 0,20, 0,25, 0,41 %, respectively), because of active layer of peat spot is thicker, that property allows CO2 to accumulate under peat spot. An average annual temperature of peat spots soil is lower than under vegetated surface (-1,12°C and – 0,01°C, respectively at the 20-40cm depth).

The analysis of chemical properties revealed essential difference of peat spots soils to surrounding area soils. Peat horizons of peat spots have higher total contents of carbon (50,9% for bare peat and 42,1% for vegetated peat) and nitrogen (2,5% and 1,6%, respectively). Peat spots have the lower content of such biophile elements as potassium (4,6 mg/100g peat spots and 37,3mg/100g soils of peat plateau) and phosphorus (1,5mg/100g and 2,5mg/100g respectively), and also the lower content of exchange forms of iron (37,6 mg/100g and 89,7 mg/100g, respectively) . Water Extractable Organic Carbon (WEOC) is less in peat spot (169,2 mg/100g peat spots and 215,6 mg/100g for vegetated peat). WEOC/total carbon ratio is less for bare peat too. So, Particulate Organic Carbon (POC) is less for peat of peat spot. The different correlations were established for Nitrogen determined from Water Extractable Organic Matter (WEOM). Nitrogen is more in peat spot (15,9 mg/100g peat spots and 12,2 mg/100g for vegetated peat, respectively). All measurements were performed in five replicates.

It was established under laboratory conditions, that parameters of intensity of initial growth of plants, (such parameters as total length of root system and length of green sprouts, defined by a sprouting method) on the average for 20-30 % are lower for peat spots soil samples compared to surrounding soils (0,74 and 1,36 cm for sprouts and 0,48 and 1,13 cm for root system). These parameters due to lack of biophile elements in peat spots such as potassium and phosphorus.

So, our results show that Peat spots are specific landscape of peat plateaus, they are widespread in the area of researches and diagnosed by the absence of vegetation on the surface. Peat spots differ from typical peat plateau their morphological characteristics, their chemical properties, and their microbiological characteristics.

We assume that the genesis of peat spots due to different causes. Properties of peat (his relict genesis and high decomposition rate) are one of the main causes. Equally influenced by cryogenic processes, such as swelling, turbations (impeding settlement of vegetation) also cycles of freeze-thaw (accelerating mineralization of peat).

Keywords：*bare peat spots*

P3-574

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Soilcapes at the Volcanic Rocks of Lions Rump, Maritime Antarctica

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Lions Rump in one of the oldest exposed, ice free areas in the Shetlands. We studied, classified and mapped soils , according to WRB and USDA soil classification systems in association with geomorphological features. Twenty-six soil profiles from study area were described, sampled and analyzed for their physical, chemical and mineralogical attributes. Results showed soils are most formed from weathered basalt-andesitic rocks, naturally rich in apatite, with high P background. Typic Dystrogelepts ornithic and Typic Gelorthents ornithic are the main soils in study area, which possibly represents one of the first ice-free areas colonized by penguins in Maritime Antarctica. Typic Dystrogelepts ornithic represent the deepest, most structured and reddish soils so far described from Maritime Antarctica. Typic Haplogelepts ornithic are the main soils on first and second moraine levels from the White Eagle Glacier. Typic Haplorthels and Lithic Haplorthels are present just above 80 m a.s.l., especially on the top areas and paraglacial spots, and represent Gelisols in study area, with gelic materials within 100 cm and permafrost within 200 cm from soil surface. Despite their occurrence only at higher altitudes, they represent the greatest soil cover in Lions Rump. Turbic Haplogelepts and Typic Haplorthels are situated between 40 and 80 m.a.s.l., without bird nesting influence and absent of permafrost within 200 cm depth. Vitrandic Cryopsamments and Oxyaquic Cryopsamments dominated the first level of terraces and former beaches along the coastal area. Other soils classified are present in very limited areas: Lithic Cryorthents ornithic on the sea stacks rock outcrops (basaltic plugs) close to the beach, and Typic Gelifluvents ornithic in a small area on glacial alluvial fans. Overall, soil distribution and classification in Lions Rump allowed identified two main soil domains: Ornithogenic soils (without permafrost) and the Gelisols (above 80 m.a.s.l.).

P3-575

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Biological Productivity of Some Natural Ecosystem Soils of Yamal Forest-Tundra

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The research in Ural Federal University is supported by grant of Government of Russian Federation, the agreement № 11.G34.31.0064

Data of the structure and biomass stocks for each type of ecosystem are requiered to identify regional patterns of the carbon cycle. Vegetation is associated with the soil mostly closely. The type of substance and energy exchange between the soil and the vegetation, essentially, determine the functioning and dynamics of the whole natural ecosystem. Specificity of pedogenesis in the tundra zone of Western Siberia is connected with primarily the plain character of the territory and the development of a soil cover on permafrost. These conditions cause poor soil drainage, widespread water logging and the relative slowness of the processes of decomposition and synthesis of organic substances. Forest-tundra zone soils which are formed on permafrost are largely similar to the tundra soils.

The paper presents data on biomass stocks of overground vegetation and bog tundra communities developed on frozen forest-tundra zone soils on the left bank of the Ob River (Yamal-Nenets Autonomous District). According to climatic division it is Atlantic-Arctic moderately cold humid area. The country is flat, soils are formed on layered sediments of Quaternary period and have different texture. Height above sea level varies from 90 to 110 m. Detailed description of soils and vegetation was done on the experimental squares 10x10 m. Plants were cut at the border of the green and brown mosses part, dead parts (rags and litter) were also taken into account. Soil productivity was estimated taking into account overground phytomass reserves, which was determined during the period of maximal development by method of cutting grass from the registration arears 25x25 cm in 16–25 replicates in each community.

Experimental square 1. Ledum-dwarf shrub-moss-lichen waterlogged tundra. Total plant cover is 100%. The soils (Turbic Cryosols and Histic Cryosols) are formed on clay and loam.

Experimental square 2. Dwarf shrub moss-lichen. Total plant cover is 93%. The soils are Turbic Cryosols and Histic Cryosols.

Experimental square3. Shrub-moss-lichen with dwarf birch and ledum frost mound tundra. Total plant cover is 95%. The soils (Albic Podzols, Entic Podzols) are formed on sandy loam.

Experimental square 4. Complex flat frost mound bog which is shrub-moss-lichen in the upper parts and carex-cotton grass-sphagnum in the lower parts. Total plant cover is 100%. Soils are Histic Cryosols.

Zonal types of forest-tundra communities are spruce-larch and larch-spruce forests, combined with tundra communities, large areas are waterlogged. Tundra and marsh vegetation occupy 83 % of the area on the first key site and 93 % of the second key site.

The floristic composition of key sites, according to preliminary data, is presented by127 species of different life form plants: 3 species of trees, 11 shrubs, 8 semi shrubs, 53 grasses, 24 species of mosses and 18 species of lichens. Species, that play a key role in the composition of vegetation, were established for each type of vegetation on the basis of the occurrence constancy analysis (dominants Betula nana L., Ledum palustre L., Vaccinium uliginosum L., V. vitis-idaea L., Empetrum hermaphroditum (Lange) Hagerup., Rubus chamaemorus L. and others).

Live overground phytomass stock values of the studied communities varied. Maximum stock was defined in the waterlogged tundra, dwarf shrub tundra and flat frost mound bog communities – 716±61, 689±66 and 698±59 g/m2 respectively. The smallest phytomass stock is defined in the tundra on sandy loam – 270±40 g/m2. The share of mosses, lichens, shrubs, dwarf shrubs and grasses in the structure of the overground phytomass communities differed. In the waterlogged tundra there are 33% mosses from mass; 23% – lichens; 26% – bushes; 15% – shrubs and 3% – grasses. In dwarf shrub the amount of shrubs was 49 %, dwarf shrubs – 24%, mosses – 10%, lichens – 16% and grasses – 1%. In lichen tundra on sandy loam the share of lichens and shrubs increased up to 39% and 28%; the proportion of mosses, shrubs and grasses reduced to 12%, 19% and 2% consequently. Two-thirds (62%) of the flat frost mound bog community stock biomass belonged to mosses, 20% – to shrubs , 3 % – to dwarf shrubs , 4 % – to lichens, 11% – to grasses.

Keywords：*biological productivity, biomass stocks, permafrost, soils, forest-tundra*

P3-576

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Soils and Landscapes on Quartzite and Associated Drift at the Heritage Range, Ellsworth Mts, Continental Antarctica

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Recent studies on the Elssworth (Heritage Range) described three toposequences of soils from three contrasting lithologies, well representative of soil at this sector of the southern Ellsworth: On the Crashsite Quartzite and associted drift deposits; (2) on Limestone and marbles of the Minaret Group, and associated drift; (3) On phyllite to quartzite of the Heritage Group. All toposequences are located at the margins of the Union Glacier. In this paper, we describe the toposequence study on the Crashsite Quartzite from Enterprise Hills

The Mt Dolence dry valley is the largest ice-free slope of the Enterprise Hills, varying from 800 meters up to 1950m, where steep slopes with pinnacles of quartzite show no evidence of overriding glaciation. This toposequence (EH 1- EH 6) thus represents the soil formation on the most resistant rocks of the Ellsworth. The six soils are distributed from the top stable surface, at 1300 m, just below the trimline, down to the Union Glacier margin, just above the large lateral moraines, where no soil development took place. The most important variations observed along the toposequence were expected: soil depth, presence of carbonates or sulphates, presence of salt flecks. They represent weathering stages 2 and 3 sensu Bockheim et al., (2012) . The amount of clay is invariably low, and below 6 %, with silt increasing to the higher landscape position, where salt formation increased (EH 1). The coarse sand fraction is much higher than fine sand, and distinct fine sand accumulation at altitudes greater than 1000 meters were attributed to Aeolian deposition, since grains are wind-polished and well-selected. This is consistent with the overall characteristics of Gelisols from Antarctica, which have very low clay content, seldom above 4%, even in the oldest soils from Continental Antarctica (Beyer et al., 1999). The soil colour is quite homogeneous, varying from pale yellow to light olive gray, with 5Y hue throughout the sequence, with low value due to very low organic carbon amounts. High CEC, salts (Na and Ca sulpahtes and Carbonates) and high EC indicate that nutrient concentration was the result of atmospheric depositions, since these lithologies are virtually free from nutrient reserves. High P in some soils deserve further studies to assess its source.

Keywords：*antarctic soils, permafrost, polar desert*

P3-577

[WG10] Cryosols on a Changing Planet: Properties, Processes, Regimes and Functions

Soil Temperature Regime of Taiga-Alas Landscapes in Central Yakutia

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Study of the long-term dynamics of soil temperature under different forests (pine, larch, birch) and alas grassland in the basin of the middle Lena was carried out. The results showed great diversity and high dynamics of thermal parameters of Central Yakutia soils.

Soils occupying the uppermost layer of the earth's surface have influence in the formation of surface climate and thermal regime of Cryolithozone grounds. The composition, structure, organic matter content and moisture of soils play an important role in the

To study the soil temperature regime of taiga-alas landscapes were selected 4 sites. Site 1 - pine forest. Dominated by Pinus sylvestris, with small admixture of undergrowth of Larix gmelinii. The height of the first tier is 17-18 m, the second tier is 5-8 m Soil: Permafrost podzolized . Point 2 - larch forest. Dominant tree species - Larix gmelinii, accompanied by Betula divaricata. Height of canopy 15-20 m Soil: Permafrost pale weakly solodic. Point 3 - birch forest. Dominated by Betula platyphylla with height of 8-10 m. Soil: Permafrost pale. Point 4 - dry meadow in alas depression. Dominated by Poa pratensis, Agrostis trinii Turcz., Elytrigia repens covering up to 50% . Measurement of soil temperature was carried out using THERMOCHRON TCR -G (ELIN, Russia) on standard depths of 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.6, 2.4, 3, 2 and 5 m during 2005-2009 period.

During observation period the weather conditions had significant variations, as in temperature and precipitations. The average air temperature of the period was higher than long-term average by 2.1°C and amounted -8.1°C. The average summer temperature during observation period was 13.2°C, it is also higher than long term average by 0.9°C. Studied period in most years have high snow winters. Exceeding of the maximum snow height in those years winter was 118-176 % of long term average and had a significant influence on the temperature of the of soils and permafrost upper layer. For formation of temperature regime of permafrost soils in winter the dominant role belongs to snow cover depth, but not the temperature conditions of the cold season. By the temperature regime all studied soils belong to the permafrost type, where the average annual temperature of the soil profile is negative. The average annual temperature of the active layer in soils of pine forest is -0.8°C, birch forest is -2.5°C, larch forest is-2.9°C and alas meadow is -0.02. Maximum depth of summer thawing in pine forest soils reaches 2.7 m, birch - 1.9 m, larch - 1.5 m and alas meadow is 3.2 m The average temperature in the 0-3.2 m soil layer in the pine forest during observation period was -0.95°C, birch is -2.6, larch is -3.0 and alas meadow only -0.07°C . The average temperature in the soil layer of 0-5 m in the pine forests was -1.1°C, in larch forest -3.1°C.

Trends of soil temperature fluctuation to the depth of 0.4-0.8 m are negative and follow the weather conditions of the studied years. Trends of temperature at the depths from 1.0 to 5.0 m show a significant increase in annual temperatures of suprapermafrost layer of soil and upper permafrost. Temperature of +10°C in the larch and birch forests soil was marked only in a thin surface layer. Thermal regime of soils under larch and birch forests can be attributed to permafrost cold subtype. Higher temperatures were observed in soils of pine forest and alas meadow. Temperature of +10°C during temperatures rising in July reached a depth of 0.6 and 0.8 m, respectively. Thermal regime of the soil under the pine forest and alas meadow can be attributed to permafrost moderate subtype.

Obtained results showed great diversity and high dynamic of thermal properties of taiga-alas landscapes soils in Central Yakutia. They reveal the abrupt fluctuations in the heat supply of the soils active layer, in space and in time.

P3-578

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Optimal Soil Moisture Monitoring Design Based on Hierarchical Cluster and Temporal Stability Analyses

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Soil moisture is an important factor linking the transportation of materials and energy among different spheres in the earth's critical zone. Field in-situ observation is the most direct and accurate soil water content monitoring approach. However, good spatial and temporal coverage of soil water content monitoring is time consuming and costly. In this study, 39 and 38 soil water monitoring sites were installed along a tea plantation hillslope and a bamboo hillslope, respectively, in Gaochun District, Nanjing, China. Based on the soil water content temporal stability and hierarchical cluster analyses, different combinations of monitoring sites were selected for each hillslope. These combinations were used to construct the stepwise multiple linear regressions and simulate the soil water contents in other unselected monitoring sites. Results showed that temporal stability analysis can help to select the sites that best reflect the mean soil water content, highest soil water content and most temporal unstable soil water content, in this study area. Six sites were selected from each hillslope to cover different temporal stability properties and hierarchical cluster classifications. When only these six sites were monitored for each hillslope, 85% of the other unselected sites had R2 values of regression models more than 0.80, indicating that using the readings of these six sites can acceptably predict the soil water contents of the other sites. Soil water contents collected in seven different dates were used to validate our regression models. The RMSE values of these three dates were all less than 0.9 m3 m-3, and the spatial interpolation results using the measured and simulated soil water contents were quite similar. This optimal soil moisture monitoring design can significantly reduce the field work and assurance the monitoring accuracy.

Keywords：*Soil moisture; Spatial prediction; Temporal stability; Hierarchical Cluster*

P3-579

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Flood and Dikes Spatial and Temporal Changes Delineation Affecting Rice Soil Ecosystems in the Lower Mekong Using Modis Satellite Images

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With large coverage, moderate spatio resolution acquisition, MODIS data is effective to detect spatio-temporal extents inundation of floo. MODIS satellite image data (MOD09A1, 500m spatial resolutions, 8 days composite) in the lower Mekong basin from 26/02/2000 to 27/12/2011 were used to monitor changes in flood. The results showed that MODIS MOD09A1 time-series data has a great ability to detect changes in flood at the country and regional scale, and an good correlation with daily water-level data collected at hydrological monitoring stations (R2: (0.79 - 0,90)). Otherwise, more dikes for agricultural production were also delineated in the delta, which can cause changes of rice soil ecosystyems and more urban inundation due to less water way for flood to run to downstream then the sea. There was a close relationship between Enhanced Vegetation Index (EVI) and Land Surface Water Index (LSWI) with growing stages of plants and surface water of the flood. The inundation map created from MODIS data has helped assess extent and temporal characteristics of annual floods from 2000 to 2011. MODIS products show their great advantage to monitoring changes of flood in the high-frequent observation. Otherwise,

Keywords：*MODIS, EVI, LSWI, flood , lower Mekong, Mekong river delta.*

P3-580

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Uncertainty Analysis in Near-Surface Soil Moisture Estimation at Two Typical Hillslopes in Taihu Lake Basin, China

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Spatial prediction of near-surface soil moisture content is necessary for both hydrologic modeling and land use planning. However, uncertainties associated with the prediction are always neglected and lack of quantification analysis. In this study, stepwise multiple regression models with terrain indices and soil texture were derived to spatially estimate near-surface soil moisture of two typical land use hillslopes (tea garden and forest land) at 10 dates from January to September 2013. The uncertainties due to limited samples used for developing regression models (model uncertainty), DEM resolutions of 1, 2, 3, 4 and 5m (terrain indices uncertainty) and spatial interpolations of soil texture by kriging or cokriging with electromagnetic induction (soil texture uncertainty), were investigated by using bootstrap, resampling and Latin hypercube sampling techniques, respectively. Results show the acceptable soil moisture predictions of both tea garden ($R2 = 0.34$) and forest land ($R2 = 0.57$) by topographic and soils data that can be obtained. The model uncertainty is more important in the spatial estimation of soil moisture of tea garden hillslope than that of forest land hillslope. A significant negative correlation ($P < 0.001$) is found between the model uncertainty and the mean soil moisture across hillslopes. Although the terrain attributes vary with the grid size change, the resolution uncertainty has less effect on soil moisture predictions compared to the model uncertainty. The texture uncertainty is found to be weak on soil moisture estimations of tea garden hillslope. However, this uncertainty is much more important than the model uncertainty at the forest land hillslope. Ultimately, improving the regression model structure and the within-hillslope soil texture mapping are very critical in the accurate spatial prediction of soil moisture of tea garden hillslope and forest land hillslope, respectively.

P3-581

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Nonchemical Water Treatment in Water Treatment

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Currently various chemical reagents are used in water treatment technology that lead to great inconvenience and extra costs expenses with the removal of residual alkali and acid that remain in the water after treatment. Using reagent-free methods for water treatment can reduce both ma-terial costs and treatment time. The current work represents some of the results we obtained in recent years while studying the water activation with reagent-free methods.

The idea of this method is based on a fact that as a result of external influences on the water the long chains of molecules - assiociants break. This leads to a change in the value of the integral feature of water - the surface tension .

Reagent-free treatment was carried out by us saturating water with air, ozone, exposure to water with barrier electric discharge and electromagnetic waves in the centimeter range. The effect of treatment on the properties of water was estimated by the change of coefficient of surface tension of the treated water compared with coefficient of drinking tap water left for 24 hours for a test.The metod of determining the height of water elevation in capillary tubes was used to find the coefficients of the surface tension.

Saturation of water with air and ozone was produced in the glass tube with 1 height and 40 diameter. The air of mixture of ozone+air was fed via the divider of the fine pipes in the bottom for 22 minutes. As for the gas flow rate of 4 , the air flow rate was 88 . Here oxy-gen was on volume of 18.48 and mass of 26.4 and out of it in one liter of water dis-solved 67.88 . At the same feed rate of the mixture of air and ozone, consumption of ozone by weight was 352 and out of it in one liter of water dissolved 9.68 .

The measurements show that the value of the coefficient for fresh water taken from the public water line is almost equal to the coefficient for water saturated by air. This coincidence is due to the fact that the water is fed to the water line by powerful pumps and is chlorinated whereby it is inflated with air saturation. Ozonation significantly reduces the surface tension of water. So, for example, after 22 minutes of ozone bubbling (water saturation with ozone time is 22 min) the surface tension decreases to a value of which is significantly less than the sur-face tension of the reference water, where . We note that we have measured the surface tension of the same ozonated water at 1.5 hours after ozonation. Experiments have shown that the coefficient in this case amounts to which is almost the same coefficient of surface tension of water, saturated with air, which is . In-crease in of ozonated water over

time is dueto the splitting of the molecules of ozone. Increas-ing of from to is due to the decomposition of ozone for 20 minutes of waiting (the collapse of the ozone is ?20 min in water) and 1.5 hours portion of the hydrogen bonds in water are reduced and grows.

The water electric discharge machining was performed in a glass tube 7.5 in height and 30 in diameter. With the purpose to eliminate the influence of material erosion electrodes one of them (enamelled copper helix) was located inside a glass tube with a diameter of 10 , lowered into the tube with water, and the other was outside. Water was actually between two barrier of electric discharge with frequency of 20 and voltage 10 and current of 100 , duration of exposure of the water discharge in this case was 1 minute. This experimental setup eliminates contact with the electrodes investigated water discharge and the ability to move products of erosion of the electrodes in the water and formation of ionids. Our experiments showed that the electric barrier discharge treatment of water reduces the surface tension to a value .
Controlling the surface tension of water by various methods without any auxiliary reagents can be used to control the rate of water transport in the soil-plant.

Keywords：*Water, reagent-free, soil, surface tension, ozonation*

P3-582

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Evaluation of Soil Water Retention PTFS for Tropical Mekong Delta Soils

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The knowledge of soil water retention characteristic (SWRC) is crucial for solving many soil and water management problems related to agricultural, ecological, hydrological and environmental issues. However, the information on this soil property is usually missing in soil databases, since the methods for determination of SWRC are cumbersome and expensive. The dearth of this information in developing countries located in the tropics is even worse than elsewhere due to additional problems linked to personnel training and acquisition of needed equipment for these measurements. Pedotransfer functions (PTFs) which are used to estimate soil water retention characteristics (SWRC) from other available soil properties has been considered as an attractive alternative for direct SWRC measurement.

Since developing new PTFs for particular regions is very arduous and mostly requires a large soil database of good quality, utilizing existing PTFs where possible is highly recommended. However, many PTFs have limited portability and predictive capacity, since they have been derived for specific soils within limited geomorphic and geographic domain. Predominant clayey soils being mainly exploited for intensive rice-based agriculture in the tropical Vietnamese Mekong Delta (VMD) have distinct characteristics, which implies that PTFs derived elsewhere could not be directly utilized without evaluating.

Therefore, the objective of this study was to evaluate the applicability and reliability of published PTFs in predicting SWRC for tropical VMD soils. The predictive performance of a number of well-known regression based and pattern-recognition based PTFs developed from soils in both tropical and temperate regions were evaluated based on the dataset of 160 soil samples. The sampling locations were selected so that the dataset well represents the distribution of different soil types and textures in the delta. The ME, SDE and RMSE are validation indices used to assess PTFs' performance.

The results of this study show that most of the investigated PTFs which were derived from soils in both tropical and temperate climates have somewhat limited predictive potential for tropical Mekong Delta soils. The difference in soil texture (i.e. clay and sand content) as well as the mineralogy of the clay fractions in PTFs calibration datasets compared to evaluated dataset are mainly explain the inadequate performance of the investigated PTFs for tropical Mekong delta soils. In order to acquire accurate and reliable SWRC estimations for further uses in the Delta, it is necessary to develop new PTFs based on an extensive database of soils of tropical deltas.

Keywords：*pedotransfer functions, soil water retention characteristic, tropical delta soils, Vietnamese Mekong Delta*

P3-583

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Spatio-Temporal Variability and Temporal Stability of Profile Soil Moisture at a Hillslope Scale

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Information about soil water content (SWC) within soil profiles in terms of its magnitude, spatio-temporal variability and temporal stability is crucial when selecting appropriate soil water management practices. This study aimed to investigate the depth dependency of spatio-temporal variability and temporal stability of SWC at the hillslope scale. The SWC within the 0-300 cm soil layer was measured with neutron probes on 20 occasions between July, 2008 and October, 2010 at 91 locations on a hillslope on the Loess Plateau, China. The temporal variability of SWC decreased within the 0-160 cm soil layer and was relatively constant below this layer; in contrast, the spatial variability of SWC exhibited a constant-increasing-constant pattern, with the two inflexion points occurring at depths of 70 and 140 cm. The soil moisture heterogeneity had a significant positive correlation with mean SWC values at all 20 soil depths ($p < 0.01$, Pearson test). Both the depth and the thickness of the studied soil layer had important effects on the apparent temporal stability of SWC. The time-stable locations, which can directly represent the mean SWC value of the study area, always occurred at the moderate soil depth (approximately 200 cm) in the present study. Based on both the spatio-temporal variation and the temporal stability characteristics using six indices, the studied soil profile (0-300 cm) could be divided into three soil layers, 0-60 cm, 60-160 cm and 160-300 cm, named the “irregularly changing layer”, “regularly changing layer”, and “relatively constant layer”, respectively.

The greatest rainwater replenishment depth was approximately 160 cm in the study area. Therefore, choosing 200 cm as soil sampling depth would be sufficient in similar areas. Both the variation and temporal stability of SWC were depth-dependent, the patterns of which depended on the interactions among topography, vegetation and soil properties. Such findings are useful when designing an optimal strategy for sampling and management of profile soil moisture.

Keywords：*Profile soil water content; Spatio-temporal variability; Temporal stability; Hillslope hydrology*

P3-584

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Effects of Initial Aquifer Thickness and Extent of Water Application on Propagation of Water Pressure along Shallow Groundwater in a Simple Slope

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INTRODUCTION

In hillslope hydrology, saturated lateral flow along soil-bedrock interface greatly contributes to the increase in rainfall runoff volume[1]. van Meerveld and McDonnell (2006b) reported interesting phenomena that during rainfall, groundwater level at the upslope wells responded quicker than that sited at downslope. Traveling velocity of the peak water level between the wells was about ten times as fast as pore water velocity[2]. Various theories have been proposed to explain rapid water movement in soil and quick runoff response (macropores and soil pipes, translatory or piston flow, groundwater ridge and so on). However, difference between traveling velocity of peak water level and pore water velocity is not clarified sufficiently. Also, the factors that affect traveling velocity have not been specified yet. The objective of this study is to discuss the factors affecting traveling velocity of peak water level through the homogeneous simple sloped aquifer.

METHODS

Toyoura sand was packed homogeneously to form a model slope of 210 cm long, 100 cm high and 5 cm wide, with a water reservoir at the upslope boundary, and an outlet at the downslope end. Nine tensiometers were inserted to monitor reservoir water level and groundwater level. Tipping bucket was used to measure outflow rate at the downslope end. First, we kept reservoir water level constant in order to make steady state water flow in the slope. Then, we added water to the reservoir to simulate groundwater level fluctuation. Several trials of water addition were conducted to various combinations of initial aquifer thickness and size of water impact to discuss effects of initial and boundary conditions on propagation of water pressure change.

Beside the experiment numerical analysis was conducted. To reproduce the model experiment HYDRUS-2D, which simulates two-dimensional water flow through soil, was employed. Reservoir water level was controlled by the water flux boundary condition at the top of the reservoir. Downslope outlet was assigned as seepage face boundary condition, and the other boundary surrounding the model slope was no flux boundary condition. Soil hydraulic function was described by the van Genuchten-Mualem model.

RESULTS and DISCUSSION

As soon as reservoir water level rose, all tensiometers and the flow rate at downslope outlet responded simultaneously. This means that fluctuation of groundwater level in part may influence groundwater level of whole aquifer. Groundwater level peak occurred at upslope and transferred to downslope, and maximum discharge was observed just after the groundwater level peak at the vicinity of the downslope outlet was detected. Traveling velocity of peak water level was 5-35 times as fast as pore water velocity. As packed toyoura sand was a homogeneous medium, translatory flow could explain the difference between traveling and pore water velocity. As the initial and boundary condition were changed, traveling velocity also changed. The thicker initial aquifer and less water application caused faster peak travel velocity. In our experiment, traveling velocity was a function of the ratio of initial aquifer thickness to the amount of water application.

Numerical simulation quantitatively reproduced amplitude of the groundwater level fluctuation, but time required to transfer the fluctuation toward downslope part was overestimated.

In conclusion, translatory flow might play an important role in the rapid propagation of peak water level. The ratio of initial aquifer thickness to amount of water application may be a useful parameter to predict the traveling velocity of the peak level. Quantitative discussion on propagation of peak water level in aquifer is important to understand quick runoff from hillslope at the rainfall event.

References 1) van Meerveld and McDonnell. 2006a. Water Resour. Res. 42 W02410; 2) van Meerveld and McDonnell. 2006b. Water Resour. Res. 42 W02411

Keywords：*pressure propagation, traveling velocity*

P3-585

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Soil Organic Matter Controls of Soil Hydrological Functions in an Alpine Ecosystem in the Qinghai-Tibet Plateau

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Typically soils in the Qinghai-Tibet Plateau which spread across subalpine to alpine have a thick 'mattic horizon'. These soils are often overlying a less developed cambic B horizons consisting of coarse soil materials. The hydrological functions of these soils, i.e., the ability to facilitate water movement, to hold soil water and to buffer water infiltration, are critical to the ecosystem development and functions in this fragile ecosystem and also very important for water movement in watershed scale.

Soil water retention as one of the most important functional factors has an influence on many soil properties and is itself a function of some soil basic properties. Organic matter affects soil water retention in many ways; it absorbs water on its surface, and also enhances porosity and aggregation in soil development. In cold alpine regions, organic matter is hampered from decomposition and extensively accumulated in the top soil, and these "soft" soils have a high capacity for water storage and exert profound influences on soil water balance.

The study area is a typical alpine region at the Qilian Mountain, which is the northeast border of the Qinghai-Tibet Plateau. Mollisols and Inceptisols are the dominant soil types, Gelisols only appear above 3600 m and Histosols are sporadically distributed in lower wetlands. Lithological discontinuity is widespread in this area and is usually formed by wind-blown dust covering glacial debris.

In this study, 33 undisturbed soil samples were collected from different pedogenic horizons within 14 profiles in alpine meadow and grassland areas, covering Mollisols, Inceptisols, and Histosols. Correlation analysis was taken among soil water contents at 0, -10, -100, -500, and -1500 Kpa, and 8 soil physiochemical properties. Bulk density has the highest correlation coefficients with soil water content at low matric potentials, reaching -0.949 at 0 Kpa. When the matric potential is -1500 Kpa, organic matter content becomes the dominant controlling factor of soil water content.

It is notable that soil particle size has a negligible influence in predicting the variability of soil water contents. This can be explained by the homogeneity of soil particle size distribution due to the long-term dust input in this area. Considering that the wide range (0.35-1.72) of bulk density, CEC, and many other properties are mainly controlled by soil organic matter content, we naturally come to the conclusion that organic matter has a dominating control over soil hydrological functions in this cold alpine mountains region. The organic-riched 'mattic horizon' is thus a critical component of the special alpine ecosystem and should be well protected, otherwise the destruction of this layer will lead to serious soil degradation even ecosystem collapse.

Acknowledgement: This work was supported by the Natural Science Foundation of China (No. 41130530, 91325301).

Keywords: *Soil organic matter, Mattic horizon, Soil water retention, Soil hydrological functions, Alpine ecosystem, Qinghai-Tibet Plateau*

P3-586

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Pgis Tool for Erosion Susceptibility and Soil Conservation Planning in a Watershed of Nepal

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Abstract: Stakeholders can be mobilized by several approaches in soil and water conservation activities. In this research, stakeholders were involved in Participatory Geographic Information System (PGIS) based Current Erosion Damage Assessment (CEDA) in the some plots. This study aimed to find the soil erosion susceptibility by PGIS based CEDA tool. Tool was employed existing knowledge of stakeholders and expert knowledge by focus group discussion to erosion mapping and to select soil conservation measures for the benefit of conservation measures in watershed. The tool involved stakeholders to map soil erosion indicators and determine the soil erosion status in which they plan for soil conservation measures in sub watershed. This tool helped to increase awareness among farmers and identification of fields that were severely eroded and causing run on down slope fields. Farmers approved the soil erosion status map with their own indicators and perceptions and export

Keywords：*Participatory GIS, water conservation ,stakeholders, erosion mapping ,watershed*

P3-587

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Developing Pedotransfer Functions to Simulate Wetting and Drying Branch of Soil Water Characteristic Curve

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In most recent studies the developed pedotransfer functions (PTFs) for determining soil water characteristic curve θ(h) have been oriented toward the predicting of the drying or desorption branch of θ(h) curve, and few studies have been accomplished in developing of PTFs describing the wetting or sorption branch, and in particular the nature of the relationship between the two branches. Several important natural phenomena such as irrigation, infiltration and solute transport in soils do occur under the conditions of soil getting wet. In such circumstance wetting branch of the θ(h) is needed. With this in mind, experimental data describing both wetting and drying branches were obtained by using, respectively, Shani field method and pressure plate apparatus in 24 diverse soils collected from Miyaneh district, north- west of Iran. The Brooks-Corey (BC) and van Genuchten(VG) parameters(he, β, α, n, θs, θr) were calculated by fitting the two models to the experimental data separately for both drying and wetting branch. At the 2nd step each parameter for the wet branch, separately, was regressed against the corresponding parameter for the drying branch and the correlation coefficient was calculated. The purpose was to examine how accurate a parameter for wetting branch may be predicted from the corresponding parameter for the drying branch. At the third step each parameter of BC or VG model was regressed against the various soil attributes including clay, silt and sand percentage, bulk density, organic matter, electrical conductivity, geometric mean particle diameter by using of multivariable curvilinear regression and PTFs were developed to predict the two models parameters directly from the readily available soil attributes for both dry and wetting branch. For each parameter (say BC he or VG a) two PTFs one for drying and the other for wetting branch were constructed leading to totally 16 PTFs. Statistical criteria such as mean absolute error, modified index of agreement, relative root mean squares deviation, geometric mean error ratio and geometric standard deviation of error ratio were adopted for the accuracy assessment of the generated PTFs. Among the 13 measured soil attributes, EC and SAR showed the largest (about 250%) and Db the smallest (13%) coefficient of variation (CV). Overall, in the examined soils, VG model better fitted to the data (mean R2 = 0.954 and 0.996, drying and wetting branch) than the BC model (R2= 0.948 and 0.937, drying and wetting branch). Considering the four parameters of each model, BC-he and VG- a possessed the greatest and θs the smallest CV. Two distinct types of hysteresis behavior and magnitudes were observed depending on the soil texture class, Db and organic matter content. The magnitude of the hysteresis (the surface area between the drying and the wetting branches plotted at the same scale) in the soils with fine texture, high organic matter contents and low Db became as much as 5 times greater than those of soils with course to medium texture, low organic matter and high Db. The functional relationship between the corresponding parameters (say VG a) for the drying and wetting branch of a given soil (denoted as ad and aw) were described by non-linear regression equations with highly significant R2 as high as 0.99 implying that the BC and VG parameters may be predicted for the wetting branch of θ(h) curve from the corresponding parameters of the dry branch. Regarding the PTFs developed for predicting the parameters of the two examined models either BC or VG directly from the soil attributes, all the PTFs were non-linear multiple regression type of equations with up to 4th power for some soil attributes with R2 ranged from 0.66 to 0.90 for the PTFs predicting θrd and he , respectively. The PTFs developed to predict BC parameters performed generally better than VG parameters. The ranks of the soil attributes in terms of their contribution to or importance in the developed PTFs were as OM>Clay ?Db>dg (geometric mean weight diameter) designating that organic matter, clay content and bulk density appear the three most dominant soil properties shaping both drying and wetting branch of the θ(h) function as well as the hysteresis behavior of the soils.

Keywords：*Pedotransfer functions, Hysteresis phenomena, Shani method, Drying and wetting branch, Soil water ch*

P3-588

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Survey and Mapping of Soil Moisture in Northeast Thailand

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Survey and mapping of soil moisture in Northeast Thailand was carried out on northeastern region that is the most risk area for drought in dry season of Thailand. Methodologies included analysis topographic wetness index (TWI) with available water content and soil moisture storage calculated from climatic data to generate monthly potential soil moisture map. The map was validated by soil moisture monitoring and field survey.

Results of the study revealed that the TWI of Northeastern Thailand is 26% of the total studied area for wet rating and 21.59%, 13.83%, 10.15% for moderately dry, moderately wet and dry, respectively. The most area (47.2% of the region) has moderate available water contents. The estimated soil moisture accumulation from available water content and TWI is moderate to high. Potential soil moisture evaluation for northestern Thailand found that dry season (January-April) has very low soil moisture content then rainy season (May-October) has variably low to very high soil moisture content. After rainy season (November-December), in this period, the soil moisture content dramatically decrese to low but still has enough soil moisture for some crops after rice harvesting.

Keywords：*Soil moisture map, Topographic wetness index, AWC*

P3-589

[WG12] Unique contribution of hydropedology to Integrated soil and Water Sciences

Relationship between Stream Water and Groundwater Using Time Series Analysis in the Lower Nakdong River Basin, South Korea

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In South Korea, total sixteen river dams have been constructed across four major rivers (the Han, Nakdong, Geum, and Yeongsan rivers) for the purpose of control flood and more efficient water resources. However, after the construction of the river dams groundwater level rose up adjacent to the upstream regions of the river dams especially in wet season. This study was carried out to reveal groundwater change due to the Haman River dam located in the downstream of the Nakdong River. For the study we analyzed cross correlation among groundwater level, electrical conductivity (EC), and river level. Groundwater level and EC were periodically measured at 62 locations in the riparian zone of the tributaries (Gwangryeo Stream, Iryeong Stream, and Yeongsan Stream) of the Nakdong River during the past 40 months (May 2011-September 2013). The relationship of the measured groundwater level and the river level data were also estimated with the influence of rainfall. A preliminary result of the study revealed that the groundwaters level rose up an average of 1.65 m during the studied period. The groundwater level and river level have a relatively good correlation with cross-correlation function of -0.31 to 0.91 and with response time of 0 to 360 hours which is better than the correlation between the groundwater level and rainfall. Hence, it evidences that the groundwater level rise and river level rise due to the to the Haman River dam have a relatively close correlation in this area. Furthermore, even better cross-correlation appeared between EC and river level.

Acknowledgments

This work was supported by the research project of “Advanced Technology for Groundwater Development and Application in Riversides (Geowater+)” in “Water Resources Management Program (code 11 Technology Innovation C05)” of the MLTM and the KICTEP in Korea.

Keywords：*Stream water groundwater interaction, Groundwater level, Electrical conductivity, Cross-correlation*

P4-1

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Chemical Properties of Tsunami Sediment and Risk Assessment of Heavy Metals by the Great East Japan Earthquake of March 2011

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The tsunami generated by the Great East Japan Earthquake of March 11, 2011, deposited a lot of shoreline sediment or submarine deposit as tsunami sediment on farmland or urban areas. These tsunami sediments contain toxic heavy metals such as arsenic or lead which affect human health. There is a possibility that people living in these areas are exposed to these heavy metals by ingestion or inhalation of the sediment particle directly. In addition, the heavy metals might migrate into groundwater or crops, because elution of the heavy metals is accelerated by being exposed the tsunami sediment to the air or the rainwater. Therefore, it is very important to know chemical or physical properties of the tsunami sediment and the environmental effect for making the management of tsunami deposits and the restoration works. In this study, information of the hazardous heavy metals containing in the tsunami sediment have been developed and their health risks for human were evaluated using by our risk assessment model (Geo-Environmental Risk Assessment System; GERAS) The tsunami sediments were obtained from the affected area (Aomori, Iwate, Miyagi, Fukushima, Ibaraki and Chiba prefecture). The thicknesses of the tsunami sediment were almost a few to several dozen centimetres, which varied by the geographical factors. Although almost all of tsunami deposits were sandy sediment, there were some samples which contained iron sulfide or were grown fungus on the surface of the sediment. The samples were analysed by a lot of methods and basic properties such as pH or electric conductivity were obtained. And the chemical properties of heavy metal content and the leaching values of tsunami sediment were measured by the leaching method which authorized by the Ministry of the Environment Japan. Although there were some samples that the leaching values for arsenic and lead were exceeded Japanese criteria, almost all of heavy metals in the tsunami sediment were within the criteria. Samples exceeded the criteria of leaching values were 15 samples with arsenic, 4 samples with lead in 134 samples. Especially a lot of samples obtained from Miyagi and Iwate prefecture were likely to exceed the criteria. The heavy metal contents in the tsunami sediment were below the reference values. A lot of tsunami sediments were piled up in the range of human activities such as urban or farmland area in this earthquake. In order to evaluate the risk of heavy metals in the tsunami sediment, risk assessment based on the exposure to human is very important. Therefore, the exposure rates were estimated by using the data such as chemical properties, and risk levels were evaluated by comparing the exposure rates with the reference dose. Although there were any sites in excess of Japanese criteria for the leaching values of arsenic and lead, the exposure rates of these heavy metals were estimated not to be so much high for people living in the general environment. The major exposure pathways to human were different between heavy metals. Human was mainly exposed to copper and chromium from the groundwater intake, lead from the direct ingestion of soil. In the case of arsenic and cadmium, the major exposure pathways were both of them. The risk levels of heavy metals in the tsunami sediment to human health were not so much high, because the exposure rates were much lower than their acceptable intakes.

P4-2

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Assessing Risk of Heavy Metals from Human Activity on Rural Soils: A Case Study

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Background values for heavy metals were proposed in Azul (Argentina), a representative agricultural-grazed grassland area of South America, as a basis to identify and assess soil pollution processes at regional level. Forty-two top soils were sampled and heavy metals concentrations were analysed for seven elements (Cd, Co, Cr, Cu, Ni, Pb, and Zn) with an inductively coupled plasma-mass spectrometer (ICP-MS) after acid digestion with HNO3 and HCl. Background values in Azul were proposed using different statistical techniques. These populations were obtained by dividing the raw data set, which contains normal and anomalous values, into its constituent populations to yield realistic and plausible values. The background values were in mg kg-1: Cd 0.15, Co 10.8, Cr 22.1, Cu 39.2, Ni 13.7, Pb 11.8 and Zn 133.9. The experience gained in this work further suggests that the statistical techniques tested to obtain background values for heavy metals should be proposed in other areas. This is necessary to establish the anthropogenic signatures on soil as a basis for undertaking appropriate action to protect soil resource quality. Once the background upper limits were established, a few points with anthropogenic signatures were observed. The most contaminated point is detected in a grassland soil with an unauthorized rubbish dump. It should be noted that the Igeo for Cd (Igeo=5) is classified as heavily to extremely contaminated. The other polluted area is located around a municipal dump with a composting plant at Talpaque village, close to the boundary of Azul's municipal district. In general Co appears to be the least contaminated element in all top soils, while Cd and Pb show the highest values (mg kg-1) for the two most contaminated points (7.4±0.9 and 164±23 respectively for grassland soil; 0.7±0.1 and 41±4, respectively for municipal dump). Significant differences were also observed in all heavy metal concentrations, except for Pb, when using land use. All heavy metals were present at greater levels in cultivated top soil. These results suggest a slight diffuse contamination across the agricultural area.

Keywords：*background, trace elements, soil pollution, Pampean Soils, Argentina*

P4-3

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Effect of Conjoint Application of Sewage Sludge and Fertilizers on Trace Metals Accumulation in Plant and Soil under Rice Cultivation

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The agricultural use of sewage sludge has been a common practice in waste disposal in recent decades. Large scale urbanization, as a consequence of economic development is leading to production of huge quantities of effluents and posing serious environmental problems for their disposal. Sewage sludge (biosolids) generation is also increasing at a faster rate as more and more waste water treatment facilities with enhanced efficiencies are being developed. Sewage sludge and effluents are frequently disposed off on agricultural lands for irrigation/manures purposes that create both opportunities and problems. Opportunities exist as sewage sludge and effluents from municipal origin are rich in organic matter and also contain appreciable amounts of major and micronutrients. Therefore, continuous use of sewage sludge and sewage irrigation reduces the nutrient requirement of the soil considerably. Limitation in sludge use is related to a need to prevent excessive metal accumulation in soils. Sewage sludge contains plant nutrients and organic matter but their positive influence may be limited by contents of potentially harmful substances such as organic micro pollutants and trace metals.

A pot culture experiment was conducted in the net house of the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during kharif [July-October] 2009 to study the "Effect of conjoint application of sewage sludge and fertilizers on trace metals accumulation in plant and soil under rice cultivation". The experiment was set up in factorial completely randomized design keeping three replications. Five levels of recommended dose of fertilizers (RDF 0, 25, 50, 75 and 100%) taking 120 kg N, 60 kg P2O5, 60 kg K2O ha-1 as 100% RDF and five levels of sewage sludge as 0, 10, 20, 30 and 40 t ha-1. Dried sewage sludge was collected from sewage treatment plant Bhagwanpur, Varanasi, U.P and analyzed for trace metals content. The content of Fe, Mn, Cu, Zn, Cd, Cr, Ni, and Pb in the rice and DTPA extractable content of these metals in soil were determined.

The results showed a significant increase in trace metals content of soil with application of sewage sludge. The DTPA extractable Fe, Mn, Cu and Zn in soil ranged between 18.65 to 48.67,10.72 to18.64, 5.28 to7.10, and 2.42 to 8.53 mg kg-1, respectively. The Cd, Cr, Ni and Pb content of soil increased from 0.71, 0.10, 5.10 and 0.27 to 4.32, 0.58, 9.31 and 3.29 mg kg-1, respectively. The highest value for DTPA extractable trace metals in soil was recorded with the application of 40 t ha-1sewage sludge. The maximum value of Fe, Cu, Mn, Zn, Cd, Cr, Ni and Pb in rice straw was 160.66, 5.60, 18.61, 38.88, 5.89, 7.33, 25.88 and 0.92 mg kg-1while minimum was recorded as 73.99, 3.48, 15.40, 22.25, 0.74, 2.14, 3.60 and 0.44 mg kg-1, respectively. As regard to trace metal content in rice grain, maximum value of Fe, Cu, Mn, Zn, Cd, Cr, Ni and Pb content was 67.53, 3.59, 6.55, 23.04, 2.40, 6.42, 15.74 and 0.93 mg kg-1, while minimum was 37.08, 2.09, 2.50, 12.67, 0.30, 1.33, 3.30, 0.07 mg kg-1, respectively. Increase in trace metals content in plant and accumulation in soil may be attributed to its content in sewage sludge. The soil pH was 8.05, 8.10, 8.15, 8.23 and 8.33 with the application of 0, 10, 20, 30 and 40 t ha-1 sewage sludge in post harvest soil and the corresponding values of Zn/Cd ratio were in the order of 35.5, 10.76, 11.12, 10.39 and 9.90, respectively in rice grain. Application of higher doses of sewage sludge appreciably increased trace metals accumulation in soil as well as plant parts. Thus its application in soil needs regular monitoring to keep the level of trace metals with the permissible limit.

Keywords：*Sewage sludge, fertilizers, trace metals ,accumulation ,rice, soil*

P4-4

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Effect of Fe(ii)/cu(ii) Interaction on Reductive Transformation of Pollutants and Copper Aging Enhancement

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Iron is the first abundant transition metal in the Earth's crust, and iron is an essential nutrient or micronutrient for almost all living organisms in terrestrial ecosystems. The high redox activity of iron triggers many processes in soils such as mineral weathering, nutrient cycling, and contaminant mobility and transformation, many of which further influence soil genesis and soil physicochemical properties. Copper is an essential trace element in plant growth and development, and is also a heavy metal that provides numerous advantages under controlled conditions. The chemical speciation, bioavailability, toxicity, and mobility features of copper in soil are controlled by redox processes, especially the redox process of iron in soil. The reactions between Fe(II) and Cu(II) are so complicated, they react not only directly but also indirectly both in heterogeneous suspensions and in homogeneous suspensions. Thus, Fe(II)/Cu(II) interaction can affect the reductive reactivity of sorbed Fe(II) species. The overall objective of this study was to investigate the impact of the Fe(II)/Cu(II) interaction on reductive transformation of organic pollutants [i.e. 2-nitrophenol (2-NP) and pentachlorophenol (PCP)] and copper species transformation using various analytical methods including cyclic voltammetry (CV), sequential extraction procedure (SEP) and etc. CV measurements were performed to identify the redox behavior of the active species, whereas SEP method was used to extract and analyze Cu species. Kinetic measurements demonstrated that rates of 2-NP and PCP reduction rates (k) by Fe(II) species can be promoted by adding Cu(II), whereas the impact of the Fe(II)/Cu(II) interaction on different minerals differed significantly with the k values. With the increase in the extent of interaction of sorbed Fe(II)/Cu(II), CV tests provided direct evidence that k values of pollutants transformation increase because of the negative shift of peak oxidation potential (Ep). The increasing trend in k values of pollutants transformation (kaolin < TiO2 < α-FeOOH) are consistent with the declining trend in Ep values of the active species obtained for the mineral-coated electrodes (kaolin/GC > TiO2/GC > α-FeOOH/GC), as well as with the increasing trend in the normalized sorbed Fe(II) density (kaolin < TiO2 < α-FeOOH), demonstrating that the enhanced interfacial reactions of pollutants reduction on α-FeOOH are possibly attributed to the lower EP values and the higher k/sorbed Fe(II) values, thereby illustrating that pollutants reduction on α-FeOOH is slightly more sensitive to the Fe(II)/Cu(II) interaction than the two other cases. On the other hand, SEP results showed that the dissolved Cu(II) is gradually transformed into immobilized Cu species, and X-ray photoelectron spectroscopy (XPS) results showed that the active sorbed Fe(II) species could reduce Cu(II) to both Cu(I) and metallic Cu under the effects of iron reduction microbial, which indicates that Cu aging is also enhanced by Fe(II)/Cu(II) interaction. Although the concentrations of Cu(II) used in the present study were higher than in naturally available Cu(II), the results obtained are expected to improve our general understanding of Fe(II)/Cu(II) interaction on soil iron redox chemistry. Likewise, the findings will provide positive implications for detoxification of polychlorinated pesticides and immobilization of heavy metal ions.

Keywords：*Fe(II)/Cu(II) Interaction, Adsorbed Fe(II), Copper aging, Cyclic voltammetry, Sequential extraction procedure*

P4-5

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Uptake of Pharmaceuticals by Soil Minerals

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Swelling clay minerals are an important soil component. They have strong affinities for many ionizable drugs, resulting in a higher amount of drug adsorption. The adsorption occurred on the external surfaces and, mostly, in interlayer spaces, attributed to cation exchanges between hydrated metals cations previously adsorbed on clays and the ionizable drugs in cationic and zwitterionic forms. The consequences of cation exchange of organic cations for inorganic cations would result in interlayer expansion due to the larger sizes of organic cations and different interlayer configurations. The intercalated cationic drugs are more stable against desorption by regular water. However, multiple cycles of desorption using Al3+ could remove the intercalated drugs from the interlayer. The intercalated antibiotics may render their antimicrobial activities due to a much lower equilibrium solution concentration of the drug. The inhibitive effect of antibiotic intercalation may lead to development of increased antibiotic resistance of bacteria once in contact with the antibiotic-intercalated clay system over prolong periods of time.

Keywords：*clay minerals, pharmaceuticals, adsorption, desorption*

P4-6

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Fate of Munitions Constituents in the Environment by the Influence of the Cesium Charge Sites in Soils

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The fate of Munitions Constituents in the Environment is governed by the properties of soils among others and the literature indicates that organic carbon and clay minerals are the most important soil components influencing that. The experimental problem to use clay is that, clay is usually reported based on particle size, not mineralogy. The clay mineral content is rarely determined; the results for clay-size particles are sometimes used as a surrogate for the content of clay minerals. However, there can be large differences between these two values. Anderson and Sposito in 1991 developed a method for measuring the contribution of permanent and variable surface-charge sites to the net surface charge density in clays, based upon the strong preference of permanent-charge sites and low affinity of most variable-charge sites for cesium. This research modified and refined the experiment of Anderson and Sposito and in a novelty way used it with organic carbon to determine the fate of MC in soils. We conducted batch experiments near 1:1 soil to solution ratios reflecting field conditions using a mix of HMX, RDX, nitroglycerine (NG), nitroguanidine (NQ), TNT and 2,4-dinitrotoluene as MC. We used twenty five soils that varied from 5 to 40% clay and 0.04 to 18% total carbon in an experiment that involved 2 days of adsorption followed by four consecutive desorption steps. The most important observation was that for each MC, even if they were in a mixture, we successfully predicted the fate of MC in the environment by the partition coefficients improving them in the accuracy compare with the carbon normalization traditional approach, when we used the cesium charge sites.

Keywords：*Charge Sites, Munitions Constituents, Cesium*

P4-7

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

The Bean (phaseolus Vulgaris L.) Rhizospheric Effect on the Desorption Kinetics of Zinc in Sewage Sludge Amended Soils

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Zinc (Zn) deficient soils are widespread in different zones of the world, being more common in calcareous soils of Iran. Municipal sewage sludge has been increasingly used in numerous countries around the world as fertilizers on farmlands because of their high content of organic matter and essential nutrients that favor crop growth. Desorption of Zn in the rhizosphere soil is the primary factor that impact bioavailability of Zn. The greenhouse experiment was performed to determine Zn desorption characteristics in the bean rhizosphere and the bulk of 10 calcareous soils amended with sewage sludge (1% w/w) using rhizobox. The kinetics of Zn desorption were determined by successive extraction with DTPA-TEA in a period of 1 to 504 h at 25±1 oC in the bulk and the rhizosphere soils. Moreover, Zn extracted by using 3 extractants (DTPA-TEA, AB-DTPA, and Mehlich 3) in the bulk and the rhizosphere soils. The results showed that Zn extracted in the rhizosphere soils were significantly ($P<0.01$) lower than the bulk soils. The mean of Zn desorption in the bulk and the rhizosphere soils were 13.78 and 12.93 mg kg-1, respectively. Desorption kinetics of Zn conformed fairly well to power function, first order, parabolic diffusion, and simplified Elovich equations. The results of kinetics study indicated that desorption rate coefficients decreased in the rhizosphere soils compare to the bulk soils. The correlation studies showed that Zn desorption after 504 h were significantly correlated ($P<0.05$) with Zn extracted by using DTPA-TEA, AB-DTPA and Mehlich 3 in the bulk and the rhizosphere soils. The results of this research showed that in amended calcareous soils with sewage sludge, Zn desorption characteristics in the bean rhizosphere were different from the bulk soils.

Keywords：*Calcareous soils, DTPA, Rhizobox, Successive extraction*

P4-8

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Cadmium Contents of Soils and Cocoa Beans from Ghana

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The suspected increases in cadmium concentrations in cocoa and chocolate products have recently become a concern among European Countries. The E.U. Commission of Regulation intends setting up maximum levels for cadmium in cocoa and chocolate products which could significantly affect the capacity of cocoa producing countries to export cocoa into E.U. countries. Studies were undertaken to evaluate the status of cadmium residues in cocoa beans and in soils of Ghana. Soil samples were taken from fertilized and unfertilized cocoa farms ranging between 10 and 15 years and also from adjacent forests across the major cocoa growing regions of Ghana. Dried cocoa beans were also sampled from the main crop purchases of the 2011/2012 cocoa season. The results indicated that cadmium concentrations were higher in the top layer of soils and decreased with depth. In the fertilized cocoa farms, the average concentrations of cadmium were 0.047, 0.031 and 0.031 mg/kg soil for the 0-15 cm, 15-30 cm and 30-45 cm soil depths respectively. The average cadmium concentrations in the unfertilized farms were 0.035, 0.029 and 0.030 mg/kg soil for the 0-15 cm, 15-30 cm and 30-45 cm soil depths respectively. Compared to the adjacent forests soils, cocoa cultivation and its management practice of phosphorus fertilizer application for 3 years did not significantly influence the cadmium concentrations at all soil depths. The average cadmium concentrations in cocoa nib and cocoa bean shell were 0.269 and 0.306 mg/kg dry matter respectively. The cadmium concentration in the bean shell was significantly ($p<.005$) higher which suggest that cadmium accumulate in the cocoa bean shell. Cadmium concentrations in cocoa soils and cocoa beans from Ghana are below the optimum limits allowed in the soil and in the cocoa bean.

Keywords：*cocoa, soil, cocoa bean, cadmium concentration*

P4-9

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Arsenic Immobilization in Soil Using Iron-Based Amendments: Process Optimization by Response Surface Methodology

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Following the reports regarding high concentrations of arsenic in soils and groundwater of many areas around the world, the concern about arsenic exposure in humans and other live organisms has been increased. Given the high toxicity of arsenic, it is necessary to remediate the contaminated soil as well as groundwater resources, there by preventing adverse impacts on human and environmental health. Arsenate [As (V)] and Arsenite [As(III)] are the most common forms of arsenic in the environment depends on pH and redox conditions. However, arsenite is more toxic and mobile than arsenate. The distribution of arsenic in soils is largely governed by it's adsorption on the surfaces of minerals. In this regard, the effectiveness of Fe (II) ,ZVI and Fe-Z has been proven to remediate As-contaminated soils and groundwater. In this research, modeling and optimizing the arsenic immobilization using three iron amendments (soluble Fe(II), zero-valent iron(ZVI), and Fe(II)-modified zeolite (Fe-Z) in a spiked soil was conducted by response surface methodology. Three factors of initial concentration of As (III) (20 to 580 mg kg^{-1} of soil) as sodium arsenite, amount of added Fe (0.5 to 2.5 weight percent of soil for Fe(II) and ZVI and 0.05 to 0.25 weight percent of soil for Fe-Z) and shaking time (15 to 960 minutes) were selected as the effective factors on arsenic immobilization efficiency in the soil. The method of central composite design (CCD) with 5 levels for each factor was used to optimize the parameters of the model. The analysis of variance showed that the polynomial model was statistically significant ($p<0.01$) for all three amendments. The results of arsenic immobilization in the study showed that at 200 mg As kg^{-1} soil and 10 hours shaking time, the immobilization percentages of As(III) in 0.5% Fe (for Fe(II)), 1.5% Fe (for ZVI) and 0.17 % Fe (for Fe-Z) were 90.6, 91 and 81.4 %, respectively. Furthermore, the results obtained showed that Fe (II) was more efficient and cost-effective than ZVI and Fe-Z in long-term immobilization.

Keywords：*Arsenic, Central compound design, Iron, Zeolite,*

P4-10

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Environmental Fate of Fluoride Applied to Soil and Plants

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Fluoride (F-) is not an essential plant nutrient but high rates of F- ingestion may lead to fluorosis in animals. Groundwater in parts of the Great Artesian Basin in Australia may contain up to 0.42 mM F- and fluorosis may occur should this water be used for irrigation or livestock. With the reliance on groundwater for irrigation in parts of Queensland, the fate of F- in the environment needs to be understood. The aim of this study was to investigate the reactivity of F- with soils and the uptake of F- by plants from soil and overhead irrigation.

First, adsorption isotherms were obtained by mixing soil with solutions containing increasing F- and measuring free F- in the supernatant. Second, desorption was measured by mixing F-loaded soil with water and measuring F- in the supernatant. Third, F-uptake from soil by Lucerne (Medicago sativa cv. L91), leucaena (Leucaena leucocephala cv. Tarramba) and Rhodes grass (Chloris gayana cv. Top Cut) was determined by growing the plants in a glasshouse in pots containing either a Red Kandosol (Rhodic Ferralsol), a Yellow Kandosol (Xanthic Ferralsol), a Red Vertosol (Rhodic Vertisol), or sand (Arenosol) and amended to contain 0-26.3 mmol/kg F-. Finally, foliar uptake of F- from overhead irrigation was determined by growing plants in Ferrosol (to avoid soil uptake of F-) and irrigated up to six times with solutions containing 0-0.31 mM F-. Dried and ground foliage was digested using the alkaline fusion method prior to the measurement of F- in the digest.

Sorption of F- by the Red and Yellow Kandosols removed 90-95% of added F- from solutions but there was low F- sorption by the sand. Adsorption of F- released only a fraction of OH- from the mineral phase, discounting ligand exchange as an important F-binding mechanism. In the three soils, apart from sand, desorption of F was low, with ≤ 20% of added F- being desorbed after 10 steps; F- in the supernatant decreased to ≤0.1 mM after two desorption steps. Therefore, mobility of F- in soil is low and the environmental risk of applying F-containing groundwater (containing 0.26 mM) is low at typical irrigation rates of <60 ML/ha. Desorption of F- decreased at higher ionic strength, thus, saline irrigation water is not expected to increase desorption. Furthermore, SO42- present in the soil solution does not affect adsorption or desorption of F-, most likely due to SO42- and F- having different sorption mechanisms.

Lucerne accumulated up to 4.2 mmol F/kg in foliar parts with 26.3 mmol F/kg applied to the Red and Yellow Kandosols, and up to 2631 mmol F/kg when grown in sand, but < 1 mmol F/kg when grown in the Red Vertosol. By contrast, foliar F- concentrations in leucaena and Rhodes grass did not exceed 1mmol F/kg with increasing soil concentrations on any of the soils tested. Accumulation of F- by lucerne was due to the uptake of Al-F complexes. Both the amount and bioavailability of F- in these complexes will determine toxicity to grazing livestock.

Uptake of F- from overhead irrigation increased with the number of irrigations. Lucerne accumulated more F- (2.3 mmol F/kg) than the other species (~1 mmol F/kg), possibly due to differences in leaf morphology. Fluoride was retained on the outer leaf surfaces and could partially be removed by simulated rainfall. Thus, rainfall or heavy irrigation with good quality water may remove a substantial amount of accumulated F- from foliar surfaces.

In conclusion, these plants may be irrigated with groundwater containing ≤ 0.31 mM F- without accumulating F- in foliar tissues above the maximum tolerable level of 1.8 mmol F/kg body weight for young beef cattle provided that: (1) a suitable soil, with high F- adsorption capacity, is irrigated, (2) irrigation water does not add more than 26 mmol F/kg to the soil over the life of the irrigation program, and (3) irrigation with good quality water is regularly applied to remove F accumulated on the foliar surfaces of lucerne. Soils containing a high proportion of sand (quartz) are not suitable for irrigation with groundwater containing even low concentrations of F-, whilst soils high in Al- and Fe- oxides, kaolinite, and Ca are appropriate.

Santos GLNG Ltd (Australia) funded this research.

Keywords：*adsorption, desorption, uptake, complexation, mobility, bioavailability*

P4-11

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Zonation of Heavy Metals (CD, PB, NI, ZN, FE, MN and CU) in Arable Land of the Alborz Dam Downstream Basin-Iran

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Soil pollution and heavy metal accumulation is one of the most important environmental problems to plants, animals and human health. Naturally, heavy metals exist in soil but industrial and agricultural processes and municipal activities cause heavy metals accumulation in soil and food chain pollution, that cause plants to absorb heavy metals.

Because the lack of heavy metal distribution map in Iran, the objective of this research is to provide map of heavy metal (Cd, Pb, Ni, Zn, Fe, Mn and Cu) distribution and evaluate pollution pattern in arable land of the Alborz Dam downstream basin in area of 95000 hectare. Composite soil samples with systematic sampling scheme in 2-Km regular grid were provided. A total of 215 surface soil samples were collected. In each site, one surface composite soil sample has been collected in 50 m2 in depth of 0-30 cm and geographic features of samples were addicted by GPS.

Total Cd, Pb and Ni content were extracted by 4M HNO3. Carbonate form (as potentially available form) of Cd, Pb and Ni were extracted by 0.05M Na2EDTA and available Zn, Fe, Mn and Cu extracted by DTPA. Spatial distribution maps were drawn using the ordinary kriging method, in order to identify the most affected areas and the main pollution sources. ArcGIS 9.0 was applied in order to create the spatial database. The best interpolator were monitored with respect to some statistics such as mean error, mean square error and root mean square standardized.

Results showed that carbonate form of Cd, Ni and Pb were not acceded the maximum permitted standard level. Total content of Cd, Ni and Pb was normal, but in some areas is more than toxicity level. Soil contamination of Cd, Ni and Pb was mainly derived from anthropic activities such as agricultural practices, irrigation with polluted water. Cu and Fe with high correlation coefficient have high content around babol, kiakola and babolsar. Zn content is normal in study area and in some places is less than normal content but rather is suitable for plants. Evaluating kriging method showed that, ordinary kriging is the best way of estimating unsampled areas, but not for Fe. In the maps, the most contaminated area was near Siahrod River in east, especially between Joibar and Kiakola and near Ghaemshahr.

Keywords：*soil pollution, heavy metal, Cd, Pb, Ni, Zn, Fe, Mn , Cu*

P4-12

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Approaches to Revealing Relationships between the Heavy Metals Sorption and the Formation of Their Compounds in Soils

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Introduction. The integrated study of the sorption of heavy metals by soils and the formation of different compounds by the metals sorbed contributes to the understanding of transformation mechanisms of their compounds in the soil and the assessment of tendencies in changes of their mobility under contamination.

Object and material. Experiments were conducted with samples of ordinary chernozem, whose properties are: Corg, 2.3%; pH, 7.3; CEC, 37.1 mM/100 g; exchangeable bases (mM/100 g): Ca2+ - 30; Mg2+ - 7; CaCO3 - 0,1 %; physical clay (<0.01 mm), 53.1%; and clay (<0.001 mm), 32.4%.

For experiment on Cu sorption the soil samples were triturated to <1 mm and treated with solutions of Cu acetate with the following concentrations (mM/l): 0.05, 0.08, 0.1, 0.3, 0.5, 0.8, and 1.0 (at soil : solution ratio of 1 : 10). The suspensions were shaken for 1 h and left to stand for 24 h. Then, the solutions were filtered, and the concentrations of metal in the filtrates were determined by atomic absorption spectroscopy. The content of ions sorbed was calculated from the difference between the Cu concentration in the initial and equilibrium solutions.

The capacity of soils to sorb metals is described by empirical Langmuir equation:

$X/m = Smax\ kC/(1+kC)$,

where X/m is the amount of metal ions sorbed per unit mass of sorbent; C is the equilibrium concentration of metal in the contacting solution; Smax is the maximum adsorption of metal ions, mM/kg; and k is the equilibrium constant, l /mM.

The Langmuir equation was transformed into a linear form for determine adsorption parameters. Four linear segments were found in isotherm of Cu sorption by the soil. They corresponded to the following metal concentrations in the contacting solutions (mM/l): 0.05, 0.5, 0.8, and 1.0. Then the solutions were separated from the solid phases. In all samples, the contents of metal in 5 fractions were determined using the Tessier method (Tessier et al., 1979): exchangeable (1 M MgCl2, pH 7.0), bound to carbonates (1 M NaCH3COO, pH 5.0 (with CH3COOH)), bound to Fe, Al, and Mn (hydr)oxides (0.04 M NH2OH HCl in 25% CH3COOH), bound to organic matter (0.02 M HNO3+ 30% H2O2, pH 2.0 (with HNO3), then 3.2 M NH4CH3COO in 20% HNO3)), residual fraction (HF+HClO4, then HNO3).

The isotherms were plotted for each of 5 separated metal fractions. The curves plotted were satisfactorily described by the Langmuir equation for heterogeneous exchangers. Adsorption parameters were determined by the approximation of accumulation curves for each metal form.

Results. The absolute content of all strongly and weakly bound Cu compounds in the soil increased with increasing metal load. According to the binding strength (K, l/mM) to soil components, metal compounds formed the following: bound to silicates (5536.0±382.0) > bound to organic matter (150.7±29.2) > bound to Fe-Mn (hydr)oxides (66.7±18.2) > bound to carbonates (56.7±22.2) > exchangeable (1.6 ±0.7).

Thus, this approach allows the metal compounds to be classified in accordance with the binding strength to soil components. The results show a general tendency: the compounds of metal formed during their sorption by the soil are less stable and, hence, more mobile than their natural compounds, which determines the ecological hazard of metal-contaminated soils.

Keywords : *fractionation, isoterm, heavy metal compounds, soil components*

P4-13

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Inhibitory Effect of Silver Nanoparticles on Ryegrass Growth and Soil Enzyme Activity

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Silver nanoparticles are widespread applied as bacteriostatic agents in medicine and industry. The accident release of silver nanoparticles to environment is thus inevitable over time. However, the understanding of silver nanoparticles environmental fate is currently limited, even the effect of silver nanoparticles on plant growth. In this study, the effect of silver nanoparticles rate on ryegrass growth and soil enzyme activities is investigated by pot experiment. The growth characteristics of ryegrass and several soil enzyme activities were measured in the growth stages and after the harvest, respectively. The results shown that silver nanoparticles inhibits dry mass of ryegrass over 120 mg g^{-1} soil of silver nanoparticles. Interestingly, the low application of silver nanoparticles enhanced the dry mass of ryegrass to some extent. The total Ag content in soil taken after the harvest increased with increasing silver nanoparticles rate. The suggestion is thus that superfluous application of silver nanoparticles inhibits the growth of ryegrass. The activity of dehydrogentation enzyme, urease and alkaline phosphatase decreased with increasing silver nanoparticles rate. The invertase activity was observed in the treatment in 10 mg kg^{-1} soil of silver nanoparticles. The catalase activity was no significance in application rate of 0-160 mg kg^{-1} soil of silver nanoparticles. The application of silver nanoparticles not only significantly inhibits ryegrass growth but also markedly impact on the enzyme activity.

Keywords：*silver nanoparticles, ryegrass, inhibitory effects, distribution*

P4-14

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Sorption of Heavy Metals, PB (ii), CU (ii), ZN (ii), And NI (ii) on Pine Bark Based Composts

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A significant percentage of South African soils in the mining areas have high levels of heavy metals, notably Hg, Cr, Pb, Zn, Cu, Ni, Cd, As, etc. Therefore, there is a need to evaluate low cost materials that could be used in reducing the bioavailability of heavy metals in contaminated soils. The objective of this study was to determine the heavy metal retention capacities and hence remediation potential of pine bark-based composts for selected metals ions, namely Pb (II), Cu (II), Zn (II) and Ni (II). The composts were pine bark (PB), pine bark-goat manure (PBG) and pine bark-sewage sludge (PBS). The adsorption of Cu (II), Pb (II), Zn (II) and Ni (II), on composts was determined in three replicate sub-samples of 1.0g of compost to which 30 cm3 solution containing 0, 10, 50, 100, 200 or 400 mg l-1 of metal ions was added. 0.01 M CaCl2 was used as a background electrolyte and the experiment was conducted without pH adjustment. The compost suspensions were shaken mechanically for two hours and then centrifuged and filtered to obtain clear solutions. Heavy metals were determined in the solutions by atomic absorption spectrophotometer. The amount of heavy metal sorbed was calculated as the difference between the amount of heavy metal added and that remaining in solution after equilibration. The linear form of the Langmuir and Freundlich equations were used to calculate sorption parameters. The Langmuir sorption maximum capacity of the composts for metal ions followed the order PBG >> PBS > PB and similar trends were observed for the Langmuir constant b and the Freundlich constant KF. Higher adsorption capacities of Cu (II), Zn (II) and Ni (II) ions were found in the PBG composts than in the PB and PBS composts. The maximum sorption capacity of PBG compost for different metals followed the order Cu (II)>Pb (II)>Zn (II)>Ni (II) whereas, the maximum binding capacity of PB and PBS composts followed the order Pb (II) > Cu (II)> Zn (II) > Ni (II). The removal of heavy metals by the composts may be attributed to the binding of heavy metals by adsorption, chelation and ion exchange on the surfaces of the composts. Pine bark/goat manure (PBG) was the most effective for the removal of heavy metals, removing more than 97% of Cu (II), Zn (II) and Ni (II) and 84% of Pb (II) from solution. Thus, pine bark/goat manure compost can be used effectively for the bioremediation of heavy metal contaminated soils.

Keywords：*Compost, Goat manure, Heavy metals, Pine bark, Sewage sludge, Sorption*

P4-15

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Plant-Soil Interactions as Promoter for Increased Soil Function, Structure and Diversity in a Crude Oil Polluted Agricultural Field

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Crude oil and gas pollution is the major environmental hazard caused by oil and gas exploration, exploitation and production in the Niger Delta region of Nigeria and many parts of the world and can occur in form of spillages due to oil well blowout, corrosion of pipelines, accidental discharges and vandalisation giving rise to soil pollution. Given their heterogenous composition, fresh crude oil spill site was studied for heavy metals occurence, nutrient availability, physical and enzyme activities in relation to control agricultural soil with no history of polltion. In this study, a phytoremediation attempt with Fimbristylis was in place for 90d and soil samples thereafter were analysed for all identified parameters. Up to 17.21mgkg-1 Cd, 1.25 mgkg-1 As, 30.00 mgkg-1 Cr, 20642,50 mgkg-1Fe and 86.20 mgkg-1 Pb was detected in the spill site and <0.001 mgkg-1 Cd, 0.49 mgkg-1As, 18.70 mgkg-1 Cr, 16657.50 mgkg-1Fe, and 45.30 mgkg-1Pb in the control soil. At 95% confidence level, up to 70% clean-up was achieved. B-glucosidase, Phosphomonoesterase and Dehydrogenase activities improved significantly with this phyto- technology while microbial population increased with pollution.

Keywords：*Soil function; Heavy metals; Soil Enzyme activity; Plant-Soil interactions; Clean-up.*

P4-16

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

The Assessment of Arsenic Availability in Soils Using the In-Situ Diffusion Gradients in Thin Films Technique (dgt) - A Comparison Study of Dgt and the Typical Extraction Methods

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Risks of arsenic (As)-contaminated soils are difficult to assess. Total soil As content has been proved to be a poor indicator of arsenic toxicity. Scientists are moving toward a surrogate chemical measurement as an indicator of the risk. However, the ability of the soil to sustain the solute concentration in soil solution following depletion by plant uptake was ignored in measurements of of operationally defined fractions of As, such as fractions obtained by chemical extraction methods. Zhang et al (2001) introduced a new biomimic surrogate for assessment of heavy metals in soils, which provided a concept of effective concentration, C_E, measured using Diffusion Gradients in Thin Films (DGT), which locally lowers soil solution concentrations, inducing metal supply from the solid phase. Previous studies suggest that DGT is a reliable method for pre-concentration of total dissolved arsenic in waters and can be used as a monitoring tool to evaluate the efficiency of phytoextraction and to study the potential resupply of labile pools after phytoextraction has ceased. However, researches on assessment of bioavailability of As in soils are less available. This study was conducted to evaluate the feasibility and accuracy of available As measurement in soils using DGT and in further to shed light on the risk evaluation of As-contaminated soils. Bio-indicator method was introduced to evaluate the dependence of concentrations of As in plant tissue (Edible rape) on the effective concentration (C_E), soil solution As, chemical extracted As and total soil As. Edible rape was grown in 43 soils containing a large range of As concentrations. The results showed that better correlation relationship was obtained between As concentration in plants tissue and C_E, than other measurements across all soils, and the correlation coefficients (R^2) before and after growth were 0.8401 and 0.8309, respectively. The plant As and soil solution As are closely related, the correlation coefficients (R^2) before and after growth were 0.834 and 0.8101, respectively. Measurement of 1 mol·L^{-1} HCl-extractable As (R^2 =0.6781), 0.5 mol·L^{-1} $NaHCO_3$-extractable As (R^2 =0.6204), and 1 mol·L^{-1} NH_4Cl-extractable As (R^2 = 0.5697) were inferior. Plant As was more scattered and nonlinear with respect to soil total As (R^2 = 0.2693). Consistent results were obtained across soils at high pH (>6.5), but unexpected results were obtained across soils at low pH (<6.5). The reason for this might be various, such as a variety of anions, cations, and fulvic acids, besides, improper diffusion coefficient may also lead to incorrect results. Further study need to be done on the application of DGT in soils under low pH. The R values were obtained by DGT measured concentrations (C_{DGT}) divided by centrifugal method (C_{SOLN}). Three of the tested soils have big R values (>0.95), which demonstrated that the local lowering of pore water concentrations would be counteracted by a remobilization to the pore waters, and the rate was sufficiently fast, which were therefore referred to as the sustained case. The rest tested soils had lower R value, less than 0.95, which demonstrated that there would be some remobilization, but in sufficient to sustain adjacent pore water concentrations, which were referred to as the partial case. Temporal and spatial changes in concentrations of As in solid and solution phases of soils during in situ DGT deployments would be simulated and resupply parameters could be estimated by DIFS modal, including response time (T_c) and desorption rate constants (k_b). The results indicated that all three soils with big R value (>0.95) had a short T_c and a high k_b. For these tested soils, except for several soils, all had a large T_c and a lower k_b, which demonstrated that the resupply of solid phase in soils made lower contributes to the bioavailability of soil As. These also indicated that, for As uptake by plants in these particular soils, As supply from solution phase is the dominant controlling process. These parameters are helpful to in-depth understand the bioavailability of soil As. It is concluded that the DGT is an effective technique in the prediction and assessment of As bioavailability in soils, especially for the soils with high pH (>6.5).

Keywords：*DGT, Arsenic, Availability, Extraction, DIFS*

P4-17

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Polycyclic Aromatic Hydrocarbons in Post-Pyrogenic Soils of Drained Peatlands (Moscow Region, Russia)

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Polycyclic aromatic compounds (PAHs) are compounds formed in different natural and anthropogenic processes and could be found in many landscape components. These compounds are carcinogenic and pose danger for the population. Some sources of PAHs, for instance traffic exhausts and oil combustion are well-studied, but insufficient data are available on the hightemperature production of PAHs in natural processes like volcanism and wildfires. Wildfires are considered to be global factor of these compounds in the environment, but very little factual data are on this topic.

The peat fires differ from the forest and grassland fires, because the soil organic matter acts as burning material. The deep peat horizons are heated during smoldering fires, causing the significant change in soil properties. But the most of available data are devoted to changes in organo-mineral soils. In addition, the alteration in hydrological regime, for instance drainage, makes landscapes and soils very vulnerable to wildfires. Drained peatlands are widespread in the European part of Russia and they are affected to extreme wildfires of 2010. So there is a need of post-fire peat soils investigations in this region.

During current research ehe soils of drained peatlands affected by catastrophic wildfires of 2010 and 2002 were studied in the Eastern part of Moscow Region. A total of 14 profiles of histosols and histic podsols were investigated. These series included soils of plots subjected to fires of different intensities and age, as well as soils of the background plots. Soil samples were taken from genetic horizons and from every 10 cm.

The samples were analyzed for the contents of 14 prevailing individual PAHs compounds: fluorene, naphthalene, phenanthrene, chrysene, pyrene, anthracene, tetraphene, benz[a]pyrene, benzo[ghi]perylene, benzo[e]pyrene, coronene, dibenztiophene, triphenilene, benz(k)fluorantene.

After wildfires on drained peatlands morfological properties of soils were changed, the horizons of ash (up to 5 cm) and char (up to 3 cm) instead of organic layers were formed. In addition, the plots of post-pirogenic landscape were characterized by high variability of soil properties. For instance, the thickness of organic layer changed from 5 to 30 cm in a small plot of 5X5 m. These new horizons differ in the capability of PAHs accumulation. The char horizons have the highest concentrations of PAHs up to 300 ng/g because of incomplete burning of organic matter in this sites, and the ash horizons, where the complete burning occured, contain only 10 ng/g PAHs. The highest concentrations of PAHs in soil profiles were detected after recent fires, and in cases of thick peat layers.

After the combustion of peat chrysene, benz[a]pyrene, benz[e]pyrene, benzo[ghi]perylene, benz[k]fluorantene and tetraphene accumulated in soils. This is mainly the group of 4-6-nuclear compounds. The formation of high-molecular weight compounds is possible during smoldering process under a low oxygen supply. The oxygen deficit acts as a factor of the organic fragments recombination and PAHs production; therefore, relatively large amounts of PAHs are formed in peat fires. Moreover the peat fires occur directly in the soil layer; therefore, larger amounts of the resulting PAHs remain in the soils of the fire sites. The migration of low-molecular weight compounds occures in histic podsols, in histosols PAHs accumalate only in upper organic horizons.

Keywords：*Polycyclic aromatic hydrocarbons, peatland fires, drained peatlands*

P4-18

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

The Bean (Phaseolus Vulgaris L.) Rhizospheric Effect on the Desorption Kinetics of Copper Using Dtpa in Amended Soils with Sewage Sludge

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Copper (Cu) deficient soils are widespread in calcareous soils of Iran. Municipal sewage sludge as fertilizers has been increasingly used in some countries around the world because of essential nutrients such as Cu that favor crop growth. Study of desorption kinetics of Cu in rhizosphere soils give information about potential of soils to supplying Cu for plant uptake. The greenhouse experiment was performed to determine Cu desorption characteristics in the bulk and the bean rhizosphere of 10 amended soils with sewage sludge (1% w/w) using rhizobox. The kinetics of Cu desorption in the bulk and the rhizosphere soils were determined by successive extraction with DTPA-TEA in a period of 1 to 504 h at 25±1 °C. Moreover, Cu extracted by using 3 extractants (DTPA-TEA, AB-DTPA, and Mehlich 3) in the bulk and the rhizosphere soils. The results showed that Cu extracted in the rhizosphere soils were significantly ($P<0.05$) lower than the bulk soils. The mean of Cu desorption in the bulk and the rhizosphere soils were 15.72 and 14.74 mg kg-1, respectively. Desorption kinetics of Cu conformed fairly well to power function, first order, parabolic diffusion, and simplified Elovich equations. The results of kinetics study indicated that desorption rate coefficients decreased in the rhizosphere soils compare to the bulk soils. The correlation studies showed that Cu desorption after 504 h were significantly correlated ($P<0.05$) with Cu extracted by using DTPA-TEA, AB-DTPA and Mehlich 3 in the bulk and the rhizosphere soils. Moreover significant correlation ($P<0.05$) was found between Cu uptake in shoot and Cu desorption after 504 h in the rhizosphere. The results of this study illustrated that in amended calcareous soils with sewage sludge, Cu desorption characteristics in the bean rhizosphere were different from the bulk soils.

Keywords：*Rhizosphere, Wheat, Cu, Desorption kinetics*

P4-19

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Btex Analysis Using A Headspace Gc-Ms In Soil And The Germination And Radicle Growth Inhibition By Btex

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Benzene, toluene, ethylbenzene, and xylene (BTEX), which are volatile aromatic hydrocarbons and main constituents of gasoline, are neuro-carcinogenic organic pollutants in soil and groundwater. World Health Organization (WHO) has limited their content in drinking water to 10, 700, 300, and 500 μg/L, respectively. Also, Korea Ministry of Environment which established the Soil Environment Conservation Act in 1996, the maximum permissible level and the countermeasure standard of BTEX in arable land to 1, 20, 50, and 15 and 3, 60, 150, and 45 mg/kg, respectively. BTEX determination in soil was conducted by gas chromatography mass spectrometry method with headspace assembly. Linear correlations from 0.1 to 20 mg/L for BTEX detected with coefficient correlations as 0.9807-0.9995, respectively. Recoveries of BTEX ranged from 73.7 to 96.9% using the established method. The method was reliable since RSD % was below <15% (0.7-7.5%).

To determine the effect of BTEX on crop growth, we investigated the germination and radicle growth of major crops (lettuce, leek, kidney beans, rice, green perilla, tomato, soybeans, Chinese cabbage, radish, broccoli, onion, rape, and red pepper) consumed in Korea. Seeds were immersed in 0-2,500 mg/L BTEX solution for 6 hours, and then were germinated in growth chamber (23±2℃, dark condition). The germination rates of control in all investigated crops ranged from 80.0-100%. The germination and radicle growth of the majority of investigated crops were not inhibited germination and radicle growth even at 2,500 mg/L. However, the germination in lettuce and kidney beans, and the radicle growth in lettuce and leek were significantly inhibited by BTEX. Germination and radicle growth inhibition of lettuce by ethylbenzene and xylene were the highest, and the 50% inhibition of germination and radicle growth by them were 18.4 and 33.0 mg/L, 16.3 and 19.8 mg/L, respectively. Also, the half-lives of 10 mg/L BTEX in soil were 3.3, 10.8, 6.1, and 6.8 hours, respectively.

Keywords：*BTEX, headspace gas chromatography, mass spectrometry, germination*

P4-20

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Adsorption of Anionic Surfactant on Silica

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Introduction: Surfactants are widely used in many fields which are closely related to our life and environment. Household productions such as detergent, shampoo and toothpaste; industrial materials such as paint, food, cosmetic, and print contain large amount of surfactant. Enormous quantities of surfactants have been used and discharged into the environment. Because surfactant an destroy cells, it strongly affect living organisms and ecosystem. Conversely, surfactant is also used for the remediation of degraded soils and enhancing oil recovery from strata on account of their amphiphilic nature. Their overall influence on the soil environment is not fully understood. The basic transport, adsorption and decomposition of surfactant in soils are not clarified.
Silica is a most commonly found mineral in soil as quartz and is always negatively charged. There are many studies about adsorption of cationic surfactants on silica, and considerable adsorption amount was detected, but because of the weak hydrophobic interaction and relatively strong electrostatic repulsion between silica surface and anionic surfactants, its study is few.
Sodium dodecyl sulfate (SDS) is an anionic surfactant, which has a simplest carbon chain structure. SDS is adsorbed on the surface of humic soil which is also negatively charged. Because SDS is decomposed in the soil, its precise adsorption phenomenon cannot be indicated clearly.
In this research, SDS adsorption on silica is investigated under different pH and electrolyte concentration.
Materials and Methods: Quartz silica of 1.2 μm in average diameter was purchased from Sigma-Aldrich. SDS with linear alkyl chain was used. A batch method was taken to obtain the adsorption amount of surfactants. The adsorption experiment was conducted under different NaCl concentration and pH. Surfactant adsorption amount was obtained to subtract the amount in the equilibrated solution from the added amount as follows:
adsorption(mmol/kg)=(added(mmol)-conc.(mmol/L)×volume(L))/w(kg)
where, added is the amount of added surfactant, conc. is the measured surfactant concentration under the equilibrium concentration, volume is the solution volume in the beaker and w is the measured dry soil weight. Surfactant concentration was measured by surfactant selective membrane electrode method. The surfactant electrode potential (EMF in mV) was measured relative to a commercial Ag/AgCl (3.3 mol/L KCl) reference electrode equipped with a ceramic plug.
Result and Discussion: At pH 4.5, a sharp increase of the adsorption isotherm was observed when SDS concentration was low. The slope of adsorption isotherm showed larger than unit in double logarithmic scale. When the slope is unit, it is the so called “Henry slope”, which indicates the adsorption on isolated “equal energy” site that follows the ideal adsorption of the Langmuir equation. The steeper slope indicates a cooperative adsorption which was caused by the hydrophobic interaction among the adsorbed SDS. SDS adsorption became stronger by gathering together. The adsorption at lower pH was larger than that at higher pH because the negative charge of the silica increased with increasing pH and the increase of the negative charge induced the increase of repulsive force between SDS and the silica. SDS adsorption decreased with decreasing NaCl concentration and the adsorption could not be detected at 0.1 mM NaCl. At higher NaCl concentration, SDS adsorption proceeded because the high concentration of Na+ screened the electric field generated by the negative charge of the silica and it decreased the electric repulsive force between SDS and silica. At lower NaCl concentration, SDS adsorption decreased because the screening effect decreased and the electric repulsive force became larger.
SDS is adsorbed on a silica surface by hydrophobic attraction although both SDS and silica are negatively charged and electrically repulsive force is generated between them. However, the adsorption is too small to detect when electrolyte concentration is low.

Keywords：*Silica, Sodium dodecyl sulfate, adsorption*

P4-21

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Chemical Interaction and Control of Antibiotic Tylosin in Soil/Sediment Systems

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Application of animal manure as fertilizer to agricultural lands has caused great concerns over the release of veterinary antibiotics into the environment. Tylosin, a macrolide class of veterinary antibiotic compounds, is widely used in intensive animal production and the half-life of tylosin ranged from 2 to 200 days in different environmental matrics. Recent studies have showed that tylosin has been detected in various rivers and streams. In this study, we investigated the chemical behavior of tylosin and its control in soil/sediment systems as impacted by different environmental factors. In doing so, a series of experiments based on batch, column and microcosm incubation approaches were carried out to elucidate controlling mechanisms of tylosin behavior in soil systems. In addition, adsorption-desorption of tylosin by clay minerals was conducted at different pH and ionic strength conductions followed by X-ray diffraction and FTIR characterization. Tylosin adsorption and degradation in lagoon sediments was assessed under different pH and redox status. Tylosin adsorption by clay minerals and in soil/sediment systems was found to be greatly affected by pH, organic matter, ionic strength and redox potential. Increasing solution pH and ionic strength generally decreased tylosin adsorption by clay minerals, and adsorption of tylosin by montmorillonite was much higher than that by clay mica and kaolinite. X-ray diffraction analysis showed that tylosin was able to be intercalated into montmorillonite interlayer spaces as supported by FTIR observation of tylosin interaction with Si-O bond of the mineral. Removing organic matter from manure-affected soils also enhanced tylosin adsorption dramatically especially at low solution pH, suggesting important retention role of inorganic soil constituents. On the other hand, more tylosin desorption was also observed at low pH than at high pH. Kinetic and transport experiments indicated that tylosin adsorption in soil systems was rapid at initial stages followed by slow and continued adsorption. Amounts of tylosin adsorption were also increased when soils were treated with biochar amendment. Biochar significantly increased the retardation factor of tylosin in soil. In addition, adsorption and degradation of tylosin in soil and lagoon sediment systems were strongly influenced by pH and redox conditions. Under acidic (pH 5.5) and reduced (Eh -100mV) condition, tylosin persisted in dairy lagoon sediment suspensions much longer with resident time over 70 days. On the other hand, at pH 8.5, abiotic transformation of tylosin A was the major mechanism responsible for tylosin loss in sediment suspensions regardless of the redox potential status. In manure-affected soils, treatment of manure with common chemicals/montmorillonite clays significantly immobilized the antibiotic tylosin and reduced its potential loss in surface runoff and provides an efficient control of tylosin. Overall, the results suggest that tylosin in soil systems are significantly influenced by various physical and chemical conditions and careful assessment of these conditions is important in order to manage its behavior in the environment.

Keywords：*Antibiotics, tylosin, Chemical intercation, adsorption, desorption, pH, redox impact*

P4-22

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Adsorption of PB(ii) on Goethite-Bacteria-Humic Acid Composites

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Determination on Pb(II) bioavailability is crucial to understand the fate of toxic metallic cations in contaminated soil systems, the bioavailability of Pb(II) in the soil environment depend largely on their interactions (adsorption, complexation) with inorganic and organic surfaces, principally microorganisms, minerals and humic substances and their composites. The binding characteristics of Pb(II) on individual, binary and ternary composites of P. putida, goethite, and humic acid were investigated through equilibrium sorption experiments, attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR), and isothermal titration microcalorimetry.

Good correlations were found between the adsorption isotherms of Pb(II) on the various adsorbents and the Langmuir equation. The order for the adsorption capacity was P. putida > P. putida-HA > goethite-P.putida-HA > goethite-P. putida> goethite-HA > goethite. Compared with predicted values of Pb(II) adsorption onto goethite-HA, the measured values of Pb(II) adsorption onto goethite-HA composite increased, but by contrast those on goethite-P. putida composite decreased. Compared with Pb(II)-free samples, all of the bands for goethite-P.putida-Pb(II) complex decreased, while all of the bands goethite-P.putida-HA-Pb(II) complex increased, indicating phosphate groups, carboxylic groups, and amide groups in the surface of P.putida and the hydroxy groups of goethite are responsible for the binding of Pb(II).

The adsorption enthalpies (?H) calculated from the power-time curves revealed that Pb(II) adsorption on P. putida and goethite-P. putida composite were an exothermic reaction, while that on goethite-P.putida-HA was endothermic. The positive values of enthalpy (?H) and entropy (?S) for Pb(II) adsorption on goethite-P.putida-HA composite indicate that Pb(II) mainly interacts with amide groups as inner-sphere complexes. Data obtained in this study is helpful for a better understanding on the biogeochemistry of Pb(II) in soil.

Keywords：*Adsorption, Pb(II), goethite-bacteria-humic acid*

P4-23

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Mercury Bioavailability as Affected by Organic Ligand in Aqueous Environment

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Mercury is a major inorganic contaminant in water due to its high health hazards. In the last three decades, there has been an increasing awareness of mercury toxicity in various aquatic environments. Mercury undergoes a wide variety of chemical and biological transformations in aquatic ecosystems, and its fate highly depends on microbe-mediated transformations. Mercury biotoxicity is subject to its speciation and uptake by microbial cells. Like other metals, species of mercury can alter after chelating substances from organic and inorganic ligands. Dissolved organic matter (DOM) and ethylenediaminetetraacetic acid (EDTA) have been reported to be the most important organic ligands for aqueous mercury. However, arguments exist concerning the role of humic acids in determining the interactions between mercury and organism surfaces. Decrease, increase, and no effect of mercury uptake due to DOM have all been reported. An effective approach to measuring mercury bioavailability and evaluating the ligand impact on mercury uptake is biosensing technique, which could reflect the real physiological impact of toxic compounds. This study examined the kinetic response of a lux-based engineered bacterial bioreporter (strain E. Coli ARL1) to mercury under different environmental conditions, such as solution pH and presence of HA and EDTA. Our results indicate that the ARL1 bioreporter can detect Hg(II) at concentrations as low as 0.5 μg/L and there is an excellent nonlinear relationship between bioluminescence emission and mercury concentration up to 2,500 μg/L. The ARL1 concentration for the best response was found to be ~108 cfu/L. As for ligand impact, a gradual increase in light emission was observed with increasing concentrations of HA (as natural source ligands), suggesting that HA increases the bioavailability of Hg(II). This result was somewhat unexpected because HA has a high affinity for Hg(II) and would thus be expected to decrease Hg(II) bioavailability. An increase in negative charge on the bioreporter surface and formation of a ternary complex (R-Hg-DOM) are speculated to be responsible for the increased bioavailability. In contrast, addition of EDTA (as anthronogenic source ligands) decreased Hg(II) bioavailability as reflected by the decrease in bioluminescence signal. This reduction is comprehensible because the increased size and charge of the EDTA-Hg complex could hinder Hg(II) uptake through passive diffusion. These opposite responses of ARL1 to chelate EDTA-Hg and HA-Hg suggest that inconsistent impacts of DOM on Hg(II) uptake is likely due to different chemistry of DOM that was used in different studies. The bioluminescence results also show that HA and EDTA themselves were not toxic to the cell when their concentrations were less than 20 mg/L and 50 mg/L, respectively. However, bioluminescence reduced at 50-500 mg-HA/L and increased at 100 mg-EDTA/L. In addition, we used a constitutive strain (T7) to evaluate the toxicity of HA-Hg and EDTA-Hg complexes to the ARL1 strain. Little change in light emission was observed after HA or EDTA were added to mercury solution, indicating that the complexes were not toxic and the change in bioluminescence was caused by the change in Hg(II) bioavailability (instead of change in strain activity). This research demonstrates that the ARL1 bioreporter is a much less expensive, fast, reliable method of measuring aqueous mercury at very low concentrations compared to traditional chemical methods, and it remains a great potential for application to field in-situ monitoring.

Keywords：*Mercury, Bioavailability, Organic Acid, Bioluminescence, Biotoxicity, Bioreporter*

P4-24

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Identification of Arsenic Speciation and Accumulated Organic Species in Different Environment of Organic Sedimentation

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Natural source organic materials in the soils are effect on the mobility, accumulation, and leaching into the groundwater of various toxic elements. Arsenic is notably toxic elements, and widely and naturally distributed in geo-environment. The coexisting Iron, aluminum and lesser manganese oxides are strongly controlling the arsenic concentration in soil solution. The arsenic adsorption processes have been well studied including the competition of phosphorus and dissolved organic materials. On the other hand, arsenic accumulations in several natural peat sediments have been reported and sometime caused serious arsenic pollution by leaching from organic layer. The arsenic accumulation mechanism to organic materials and the effect of organic materials on arsenic desorption and leaching character of already trapped in peat sediments are not well reported.

This work deals with the arsenic speciation and estimation of arsenic trapping organic species in alluvial organic sediments characterized by several sedimentation environments in Hokkaido prefecture, JAPAN. The arsenic speciation and organic species were identified by sequential extraction and FT-IR analysis. The difference of sedimentation is obviously characterizing the speciation of trapped arsenic. The flood plain sediments contain mainly organic speciation and Mn-oxide materials independent of terrestrial and marine sediments. The lacustrine and terrestrial sediments are Fe-Al oxide or hydroxide and sulfide. The arsenic speciation in organic alluvial sediments is directly reflected in resources of arsenic supply. The species of arsenic accumulated organic materials also differ from terrestrial and marine sediments. The sediments notably affected by seawater accumulate the arsenic in holocellulose, and the other is increase the fraction of humic acid. The amount of organic species in alluvial sediments is humin>holocellulose>>humic acid>fulvic acid, bitumen. Although the weight of humic acid is far less than humin and holocellulose, the fraction of amino group is abound in high arsenic accumulating humic acids. Amino group acts as arsenic trapping site. However, the content of amino group is not abundant in hollocellulose, which predominantly accumulate arsenic in most of alluvial sediments. In the case of holocellulose, metal-O bound group is remarkable. The metal-O bound group is assumed to assist the arsenic accumulation to hollocellulose. The sedimentation environments act on the composition of organic materials, and natural source arsenic accumulation is not a little affected organic composition.

Keywords：*Environment of sedimentation, arsenic, organic sediment, speciation*

P4-25

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Predicting Mineral Nitrogen Leaching Behavior of Soil Using Electrical Conductivity in Leachate Water Samples

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Significant literature related to soil and the environmental quality in the last decade has focused on nitrogen (N) management as one of the key areas of research, specifically the reduction of gaseous and leaching losses from agricultural lands. N leaching from applied fertilizers has the potential impacts of polluting groundwater, as well as decreasing crop N availability. Therefore, it is not just an environmental issue but also one that is closely linked to human health and food production economics. The subject underlies the important fact that in terms of the approach, the method employed to estimate N leaching losses has to be carefully evaluated and selected for maintaining soil and the environmental quality. This paper presents an analysis of the electrical conductivity (ECw) of the leachate water samples use in predicting mineral N leaching (MNL) behavior of soils receiving manure-compost and chemical fertilizer application.

The experiment consisted of N application from i) an organic source (swine manure compost), ii) an inorganic source (chemical fertilizer urea), iii) combinations of these two, and iv) an untreated control. Relatively lower rates of N application were chosen, between zero in the control and 500 kg ha-1 in the high level treatment application. At National Taiwan University, Taipei, two growth cycles of cabbage and corn were raised, from April of 2006 through June of 2008, in standard Wagner pots (30 cm high and 25 cm in diameter) using 13 kg of dry soil. The pots were irrigated fortnightly during crop growing seasons to meet crop water requirements and to induce leachate outflows (LOF). The LOF was induced by applying 60 mm of water to corn, and 80 mm to cabbage. The LOF samples were then analyzed for MNL concentrations (conc.) and expressed as the weighted mean of MNL conc. for each sampling date. The two rates of water application corresponded to 1500 mm and 2000 mm annual rainfall representing the variations commonly observed in the humid region of Northern Taiwan. ECw was measured simultaneously with MNL conc. in separate portions of the fresh leachate water samples. A correlation coefficient was used to examine the relationship between them.

The results showed that absolute values of the correlation coefficient ($r > 0.89$) observed in 100% of the MNL monitoring events (24 of 24) in 2-y were always above the critical value ($r = 0.87$) at $p < 0.01$ significance level. No outliers were found as indicated by the scatter plots. This strong correlation would indicate that leachate water samples with high ECw scores tend to have high MNL conc. Therefore, this relationship could be reliably used to predict the MNL behavior of similar soils in order to help develop sustainable N fertilization strategy in agriculture; however, a field-scale validation is warranted.

Keywords：*electrical conductivity, groundwater quality, humid region, nitrogen leaching, soil quality*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Spatialization of Pollution by Trace Metals in Urban Soils of Gounti Yena Valley, Niamey, Niger

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Trace metals pose serious environmental and health problems because they are not biodegradable and have toxic effects. Environmental protection requires knowledge of the concentrations and the fate of trace metals in the soils and in plants. This study aimed to determine the spatial distribution of trace metals concentrations (As, Cd , Co, Cr , Cu , Hg , Ni, Pb, and Zn) in soils of the Gounti Yena valley, area of vegetable crops by excellence in Niamey city. For this, 66 composite samples of surface soils were collected including 63 collected from 21 transects in Gounti Yena valley and 3 composite samples from a control site away from any pollution source. The metals concentrations in soils were analyzed by mass spectrometry with inductively coupled plasma (ICP- MS). The results show that the average concentration values were very different and varied depending of the metal and the site considered. Distribution maps of Cd, Cu , Pb and Zn in the valley Gounti Yena revealed that areas of high contamination are located near pollution sources. These pollution maps have clearly distinguished the areas at risk, and should serve as data base for research projects or for land remediation of Gounti Yena Valley.

Keywords：*Trace metals, Pollution maps, Soil, Risk, Gounti Yena, Niamey*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Adsorption of Selected Pharmaceuticals in Representative Soils of the Czech Republic

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The presence of human and veterinary pharmaceuticals in the environment has been recognized as a potential threat. Pharmaceuticals may contaminate soils and consequently surface and groundwater. Study was therefore focused on the evaluation of selected pharmaceuticals adsorption in soils, as one of the parameters, which are necessary to know when assessing contaminant transport in soils. The goals of this study were: (1) to select representative soils of the Czech Republic and to measure soil physical and chemical properties; (2) to measure adsorption isotherms of selected pharmaceuticals; (3) to propose pedotransfer rules for estimating adsorption coefficients from the measured soil properties. Batch sorption tests were performed for 7 selected pharmaceuticals (Atenolol, Metoprolol, Carbamazepin, Clindamycin, Clarithromycin, Trimetoprim and Sulfamethoxazol) and 13 representative soils (soil samples from surface horizons of 11 different soil types and 2 substrates). The Freundlich equations were used to describe adsorption isotherms. Multiple-linear regressions were applied to predict the Freundlich adsorption coefficients from measured soil properties (soil particle density, soil texture, oxidable organic carbon content, cation exchange capacity, pH_H2O, pH_KCl, CaCO3 content, salinity etc.) Evaluated pedotransfer rules for different pharmaceuticals included different sets of soil properties. In general all relationships included organic carbon content. Some equations contained also cation exchange capacity (Atenolol, Metoprolol, Carbamazepin, Clarithromycin, Trimetoprim), pH_KCL (Metoprolol, Carbamazepin, Clindamycin, Clarithromycin, Sulfamethoxazol) and clay content (Atenolol).

Acknowledgement: Authors acknowledge the financial support of the Czech Science Foundation (No. 13-12477S).

Keywords : *pharmaceuticals, adsorption isotherms, pedotransfer rules*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Spectroscopic and Chemical Speciation of Chromium in Contaminated Paddy Soils

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The Environmental Protection Administration in Taiwan estimated that 21,000 hectares - 2.5% of arable lands - have been contaminated by heavy metals, including Cr, Zn, Cd, Ni, Cu, As, Hg, and Pb (Taiwan-EPA, 2010). The contamination of Cr is particularly critical in the Changhua County, one of the major rice production sites in Taiwan, with a concentration range from 24 to 14,561 mg kg^{-1} that exceed the soil pollution regulation limit of 250, 500, and 750 mg kg^{-1} in Taiwan, Germany, and Canada, respectively. Although weathering of the indigenous Cr minerals, such as chromite ($FeCr_2O_4$), may account for the occurrence of Cr in natural soils, the majority of Cr found in the Changhua soils is derived from the discharges of wastewaters from the industrial activities, such as electroplating, pigments, and leather manufacturing.

Chromium has two predominant oxidation states in natural environments, Cr(VI) and Cr(III). While Cr(VI), occurred as chromate (CrO_4), poses a relatively high toxicity and mobility in ecosystems, the cationic Cr(III) easily precipitates and forms the insoluble $Cr(OH)_3$. Both Cr (III) and Cr(VI) can be preserved in the original minerals, co-precipitated with iron (Fe), aluminum (Al), and/or, manganese (Mn), adsorbed on surfaces of soil particles, and formed complex with dissolved organic and inorganic compounds. The bioavailability and mobility of Cr is controlled by the distribution of individual Cr species. For instance, the reductive dissolution of Fe(III) and manganese(III, IV) oxides caused by the fluctuation of redox potential in the paddy soils may lead to the release and re-distribution of Cr originally associated with these oxides. That is, Cr species is subject to change along with environmental conditions, and thus, a classification of Cr species other than total Cr amount is required to clarify and predicate the physiological and toxicological effects of Cr.

Such conventional extraction method used different chemical reagents to release different fractionation of metals in the order of the mobility. Sequential extraction method developed by Tessier et al. is one of the popular methods in assessing the metal fractionation in soils and sediments, wherein metals were classified into five categories: exchangeable, carbonate-associated, reducible (Fe- and Mn-associated), oxidizable (organic matter-associated), and residual. Although SE has provided a readily assessment for the Cr speciation, the factors of nonselective properties of extraction reagents, pretreatment of soil samples, extraction ratios between soils and reagents, and the duration of extraction period may all lead to a false metal fractionation. Compared to SE methods, synchrotron-based X-ray absorption near edge structure (XANES) spectroscopy is a nondestructive and element-specific technique. XANES can probe all of the irradiated Cr atoms in a sample and determine directly their chemical forms. Different Cr species shows unique spectral features, and thus, the quantitative estimation of Cr species in the complex sample matrices could be conducted using the linear combination fitting with the reference spectra of representative Cr groups and compounds. In this study, we aimed to determine the Cr speciation in relation to soil particle size using XANES spectroscopy as a complement of Tessier sequential extraction method.

Results of XANES Cr speciation showed that the inventory of Cr was dominated mainly by Cr(III) sorbed on Fe-hydroxides with lesser amounts of Cr(III) chelated with humic acid and Cr found in bedrock. We found that the Cr speciation quantified by XANES spectroscopy showed a strong correlation with the speciation results obtained from the conventional chemical sequential extraction. The linear relationship ($r^2 = 0.97$) between reducible Cr obtained from sequential extraction and Fe-related Cr(III) obtained from XANES analysis suggested that Fe-related Cr(III) could essentially represent the reducible proportion of Cr. Similarly, the oxidizable form of Cr could be interpreted as the chemical species of humic acid-related Cr(III).

To our knowledge, this is the first time to quantitatively compare Cr composition obtained from nondestructive spectroscopic analysis and chemical sequential extraction. The highly correlation between the spectroscopic and extraction results in Cr speciation suggested that the corresponding chemical species of Cr classified by the operational extraction method could be determined. The combination between these two methods may develop a reliable speciation result that is needed to elucidate the mechanisms for Cr migration in this ecosystem.

Keywords：*Chromium, XANES, speciation, paddy soil*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Bioavailability of Heavy Metal Compounds in the Soils Contaminated by Emissions from the Power Station

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To obtain a clearly expressed picture about the environmental situation at the territory within the influence zone of the power station, it was necessary to determine the available relationship in distribution of trace elements in soils and plants. Every metal taken up by plants for a long period of time was accumulated in them to a definite level, above which significant harmful changes occur in the plant quality. Adverse consequences of such accumulation were manifested in time, depending on technogenic loads and the response of the soil-plant system to trace elements.

The objects of research were abandoned sites of grasslands near Novocherkassk power station, one of the largest power stations in Russia.

The majority of the soils of monitoring plots were ordinary chernozems; the low-humus calcareous sandy alluvial meadow soil, which had a light texture and a low cation exchange capacity (CEC), and the low-humus silty clayey meadow-chernozemic floodplain soil with a high CEC that differed from the control soils.

Plant sampling was taken to analyze the averaged samples of grass harvest at monitoring sites. Since 2000 the soil and plant sampling has being taken yearly in the period of the active plant growth and development.

The total contents of Cr, Ni, Mn, Cd, Cu, Zn and Pb in the soils were determined with the X-ray fluorescence method. The metals compounds classified as loosely bound were transferred to solution by means of parallel extractions using the following reagents (Minkina et al., 2008): 1 N ammonium acetate buffer (NH4Ac) pH 4.8 capable of solubilizing the exchangeable forms of metals characterizing their “actual” mobility. 1% EDTA solution in NH4Ac with pH 4.8, which supposedly solubilizes the relatively unstable complex compounds of metals together with their exchangeable forms. The concentrations of the metals in the complex compounds were calculated by the difference between the metal concentrations in extracts 2 and 1. The acid soluble metal compounds extracted with 1 N HCl characterize the reserve of the mobile metal compounds in the soil. They are supposedly represented by the metal ions capable of exchange and by the specifically absorbed compounds including the Fe and Mn retained by the amorphous oxides and carbonates. The amount of specifically absorbed metal compounds was calculated by the difference between the metal concentrations in the HCl and NH4Ac extracts. The group of loosely bound compounds is the most important from ecological viewpoint and capable to enter adjacent areas and the plants in particular.

The concentration of trace elements in the plants was determined using the wet combustion in a mixture of HNO3 and HCl at 450˚C. The content of elements in extracts from soils and plants was determined by FAAS.

Metals total content in soil of the monitoring plots located far from the power station didn’t exceed the maximum permissible concentration. The content of loosely bound compounds and especially the most mobile exchangeable and complex ones was insignificant in soils of these monitoring sites and well agrees with their average content in grass plants of the given region.

Due to the effects exerted by discharges of the power station the total content of metals proved to be increased in soils located near this contamination source along the line of wind rose. The amount of loosely bound compounds increases as well. The total content of Cu, Pb, Zn and Cd and the content of their exchangeable compounds exceed the maximum allowable limit in these soils.

The plants at the sites located near the power station (within 5 km) were contaminated with Ni, Cu, Zn and Pb, thus exceeding the maximum permissible concentration in the terrestrial part of grass plants. The maximum content of metals in plants may be presented in the following way:

Zn > Mn > Cu > Pb > Ni > Cd

The trace elements accumulation by plants was affected by soil properties. The concentration of Cd, Ni, Mn, Zn and Cu in plants grown on the meadow-chernozem soil was lower by 1.2-2.6 times than that on alluvial meadow sand soil characterized by insignificant buffering capacity to metals.

Acknowledgments. This work was supported by Russian Foundation for Basic Research, (projects № 12-05-3307813)

Keywords：*trace elements, plants, chernozems, grass harvest, extractions, buffering capacity*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Sorption Behavior of Bisphenol S (4,4'-Sulfonyldiphenol) on Agricultural Soils

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Discharge, sludge, and biosolids originating from municipal waste water treatment plants have been identified as a source of many chemicals of emerging concerns that can be released into the environment through direct discharges or land-application of biosolids. One contaminant of early concern is bisphenol A [4,4'-(propane-2,2-diyl)diphenol , BPA], which was used in plastics and resins for commercial products including baby and water bottles, food and beverage cans, pipe linings, and thermal paper. BPA was found to be estrogenic to humans, which led to extensive studies in its toxicology, chemistry, and environmental fate and eventually to its ban. The latter to the development of BPA alternatives with similar chemical structures: BPAF (methyl groups replaced with trifluoromethyl groups) and 4,4'-sulfonyldiphenol referred to as BPS. Unlike BPA, little is known about the environmental fate and transport of these alternatives. Therefore, quantifying key physical and chemical properties of BPA alternatives is necessary to be able to accurately predict their environmental fate and transport once land applied. Our research focused on quantifying the behavior of BPS especially with regards to agricultural soils.

Laboratory-scale batch experiments were conducted to investigate the partitioning behavior of BPS including quantifying octanol-water partition coefficients (Kow) and sorption coefficients (Kd, L/kg) in several agricultural soils representing a range in organic matter content and pH. BPS sorption is expected to be proportional to organic matter content and affected by soil pH. BPS is an ionizable compound with pKa values of approximately 7.4 and 8. Solutions were filtered-sterilized and experimental vessels and soils autoclaved to minimize microbial degradation during equilibration with BPS. Octanol to water volume ratios in the Kow studies, and soil mass to solution volume in the sorption studies were optimized to achieve 20 to 80% mass exchange between phases. The concentrations of BPS in solution (water and/or octanol) and soil phases were measured independently and analyzed using high performance reverse phase liquid chromatography with UV detection or tandem electrospray ionization mass spectrometry. Solutions were filtered-sterilized and experimental vessels and soils autoclaved to minimize microbial degradation during equilibration with BPS.

BPS exemplified pH-dependent partitioning as hypothesized. Log Kow values of 2.40, 1.24, and -4.04 were measured at pH values of 4, 9.5, and 12.7. Sorption affinity to soils was also pH dependent and generally increased with increasing organic matter content. Compared to the literature, BPS has lower Kd and Kow values than BPA as expected, thus will be more mobile in the environment. Microbial degradation of BPS in the same aerobic agricultural soils as well as anaerobic degradation in agro-impacted sediments is currently underway. Overall, these results broaden our knowledge on BPS fate in the environment, which can be coupled to ecotoxicity studies to assess potential risk to ecosystem and human health.

Keywords：*Bisphenol S, biosolid, agricultural soil, sorption*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Lead Binding to Humic Substances: Nica-Donnan Modeling and Xafs Analysis

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Pb is a wide spread metal pollutant which can be toxic to plants, animals and humans. Fulvic acid (FA) and humic acid (HA) are ubiquitous and contain a large number of acidic functional groups which can interact with Pb to control the fate of Pb in environment. Combining chemical speciation models as NICA-Donnan model with XAFS on Pb binding to soil HS leads to an adequate prediction of model for Pb binding and a better understanding of the Pb-HS complexes molecular structure. To have a deep insight into the interaction of Pb and humic substances (HS), we investigated the Pb binding to soil fulvic acid (JGFA), soil humic acids (JGHA, JLHA), and lignite-based humic acid (PAHA) through charge-pH curves, binding isotherms and XAFS spectroscopy. The NICA-Donnan model with the materials-specific parameters can describe the proton and Pb binding to HS satisfactorily. Milne's generic parameters didn't provide a prefect prediction for both proton binding and Pb binding for soil samples. For proton binding, replacing Qmax,H1 in generic parameters with material-specific values improves the predictions for soil HA significantly. However, because of the very different pattern of site distribution of JGFA from that of generic FA, the agreement between the model prediction and data is still not satisfactory after substitution. For two other soil FAs (FH-14, FH-22 of Milne's database) the generic predictions can be improved significantly with material-specific Qmax,H1. There is no significant improvement of the prediction when adjust Qmax,H2 to HS material-specific value. In practice, Qmax,H1 and Qmax,H2 of HS can be obtained in a relatively simple way by performing one acid–base titration at a given ionic strength and applying the procedure of Lenoir et al to fit data to NICA equation. For Pb binding, the sensitivity test for a given parameter showed that for soil HA (JGHA and JLHA) the model prediction with generic parameters could be strongly improved only when the generic nPb1 (0.60) was replaced by the average value (0.92) of observed nPb1 for JGHA and JLHA (0.91 and 0.94, respectively). Replacing the generic value of nPb1 and Qmax,H1 which have led to a substantial improvement of the prediction of proton binding by the material-specific value, led for the Pb binding to a minor improvement at high Pb loading as compared to that by only replacing nPb1. Since the proton binding behavior of JGFA deviates strongly from GFA, it was difficult to improve the prediction obviously by replacing one or two generic parameters with material-specific parameters. Only when nPb1, logKPb1, and logKPb2 of the generic parameters were replaced by JGFA material-specific values was an improvement achieved. The observed high nPb1 values lead to the relative high values of nPb1/nH1 ratios (1.05−1.44) which are an indication for mono-dentate Pb binding to carboxylic groups. The nPb2/nH2 ratios of soil HS are substantially smaller (0.80−1.02) and indicate that part of the phenolic groups is involved in bi-dentate Pb binding. In addition, the fitting of C−O−Pb structure using the EXAFS spectra obtained at high Pb loading testified that Pb was bound in bi-dentate complexes of one carboxylic and one phenolic group (salicylate-type) or two phenolic groups (catechol-type) in ortho position and is not in accordance with the result of the nPbi/nHi ratios. It should be realized that here the nPbi/nHi ratios were obtained from the fitting of logPb bound vs logPb2+ which a relatively high weight has been given to very low Pb loadings, whereas the spectroscopic results are obtained at relatively high Pb binding. In the new fitting mode, the binding data use a linear scale for the bound amounts and data at low loading have a relatively high weight. The new nPb1/nH1 ratios were only slightly smaller than the ratios obtained from the classical fitting procedure and the new nPb2/nH2 ratios were in the range of 0.47−0.69, indicating at high loading Pb is bound by the phenolic groups in a bi-dentate structure. Therefore, the results of model partially agree with the spectroscopic results.

Keywords：*Pb, humic aicd, NICA-Donnan, XAFS*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Cd Distribution in the Soil and Rice in the Vicinity of the World's Largest and Longest-Operating Tungsten Mine in China

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China is the world's largest tungsten producer and consumer. Tungsten mining and smelting might contaminate nearby environments. The objective of this study is to investigate Cd contamination in soil and its enrichment in rice in the area of the world's largest and longest-operating tungsten mine in the Dayu county, Jiangxi province of China. Rhizosphere soil and rice plants were sampled at 15 sites in the agricultural field adjacent to W mines in Dayu county, Jiangxi province and analyzed for Cd content and chemical forms in the soil samples and Cd contents in the rice root, stem, leaf, and grain samples. Results showed that the total content of Cd in the soil ranged from 0.07 to 0.87 mg kg-1, with an average of 0.27 mg kg-1, higher than the soil background level (0.1 mg kg-1) of Cd in Jiangxi Province. About 5.35%, 8.38%, 15.58%, 6.05%, 64.63% of total Cd were associated with soluble and exchangeable fraction, carbonate minerals, Fe/Mn oxides, soil organic matter, and residual fraction, respectively. Average contents of Cd in the rice root, stem, leaf, and grain were 1.62, 0.49, 0.40, and 0.18 mg kg-1, respectively; leading to the corresponding average enrichment factors of 5.29, 2.57, 1.88, and 0.50. It can be concluded that W mining and smelting activities in the Dayu county, Jiangxi province led to Cd contamination of the nearby agricultural soil and led to Cd bioaccumulation in the rice. This may pose a health risk to residents via food and soil ingestion, which should be a focus of scrutiny.

Acknowledgements: This study was supported by the National Natural Science Foundation of China (41371441) and the Ministry of Environmental Protection Funded Project (201009046, 201109064).

Keywords：*cadmium, soil, rice, contamination, enrichment*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Undisturbed Column Study: Heavy Metal Transfer from Soil to underground Water With Pig Slurry Application in a Silty Loam Soil

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Spain is the second largest pig producer in the European Union, which generates 2x1010 kg yr-1 of pig slurry, over half of which is used directly as fertilizer. When pig slurry from intensive livestock operations are applied to agricultural at a high rate, large amounts of salts and heavy metals (HMs) are introduced into soils. Using a column leaching experiment, this study assessed the leaching potential of the downward movement of some after an intensive farm pig manure were applied to the top 20 cm of silty loam textured soils, and investigated the Cu, Zn , Cr, Mn, Co, Ni, Mo, Pb and Cd transfer from soil to ground-water. Soil solutions were analyzed per each week.

A soil (silty loam) column leaching study aimed to determine the extent of mobility and co-mobility of heavy metals from a surface-application of pig slurry in 3 different doses: D1 (170 kg N/ha), D3 (540 kg N/ha) and unfertilized plots (C) served as controls. The possibility of HMs (Cu, Zn, Cr, Mn, Co, Ni, Mo, Pb and Cd) transfer from soil to ground-water was investigated through the analyses of solutions each week.

The results indicated that application of pig manure containing Cu and Zn to silty loam soil might cause higher leaching and uptake risk than silty loam soil, especially at high application rates. And manure amendment at 5% and 10% significantly decreased the biomass of amaranth, in which the salt impact rather than Cu and Zn toxicity from manures played more important role in amaranth growth. Thus the farmer should avoid application the high rate of pig manure containing metal and salt to soil at a time, especially in silty loam soil. Concentrations of HMs in leachates were in the following order: Mn>Mo>Fe>Cu>Ni>Zn>Pb>Cr>Co>Cd. All the concentrations of HMs leachate samples in the permissible limits of Europe standard.

Keywords：*HMs, Leaching System, Undisturbed Soil Column*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Diffusion of Ions in Organically Modified Clays - Experimental and Molecular Dynamics Study

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Organoclays are organically modified clays, where the original interlayer cations are exchanged by organic cations, mostly of an alkyl ammonium type. Clays have high cation exchange capacity (CEC) but low ability to sorb anions. Modifying clays by organic cations increase the ability to sorb anions and non-polar organic pollutants in addition to cations [1-4]. These characteristics make them valuable for their use in various environmental and technical applications such as immobilization of pollutants in contaminated soils, waste water treatment and in situ placement for the groundwater protection [5].

Mobility of small species (e.g. ions) in these systems can be characterized by measuring and analyzing diffusion coefficients (DC). This work presents experimental and classical molecular dynamics (MD) study of diffusion of small ions (Na+, Cl-, I-, NO3-) in modified organoclays based on the clay mineral montmorillonite intercalated with hexadecyltrimethylamonium (HDTMA+) and hexadecylpyridinium (HDPy+) cations. In the MD study, DCs were calculated in a layer deposited on the montmorillonite surface. The layer consists of a monomolecular layer of organic cations, a water slab, and a corresponding number of ions. The surface coverage in models ranged from 0.125 to 1.5 HDTMA+ ion/Auc. The simulations were performed by the LAMMPS package. Inter- and intramolecular interactions in the organoclay models were described by the CLAYFF and OPLSAA force fields. We observed decreasing DCs of ions with increasing density of the organic cations. The SPC/E water model was used for water interactions. Experimentally, DCs have been determined for the NO3- anions in HDPy+? and HDTMA+-montmorillonite. The results were compared to DCs obtained from the MD simulations.

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Keywords：*Organoclays, Molecular Dynamics, duffision coefficients*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Assessment of Migration of Polychlorinated Byphenyls (pcbs) from Contaminated Plants in Soil

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Has been argued that due to the low solubility and high sorption capacity hydrophobic organic substance is not able to translocate from the root to the aerial part of the system and vice versa. Therefore, PCBs in roots go only from the soil. In green mass, they come from the air, concentrating mainly in the cuticle.

Washed from the contaminated soil, roots of Calamagrostis epigeios with the root lobe (leaf rosette) placed in vessels with uncontaminated alluvial sod soil).

In our experiment, the air transport of PCBs is excluded. We can therefore conclude that there is a PCB translocation to the green mass from the roots of the plant, although this quantity is small.

Translocation of PCBs from contaminated plants in the soil slightly higher. Thus, in a short period of experiment we got important results. They demonstrate that in the system “soil - plant roots - land mass” occurs of PCBs migration and redistribution of this compound, despite its low solubility and hydrophobicity.

Keywords：*Polychlorinated byphenyls,*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Soil Property Affect Arsenic Uptake in Garland Chrysanthemum (c. Coronarium) Fertilized with Chicken Manure Bearing Roxarsone and its Metabolites

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Roxarsone (3-nitro-4-hydroxy-phenylarsonic acid, ROX) is widely used as an excellent feed organoarsenic additive to promote growth, control parasites and improve feed efficiency in animal production in the world. While animal is fed with ROX, the most commonly detected As compounds in manures include ROX and its metabolites like As(V), As(III), monomethylarsonic acid (MMA), dimethylarsinic acid (DMA), and so on. Animal manure is commonly land applied as fertilizer in agriculture. However, the potential risk of ROX and its metabolites via the way animal feed - animal – animal manure – soil – crop is underestimation. Pot experiment with fourteen soil types was conducted to investigate the effect of soil properties on the uptake, accumulation and distribution in garland chrysanthemum plants fertilized with 2% chicken manure (CM) bearing ROX and its metabolites. The fourteen soil types cover wide longitude and latitude in China, with considerably different physiochemical properties. The results show that the biomass of garland chrysanthemum plants greatly differed in these 14 soils. Though ROX and its metabolites (4-hydroxy-phenylarsonic acid, As(V), As(III), DMA, MMA and unknown As species) in CM and one or two of inorganic As forms in 14 soils were detectable, only As(III) in shoots and both As(V) and As(III) in roots could be determined in all garland chrysanthemum plants. The highest concentration of As(III) in shoot and root (891.5 and 11976.1 μg kg-1) and that of As(V) in root (1215.3 μg kg-1) were observed in alkaline purplish soil from Sichuan province in southwestern China and in paddy soil from Guangdong province in southern China, approximately tenfold higher than the bottom levels in laterite soil from Guangdong. Garland chrysanthemum plants accumulated the maximal amount of As compounds (45.91±10.0 μg pot-1) in alkaline purplish soil from Sichuan for the highest concentrations and the medium biomass, followed by those (19.70±3.13 μg pot-1) in grey fluvo-aquic soil from Hubei province in central China, and those (0.54±0.16 μg pot-1) in laterite soil from Guangdong the least. The correlation analysis between soil properties and As uptake indicates that soil extractable Ca and soil pH significantly affected the accumulation of As species and total As in garland chrysanthemum plants grown in 14 soils. However, the selected soil properties, such as soil texture, cation exchangeable capacity, organic matter, microbial biomass carbon, total As, As(V), iron oxide, alumina, sum of iron oxide and alumina, amorphous Fe or Al, total inorganic P, available P and extractable Mg, did not affect the As accumulation in garland chrysanthemum. And, the transport of As species in plants was not related with the above soil properties. Consequently, while CM bearing ROX and its metabolites is land applied in soils with rich extractable Ca and high pH, the potential As hazard to human health via the food chain is significantly enhanced.

Keywords：*roxarsone, As species, soil property, soil pH, phytoavailability*

P4-37

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Photo-oxidation of Cr (III) by Fe (III) in the Presence of Citric Acids

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Citrate is one of main substance secreted by the plant roots, and it is likely to be a great chelator for iron. In previous study, it has shown that light-induced oxidation of aqueous Cr (III) in the presence of Fe (III) would be one potential pathway for the oxidation of Cr(III) to toxic Cr(VI). In chromium species, Cr (VI) has higher toxicity then Cr (III). There is less information of Cr (III) oxidize to Cr (VI) by Fe (III) in the presence of citric acid. In this research, we investigate the oxidation of Cr (III) by Fe (III) in the presence of citric acids with different initial Fe (III) pH (2, 3, 4) under UV light irradiation and the concentration of citric acid. The result showed that without citric acid, Cr (III) could oxidize to Cr (VI) obviously. And the low initial pH value may cause the production of Cr (VI) slower; at high pH value, the precipitation of Fe (III) will decrease the production of Cr (VI) too. Moreover, with the addition of citric acid, citric acids can inhibit the oxidation of Cr (III).

Keywords：*Hydroxyl radical, Fe(III)-citrate complex, oxidation*

P4-38

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Measurement and 1D Transport Modeling of Boron Movement in Some Calcareous Soils Affected by Different Ionic Strengths

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This study was aimed to evaluate the effect of ionic strength on boron (B) leaching and to model this process using the mechanistic modeling. Ten surface soils were collected from different land use areas in Hamedan, western Iran to characterize the native B leaching from soils. The effect of ionic strength on added B leaching was investigated in soil no.2 using a pulse of 10 mL of solution containing 100 mg B L-1 together with 7 pore volumes of distilled water (control) and 1, 3, 5 and 10 mM CaCl2 solutions under saturation conditions. The first and second pore volumes were divided into 7 separate sections, the third and the forth pore volumes partitioned in to 2 parts. Furthermore, gypsum (CaSO4.2H2O) and calcium carbonate were added to soil no.2 at a rate of 3% and were incubated for one week at field capacity moisture and room temperature. After the incubation duration, the leaching experiments were performed with distilled water as previously explained. Ultimately, the breakthrough curves of B leaching were simulated using 1D transport model in PHREEQC program. The maximum and minimum amounts of native B leaching were observed in soils no.6 and no.2, respectively. The appearance of concentration peak and the major part of applied B leaching happened within the first pore volume. The highest and the lowest peak of concentration were measured in control and gypsum treatment, respectively. The recovery percentages of applied B obtained from measurements were 99.72, 97.54, 95.56, 94.05, 91.53, 98.5 and 88.55% for control, 1, 3, 5, 10 mM CaCl2 solutions, calcium carbonate and gypsum treatments, correspondingly. The results indicated that the mechanistic model could successfully simulate B leaching trend in all studied columns.

Keywords：*Boron; Leaching; Ionic strength; 1D transport; PHREEQC*

P4-39

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Changes in Total Content and in Chemical Fractionation of Cu and Zn in Soils Amended with Compost

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The application of organic wastes in agricultural lands, particularly after land levelling operations may improve soil physical characteristics. These applications increase the soil organic matter content and as a consequence other properties such as aggregate stability or infiltration. In addition soil nutrients also increase. However, these residua usually have trace elements, which in moderate doses could be beneficial for the soil but could have a negative effect if they are increased without control. Most of the elements applied with these residues are immobilized in soil by chelation with organic matter and adsorption on clay minerals; they are precipitated as insoluble compounds, and in most cases accumulated in the upper soil layers.

In this study, the changes generated by the application of composted cattle manure in total metal content and their chemical fractionation was evaluated in a calcareous soil, whose soil profile was disturbed by land levelling. Cu and Zn, the elements in higher proportion in the applied residua, were analysed. Total Cu and Zn context was evaluated after a soil acid digestion (HNO3 65% & HCl 37%). The extractable fraction using DTPA (0.005 M), trietanolamine (0.1 M) and ammonium acetate (0.01 M) at pH 7.3 was also evaluated. In addition, a sequential extraction was done to determine different fractions: the exchangeable, the carbonate fraction, the fraction bound to Fe and Mn oxides, the fraction bound to organic matter and the residual fraction. All element concentrations were obtained by atomic absorption. Two replicates of each analysis were done.

Total Cu concentration was about 37 mg kg-1 in untreated soils and about 44 mg kg-1, in treated soils, without significant differences. The Cu DTPA-extractable fraction, increased after compost application from 5.8 to 8.1 mg kg-1, which represented 15 and 18% respectively of the total metal content. The Cu fraction linked to the organic matter increased from 22.9% to 29.5%, decreasing the residual faction although it still represents more than 64%.

Total Zn content increased from 59 to 69 mg kg-1 although values near 80 mg kg-1 were observed. The Zn DTPA-extractable fraction increased significantly from 1.3 to 4.9 mg/kg in treated soils, which represented 2.1 and 7.1% of the total content, respectively. Zn was mainly bounded as oxide (10.0%) and in the residual fraction (80%). The oxide bound fraction increased up to 16% in treated soils and the fraction linked to the organic matter increased from 1.2% to 2.1%, while the residual fraction decreased. There was a significant linear correlation between the DTPA-extractable fraction and the Zn fraction linked to the organic matter ($r^2 = 0.68$) and the oxide fraction ($r^2 = 0.69$). As a conclusion, metals applied to soil with compost or other wastes contribute not only to an increase in the total metal content in the soils, but to increase the amount of the extractable fractions that could be taken by crops. This fact must be considered for an agriculture sustainable development from an environmental point of view.

Keywords：*calcareous soil, compost, copper, fractionation, zinc*

P4-40

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Cadmium Imobilization by Amendments in Contaminated Latosols Cultivated with Lettuce

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Cadmium is one of the most ecotoxic elements, being naturally found or incorporated into the soils by anthropic actions. It may be absorbed by the plants, entering in the food chain and causing health disorder in humans. To reduce Cd availability in soils, some in situ recovery techniques of contaminated areas have been used by using mineral and organic amendments. In this case, the objective is not to eliminate the contaminant but to reduce its bioavailability by effects of precipitation or adsorption. The objective of this study was to evaluate Cd bioavailability in two Cd contaminated Brazilian Oxisols (Latossolos in Brazilian System of Soil Classification), cultivated with lettuce plants, after application and mixing of increasing doses of amendments. Soils used presented contrasting texture and were previously contaminated with de 3 mg/kg of Cd. The work was carried out in a greenhouse using an adaptation of the Neubauer method, taking into account 32 treatments, which were the result of the combination of two soils, with two pH values (natural and corrected for 7.0 with lime), mixed with two amendments (sugar cane filter cake and zeolite) at three doses (2.5; 5.0 and 10.0 t/ha), with eight control treatments. The seedlings were grown from seed and transplanted to pots, where plants were left in contact with contaminated soils for 27 days. After harvest, plants were weighted and subsamples were digested for the determination of Cd contents in the tissues of the plants. The results achieved in this work showed that Cd caused toxic effects in the plants leading to a reduction in lettuce dry matter production. These toxic effects were avoided with the correction soil pH and addition of amendments, especially for the medium texture soil. The greatest reduction of the toxic effects of Cd was observed with the use of amendments and was mainly verified for sugar cane filter cake at doses above 5 t/ha. In this case, high biomass production and low content of contaminants in the plant tissues were found, especially in limed soil at a controlled pH value. When comparing the characteristics of the soils examined, the texture is the main parameter which determine the Cd immobilization efficiency of the conditioners. This efficiency was reduced in the clayish soil. In conclusion, application of conditioners to contaminated soils potentially reduces the toxic effects of Cd in plant growth, allowing to achieve similar results of non-contaminated productions. Sugar cane filter cake can be a good alternative to in situ recovery techniques in agricultural areas contaminated by Cd.

Keywords：*heavy metals, zeolite, sugar cane filter cake, land reclamation*

P4-41

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Soil solution Partitioning of Gold and Silver in Soils Amended with Nanoparticles

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During the last decade the production and use of metal-based engineered nanoparticles (NPs) has shown an exponential growth resulting in exponential increasing quantities of NPs being released into the environment. Recent studies suggest that during wastewater treatment NPs partition predominantly associate to biosolids which are afterwards applied to agricultural soils as fertilizers [1]. There is still however major uncertainties related to the fate and behaviour of NPs in soils. These uncertainties relate specially to the potential for trophic transfer of NPs in terrestrial foodchains since the uptake of NPs from soils by feed and food crops is still not fully understood [2].

In this study we assessed soil-soil solution partitioning of two types of metal-based NPs - gold NPs (AuNPs) and silver NPs (AgNPs). Suspensions of AuNPs and AgNPs were prepared using the methods for the synthesis of these NPs described by Melo et al. [3]. The AuNPs and AgNPs were characterized by transmission electron microscopy (TEM), scanning electron microscopy (SEM), UV–VIS spectrophotometry, and dynamic light scattering (DLS). Bulk concentrations of Au and Ag were determined by inductively coupled plasma mass spectrometry (ICP-MS) following acid digestion.

Measured 300 mL of the characterized suspensions of AuNPs and AgNPs were added into pots containing 1 kg soil. Eight soils with varying pH (pH 4.3 – 7.1) and organic carbon (OC 0.94 – 6.4 %) contents were used. Soil solution samples were collected from pots from day 1 until day 45, after AuNPs and AgNPs addition to soil and were characterized using the same methods applied to characterization of NPs suspensions. After 45 days soils in the pots were air-dried and extracted with 0.43 M HNO3 and 2 M HNO3 in order to test the availability of Ag and Au retained in the solid phase.

Suspensions of AuNPs and AgNPs added into soil pots showed total Au and total Ag concentrations of 16 mg L-1 and 27 mg L-1, respectively. This represented soil concentrations of [Au]= 5 mg kg-1 and [Ag]= 8 mg kg-1. Results indicate that from 75 to 86 % of total Au and from 84 to 99 % of total Ag added into soils are retained in the solid phase during the first 24 hours. Gold concentration in solution decreased along the 45 days and was only detected until day 15 (d.l.=0.120 mg L-1). Silver in solution also decreased with time and was below the detection limit (d.l.=0.015 mg L-1) after day 3. Furthermore, UV-Vis and TEM results indicated the presence of AuNPs only until day 3 and the presence of AgNPs only in day 1 samples suggesting that particularly Ag is present in the soil solution mostly as ionic Ag. Soils extraction with 0.43 M HNO3 and 2 M HNO3 did not release Au retained in the soil solid phase suggesting that the metal may not be easily available from soil.

Moreover, since it is crucial to understand the role of soil properties in soil – solution partitioning of gold and silver in soils amended with nanoparticles Freundlich-type empirical partition functions were applied to assess the soil-solution partitioning of Au and Ag. Results indicated that dissolved Fe affects the release of both Au and Ag from soils into solution and that solution pH also controls the dissolution of Ag from soils. Since recent studies have shown that dissolution of metal-based NPs, including AgNPs is one possible mechanism for their toxicity [4] factors affecting the release of NPs from soils into the soil solution along time as well as processes controlling NPs dissolution will be further presented and discussed during this presentation.

Acknowledgments

Authors acknowledge the financial support of both FCT and "Programa Operacional Factores de Competitividade - COMPETE" through Project n.º PTDC/AGR-PRO/4091/2012.

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Keywords：*metal-based nanoparticles, soil contamination, soil solution, risk assessment*

P4-42

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Effects of Arsenic and Phosphate on Plant Biomass and Their Accumulation by an Arsenic Hyperaccumulator Pteris Vittata L

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Arsenic is ubiquitous in the environment and is derived from both natural and antropogenic sources. Arsenic can cause damage to human health through the food chain and water supply and As contaminated soil is a major source of contamination in the food chain and water supply (Warren et al., 2003). Previous research has shown that Pteris vittata L. (Chinese Brake fern) was able to accumulate arsenic in their fronds even in the presence of other metals although at a lower rate (Fayiga et al., 2004). It also has high tolerance to arsenic and efficient mechanisms of arsenic detoxification. Phosphate has been shown to increase arsenic availability in the soil leading to the increase in plant uptake (Peryea, 1998). Therefore, P-induced metal stabilization and arsenic solubilization expected from the addition of phosphate fertilizers in soils should enhance arsenic uptake by Pteris vittata L. An experiment was carried out to determine the effect of arsenic and phosphate on plant biomass and uptake of arsenic by using different rates and forms of phosphates material by Pteris vittata L. The pot experiment was carried out in the glasshouse unit of Universiti Putra Malaysia, Serdang, Selangor, Malaysia. The experiment consisted of 9 treatments including control. Plants were treated with different concentrations of phosphate which are 0, 12.5, 25.0, 50.0 and 75.0 kg P ha^{-1} in solid form of Triple Superphosphate (TSP) and liquid form of potassium dihydrogen phosphate (KH_2PO_4). Each of the polybag was fertilized with basal dose of 125 mg N kg^{-1} (NH_4NO_3) and 175 mg K kg^{-1} (KCl). After one-week of equilibration, a healthy fern with 5 to 6 fronds each was planted in each pot containing 15 kg of soil for 90 days in the glasshouse. Each treatment will be replicated four times and arranged in a randomized complete block design. Soil moisture content was maintained at field capacity. The plants were watered twice per day with deionized water. After 90 days of planting, ferns were harvested. After being washed thoroughly with tap water and then with deionized water, the ferns were separated into aboveground (fronds) and belowground (roots including rhizomes) biomass, dried in an oven at 65 ^{0}C. Once the constant weight was reached, the dry matter was weighed and then ground into powder. Then, the plant samples were digested with dry ashing method. Total As concentration was determined with an ICP-MS. The data obtained were subjected to analysis of variance (ANOVA) using the SAS and the means were compared using Tukey's method (SAS 9.2). A muck soil collected from Kampung Solok, Malaysia was used in this experiment. It has pH 6.3 and total arsenic in soil is 41.15 mg/kg. The cation exchange capacity is 28.76 $cmol_c$/kg. Exchangeable bases were potassium 0.15 $cmol_c$/kg, calcium 31.7 $cmol_c$/kg and magnesium 0.24 $cmol_c$/kg. Arsenic accumulation was determines in the frond and root tissues of the Chinese brake fern. The plant was quite healthy and did not show any symptom of phytotoxicity except slight necrosis at the tip of the fronds in few plants. This indicated that this fern species was tolerant to arsenic relatively. Biomass of hyperaccumulator is a key factor for phytoremediation practices. Results show that the frond dry biomass (38.99 g) in 75 kg P ha^{-1} (KH_2PO_4) has significantly difference compared to the frond biomass (29.08 g) in 75 kg P ha^{-1} TSP. Meanwhile, there is no significant difference in dry biomass of plant root from 0 up to 75 kg P ha^{-1} of TSP and (KH_2PO_4). Plant uptake of arsenic by frond in 75 kg P ha^{-1} TSP has significantly difference with 0 kg P ha^{-1} TSP. Meanwhile, there is no significant difference on arsenic uptake by frond from 0 up to 75 kg P ha^{-1} of (KH_2PO_4). For arsenic uptake in root, the highest treatment rate of TSP (75 kg P ha^{-1}) shows significant difference with 0 and 12.5 kg P ha^{-1}. Meanwhile, there is no significant difference on arsenic uptake by root from 0 up to 75 kg P ha^{-1} of (KH_2PO_4).

Keywords：*Pteris vittata L, Arsenic, Phytoremediation, Uptake, Biomass*

P4-43

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Characterisation of Phenanthrene Associated with Naturally Occurring Colloids in Soil Extracts Using an Isotopic Dilution Technique

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The association of polyaromatic hydrocarbons (PAHs) with colloidal inorganic and organic particles is an important factor influencing their bioavailability, mobility and degradation in aquatic systems. Despite this, our understanding of the phase speciation and bioavailability of PAH-colloid associations has been hampered by the limitations of operationally-defined analytical techniques. The objective of this study was to develop an experimental technique based on the use of 14C phenanthrene to quantify the isotopically exchangeable and non-exchangeable forms of phenanthrene as a model compound in filtered soil water or sodium tetraborate extracts. The study was also designed to investigate the exchangeability of phenanthrene as affected by filter pore size. The results showed that the isotopically non-exchangeable phenanthrene in filtered soil water or sodium tetraborate extracts ranged between 5-88 % and 16-85 % respectively. Our findings suggest that the exchangeability of phenanthrene in sodium tetraborate is controlled by both inorganic and organic colloids while in aqueous solutions inorganic colloids mainly control its exchangeability. While filter pore size had a significant effect on phenanthrene exchangeability, the filtrates still contained a large proportion of non-exchangeable phenanthrene. The method developed here by incorporating resin into dialysis tubing demonstrates a precise technique for the assessment of the exchangeable fraction of PAHs in aquatic systems, which has important implications for PAH mobility, bioavailability and biodegradation.

Keywords：*colloids, isotopic dilution technique, PAHs, exchangeability*

P4-44

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Mechanism of Phosphate and Citric Acid Affecting Pb_2^+ Adsorption by Red Soil Colloids

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The effects of phosphate and citric acid on Pb2+ adsorption by red soil colloids was studied by batch isothermal equilibrium experiments. And the affecting mechanisms of phosphate and citric acid on Pb2+ adsorption were discussed through analyzing Zeta potential and X-ray diffraction. Results showed that the Pb2+ sorption amount was characterized as peak-like curves with the increase of acid citric, which peaked when the initial citric acid concentration was 0.2 mmol L-1. When different concentration of phosphate added into this system, the peak-like curves of Pb2+ sorption was moved up even disappeared. The presence of 1.0 mmol L-1 phosphate and 0.5 mmol L-1 citric acid induced the increase in adsorption amount of Pb2+ in different degree. When the Langmuir equation was used to fit isothermal adsorption curve of Pb2+, the adsorption reaction constant (K), the maximum adsorption quantity (Xm) of several treatments were both in a decreasing order of 1.0 mmol L-1 P > 1.0 mmol L-1 P+0.5 mmol L-1 cit > 0.5 mmol L-1 cit. This showed that citric acid inhibited phosphate sorption thus reduced adsorption amount of Pb2+ on surface of red soil colloids. The influence of citric acid on Pb2+ adsorption increased with the increasing pH value in the system, and then decreased gradually. The order of Zeta potential reduction were : 1 mmol L-1 P +0.5 mmol L-1 Cit>0.5 mmol L-1 Cit>1 mmol L-1 P, which were different from that of the adsorption amount of Pb2+. The results indicated that the addition of phosphate increased the electrostatic adsorption amount of Pb2+, which dued to the formation of Pb-phosphate compounds. XRD also showed the occurrence of pyromorphite [Pb5(PO4)3Cl] in the treatment with 1.0 mmol L-1 P addition, whereas other treatments had not found. It demonstrated that mechanism of Pb2+ adsorbed in red soil colloids with addition of phosphate was primary formation of pyromorphite like compounds.

Keywords：*Phosphate; Lead; Citric; Adsorption; Red soil colloid*

P4-45

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Dissipation and Leaching of Atrazine in Maize Grown on No-Till and Conventional Tillage Soils in Peninsular India

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Winter maize in Andhra Pradesh state of peninsular India is grown in two systems of cultivation, as no-till crop in puddled rice-fallows in fine textured soils (0.25 M. ha) and under conventional tillage (0.16 M. ha) in medium and coarse textured soils under similar climatic conditions. Atrazine is the most popular pre-emergence herbicide used by the maize farmers. Data on persistence of atrazine under the winter maize in no-till and conventional tillage cultivation is not available. A field experiment was conducted at College of Agriculture, Hyderabad during winters of 2010-11 and 2011-12 in two different soils in the same farm viz., Alfisols (conventional tillage) and Vertic Inceptisols (no-till cultivation) to evaluate the dissipation and in-situ leaching of atrazine at recommended (1.0 kg a.i./ha) and double doses (2.0 kg a.i. /ha).

Red soils (Typic Haplustalfs) were reddish brown in colour (5YR ¾), neutral in pH (6.95), non-saline(0.28 d S/m), medium in organic carbon (0.52%) with a CEC of 15.8cmol P+/kg soil. Kaolinite was the dominant clay mineral (49.9%) followed by illite (36.2%). Texture of the soil was sandy clay loam and bulk density (0-15cm) was 1.25 Mg/m3. Vertic Haplustepts were very dark grayish brown in colour (10YR3/2), slightly alkaline (7.75), slightly saline (EC=1.92 d S/m), non-sodic (ESP=7.2), with high organic carbon content (0.95 %). CEC of the soil was 22.6 cmol P+/kg soil. Soil was clay in texture with 1.41 Mg/m3 bulk density. Smectite was the dominant clay mineral (41.9 %) followed by illite(36.9%).

Atrazine was applied as pre-emergence herbicide on same-day sown maize plots at 1 day after sowing in both systems at recommended (X dose) and double dose (2X). Composite surface soil samples (0-10 cm) from 1m2 area (5 spots) were collected from different plots at 0 (2 hours after sowing), 3, 8, 15, 30, 45, 60, 75, 90 days after application of herbicide (DAAH) and at harvest. Soil samples were also collected from 0-10, 10-20, 20-30 and 30-60 cm depth at 7 and 15 DAAH to assess leaching. Plant and grain samples were collected at harvest.

Atrazine residues in soil /plant/grain samples were extracted, cleaned and residues were estimated using GC-NPD. Limit of quantification (LOQ) was 0.02 mg/kg. Recovery of atrazine was 91.4-94.6 % in Inceptisols and 88.6 To 92.6 % in Alfisols. In maize grain and plant samples recovery was 94.6 to 98.2 % and 92.8 to 98.4 %, respectively.

Under conventional tillage, atrazine residues persisted up to 45 DAA in surface layer during both the years at x dose. At 2X dose residues could be detected upto 60 DAA during 1st year and 45 DAA during second year, beyond which they reached the below detection limit (BDL). Dissipation of atrazine in the Alsiols was biphasic at both rates of application. Half- life of atrazine varied from 19.5 to 22.4 days in X dose and 23.3 to 24.7 dose in 2X dose.

In no-till maize soils, atrazine residues in soil could be detected upto 60 DAA at X dose during both years At 2X dose residues could be detected upto 75DAAH both years year. In case of no-till soils dissipation of atrazine followed first order kinetics. DT50 was and 21.0 to 23.4 days during 1st and 2nd years in X-dose.

And during 2nd year DT50 varied from 26.6 to 27.5 days during 1st and 2nd years in 2X-dose. Residues of atrazine were blow detection limit in maize grain and plant at harvest.

Maximum concentration of leached atrazine in Alfisols was detected in 10-20 cm layer at X dose and 20-30 cm in 2X dose at 7 DAAH during both the years. At 15 DAAH, atrazine residues could be detected in the 20-30 cm layer, however maximum concentration was in 10-20 cm layer. In Inceptisols, maximum concentration of atrazine was in the top 10 cm layer during both years at 7 DAAH an very low concentration of atrazine could be detected in 10-20 cm layer at 15 DAAH in 2X dose.

Presence of Higher organic carbon content due to rice root mass, high content of smectitic clays in the Inceptisols contributed to longer persistence of atrazine in no-till systems. Presence of impervious puddled layer at 15-20 depth might have prevented leaching of atrazine beyond 15 cm depth.

Keywords：*Atrazine,Dissipation , Leaching, No-till,conventional tillage, Half-life*

P4-46

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Fixation of Arsenic by Fe-Nodules in Soils of the Southern Taiga

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Arsenic is one of the inorganic poisons, whose behavior in the soil constantly attracts attention. We have studied peculiarities of arsenic ions fixation by soils of the southern taiga region. The objects of the study were: 1) sod-podzolic arable soils formed within autonomous landscapes (Moscow region); 2) wetland soils formed in the contact zone between transit and autonomous landscapes and located on the terrace part of the floodplain (Moscow region); 3) heavily polluted alluvial soils in Ural region; the alluvial soils were sampled in the floodplains of the tributaries of the Kama River.

In Moscow region It was found that in sod-podzolic soils As content did not exceed 2-6 mg/kg. However, in Fe-ortsteins isolated from these soils, the Arsenic content was 10-30 mg/kg. Wetland soils were characterized by high carbonate content and a combination of carbonate precipitation zones and iron-enriched layers in the profile. The total As content in these soils was higher in the zones of iron precipitation. Given that the studied area is former agricultural land, As-containing pesticides is one of the possible As sources. Study of the tumors formed in the floodplain have shown that most part of As (up to 100 mg/kg) was adsorbed by freshly deposited Fe-hydroxides, such as ferrihydrite 2Fe2O3 · FeOOH· 4H2O. The latter is the main Fe-hydroxide in rohrensteines.

The alluvial soils in Urals region were heavily polluted by sewage water of Perm-city [1]. The concentration of Arsenic in rohrensteines was 11-42 mg/kg, that is almost nine times higher than the As amount in the fine earth. Accumulation of As in rohrensteines leads to Arsenic immobilization, preventing As ion migration in surface waters and decreasing As bioavailability.

Reference.

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This work was supported by RFBR grant No 13-05-00542.

Keywords：*sod-podzolic soils, arsenic*

P4-47

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Human Health Risk Assessment of Barium from Barite Contaminated Soils Based on Gastric Phase in Vitro Data and Plant Uptake

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Introduction

Barium (Ba) shares several chemical characteristics with calcium (Ca), lead (Pb) and strontium (Sr). Barium is widely distributed in soils, sediments and natural waters. Barium is not believed to possess any nutritional benefits to animals and plants. Clinical examples of death due to acute Ba exposure have been reported, particularly in suicidal cases. (USEPA 2005).There is presently very limited data on the bioavailabilty and uptake of Ba into the humans from Ba contaminated soils.

This paper investigates the bioaccessibility of Ba the bioaccessibilty of Ba using a gastrointestinal in vitro methodology to estimate bioavailability in humans. It was hypothesised that barite contaminated soils, aged in the field, may supply sufficient Ba to gastric solution to cause human health concerns. In addition, the concentrations of Ba in plant tissue is also reported in relation to speciation and human health. Finally, the results are discussed in the context of available data on acute and chronic health effects of Ba.

Materials and Methods

Soils

Details of the experimental soil can be found in Lamb et al. (Lamb and others 2013). In brief, seven field contaminated soils were sampled in duplicate, making a total of 14 samples with different concentrations but similar properties. In addition, another soil was spiked with 5000 mg kg-1 Ba (as NO3-).

In vitro gastrointestinal bioaccessibility

Gastric solution was prepared using the same recipe as outlined in Ruby et al.(1996). The % bioaccessible barium in the gastric (GBAc), intestinal (IBAc) phases and the average of gastric and intestinal (ABAc) were calculated using equation 1:

'%Bioaccessible Ba=' (('Ba extracted(<250μm),' 'mg' -'kg')/('Ba Acid Digestion(<250μm),' 'mg' -'kg'))'×100' (1)

The acid digestion total measure was used since it was considered to represent the maximum concentration able to be accessed by organisms.

Plant Study

For this study, spinach (Spinacia oleracea L.) was grown in soil L10, L1, L6 and L9 and the spiked soil. One leaf and some roots of every plant were sampled and chilled in freezer (-80°C) prior to examination using Environmental Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray (EDX). Samples were placed in liquid nitrogen and fractured prior to examination.

Results

The PBET study showed that Ba solubility in the in vitro bioaccessibility (BAc) measures test reached a maximum in the gastric phase at 60 minutes. GBAc increased gradually to 60 minutes, then intestinal BAc decreased with time after the pH was increased to 7.0. In soils containing high barite, the relative bioaccessiblity (%) was low but increased with low levels of barite.

The white precipitate found after plant digestion was analyzed using ESEM-EDX, as well as in tact leaves. The results indicate that the white precipitate was likely to be barite. It is unclear if barite precipitated after digestion, or if it was present as a "biomineral" prior to digestion. The suggestion that barite was present in the intact leaves suggests it was likely present as a biomineral. Either way, Ba in plant tissue appears to be somewhat bioaccessible, although a small amount of Ba is able to be dissolved in acid.

Given the high consumption rate of soil required, chronic Ba induced health problems are unlikely from the barite contaminated soils considered. Results indicates that under the conservative assumptions made in this report, a child would need to consume greater than 2 g of soil per day over an extended period to cause chronic health problems.

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Keywords：*Bioavailable, bioaccessible, biomineral, human health*

P4-48

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Mid Infrared Spectroscopy and Partial Least-Squares Regression: A Rapid and Cost-Effective Approach to Estimate Soil Arsenic Content

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Arsenic (As) is an extremely toxic and carcinogenic element, therefore, contamination of soils with As is a major environmental threat. Arsenic concentration in soils in the vicinity of cattle dip sites spread in northern NSW (Australia) varies significantly on a small scale and analyses of a large number of soil samples is required to estimate the contamination level and distribution of As at a particular site. Estimation of the total As content in soils is imperative to assess the extent of contamination and risks posed to the environment, and to evaluate the impact of remediation strategies. The existing standard methods for estimating total As concentration in soils are typically based on acid digestion procedures, which requires the use of mixtures of concentrated acids (HNO3, HClO4, HCl, H2SO4, HF). Total As concentration in soil digests is generally measured by hydride-generation atomic absorption spectrometer or inductively couple plasma atomic emission spectrometer. Although chemical techniques used to determine the total soil As content in soil are highly accurate, the procedures are hazardous and time-consuming. There is a need for a rapid, inexpensive and easy-to-use method, in order to routinely estimate total As in large number of soil samples at a given site, to monitor changes in soil As content at a specific site or to estimate variability in total As in soil at a particular site. Mid infrared (MIR) spectroscopy in combination with partial least squares (PLS) has been used as a rapid method to estimate the various soil physicochemical properties such as, pH, cation exchange capacity, clay, sand and silt contents, and sorption coefficient of pesticides in soil. However, very limited efforts have been devoted to evaluate the potential of MIR in conjunction with PLS to predict As and heavy metal contents in soils. Therefore, the objectives of this study were to (1) develop a site-specific predictive model using the combination of MIR spectroscopy and PLS regression to estimate total and phosphate-extractable As contents in soil, and (2) apply the predictive model to unknown soil samples (not used in developing the model), in order to estimate As concentration in soils and to evaluate the prediction quality of the model.

Arsenic-contaminated soil samples (n = 298) were taken from a disused cattle-dip site located at Wollongbar, NSW, Australia at three depths, i.e. 0−20, 20−40 and 40−60 cm. After digestion of finely ground (< 200 μm) soil samples, As was analyzed using an ICP-AES. Diffuse reflectance (MIR) spectra of the finely ground soil samples were obtained using a FTIR spectrometer in the wavenumber range of 4000–400 cm–1 and reflectance (R) values were log-transformed (log(1/R)) to represent spectra in absorbance units using OPUS® software. The PCA and PLS regression were performed using the JMP version 8. The samples were split into two sets, i.e. (i) calibration set (n = 149) to develop a calibration model; (ii) validation set (n = 149) of unknown samples that was used to validate the efficiency of calibration model. Various parameters such as coefficient of determination (R2), ratio of performance to interquartile distance (RPIQ), standard error of cross validation (SECV) in calibration model, standard error of prediction (SEP) in validation model were calculated to evaluate the efficiency of the MIR-PLS prediction model for As estimation.

The results showed that PCA was very helpful to identify spectral outliers in the absorbance spectra of soil samples. The MIR-PLS calibration model (n = 149) excluding spectral outliers showed an acceptable reliability (R2c = 0.75; RPIQc = 2.20) to estimate total soil As. For total soil As, the validation of final calibration model using 149 unknown samples also resulted in a good acceptability with R2v= 0.67 and RPIQv = 2.01. However, the MIR-PLS calibration model based on phosphate-extractable As was not acceptable to estimate the extractable (bioavailable) As content in soil (R2c = 0.13; RPIQc = 1.37; n = 149). The results show that the MIR-PLS prediction model based on total As can provide a rapid estimate of soil As content by taking into account the integrated effects of adsorbed As, As-bearing minerals and As associated with organic components in the soils.

Keywords：*MIR-PLS, PCA, Phytoremediation, Cattle-dip site*

P4-49

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Sorption-Desorption Behavior of Radiocesium in Soils and its Transfer to Crops

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Sorption-desorption of 134Cs on some soils, soil clays and clay size aggregates representing seven soil orders of India were studied to evaluate the time of contact, activity levels and potassium activity ratios. Radiocesium interception potential and geochemical partitioning were also determined for these soils. The sorption of cesium was rapid and near equilibrium was reached in 30 minutes. Hence, for all other experiments 30 minutes contact time was maintained. The 134Cs sorption varied from 28 to 96%, the maximum being in Vertisol (96%) followed by Inceptisol (93%). The sorption on soils was greatly influenced by 134Cs activity levels. While, radiocesium sorption after removal of organic matter from the aggregates was significantly increased with increase in 134Cs activity and the effect was marked at 25 kBq kg-1. Removal of sesquioxides from clay aggregates leaving the clean clay samples drastically lowered the 134Cs sorption and the magnitude of sorption was in conformity with the nature and content of clay mineral composition i.e. higher values being associated with smectite and mica as compared kaolonites.

The results were discussed in the light of the pedology, pH and organic carbon content. Radiocesium interception potential and geochemical partitioning data well supports the higher sorption and retaining capacities in soils dominated with 2:1 type and micaceous minerals than 1:1 type of minerals. The sorption percentage decreased with increasing activity levels. Increase in activity ratio of potassium decreases the radiocesium sorption on soils. 40 to 68 % of the sorbed 134Cs can be removed from the samples and the order of effectiveness of the extractants was NH4Cl > KCl> CaCl2> water.

Plant uptake of radiocesium from soil is an important pathway for the entry of this radiocesium into the human food cycle. Pot culture experiment was conducted to study the effectiveness of waste mica (@ 0, 10, 20, 40 g kg-1) and potassium fertilizer (0.17 g kg-1) in reducing the radiocesium uptake by Spinach (Spinacia olerecea L) and Lettuce (Lactuca sativa L.) grown in 134Cs contaminated (@ 37 k Bq kg-1 soil) Inceptisol, Vertisol and Ultisol of tropical climate. The crops grown in Vertisol recorded higher yield, K content and its uptake compared to Inceptisol and Ultisol. The average transfer factor values of 134Cs were 0.21, 0.17, 0.26 at 1st cut; 0.15, 0.12, 0.28 at 2nd cut and 0.07, 0.05, 0.23 at 3rd cut for Inceptisol, Vertisol and Ultisol, respectively. Further, transfer factors in control pots were ranged between 0.2 and 0.4. Waste mica application was observed to suppress radiocesium uptake, the effect being more pronounced at 40 g Kg-1. Compared to shoots, roots recorded higher transfer factors.

To evaluate the residual effect of applied waste mica, in the same pots after harvest of Spinach and Lettuce, Green gram and Soybean were harvested. Vertisol recorded higher biomass yield, grain yield and K uptake in Soybean compared to Green gram with waste mica application (@ 40 g kg-1 soil). The potassium application significantly increased the potassium concentration in plants. Compared to control, waste mica and potassium treatments significantly improved the yield, K content in plant and its uptake. Amongst the soils, crops grown in Vertisol recorded higher yield compared to Inceptisol and Ultisol. Irrespective of the treatments, the 134Cs transfer factor was observed to be higher in Ultisol as compared to Inceptisol and Vertisol. Among the treatments, the effect of waste mica (@ 20 and 40 g mica kg-1 soil) was significantly superior compare to K application.

Keywords：*Radiocesium, waste mica, transfer factor, sorption-desorption*

P4-50

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Sediments Phosphorus Dynamics in a Southern Brazilian Watershed with Contrasting Land Uses

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Phosphorus (P) and suspended sediment (SS) mobilization in land runoff and their subsequent delivery to freshwater systems is of most concern in catchment scale soil and water quality management. The aims of this study were to quantify the (i) soil phosphorus availability and to characterize phosphorus forms; total P (TP), inorganic P (IP), total organic P (TOP) and bioavailable P (BAP) in SS and river bed sediments (BS) as contaminant agents of waters as a function of land use; (ii) To monitor the spatial variation of the P content of SS and BS samples between the sub catchments; and (iii) To examine variation in the water total P, soluble P (SP) and particulate P (PP) content both in base flow as well as event base. The study area Guapore catchment is located between latitudes 29.2 S and 28.2 S and longitude 52.4 W and 51.8 W in the upper northeast slope of Rio Grande do Sul state in Southern Brazil with basin area of 2790 km2. The main soil types include Oxisols, Alfisols, Ultisols and Entisols. To characterize the inherent soil P, a total of 318 representative soil samples from the arable fields, grasslands and unmetalled roads were taken to cover the spatial variability. To collect representative water, suspended, rain event and bed sediment samples topographic map, aerial photographs, and field work using a GIS with ArcView program 10.1 and the digital elevation model SRTM with spatial resolution of 90m were used to identify potential representative source areas. A total of 11 points were selected. The main sub catchments selected includes; i) untreated city and house effluent; ii) no-till (NT) mixed crop cultivation like (maize, wheat, soybean) having little or no riparian barrier; iii) poultry/pig forming dominated sub-catchment; and iv) a sub-catchment with conventional tillage (CT) and mono-crop cultivation (tobacco cultivation); v) less disturbed area forest as control and vi) outlet of the catchment, where total P export and SSC concentration was measured. At each monitoring point the SS were collected by using time-integrated suspended sediment samplers and BS manually by re-suspension method from a period of March 2011 to August, 2013 approximately every two months interval while the base flow water quality sample were collected manually on fortnightly basis and rain event by automatic samplers depending on rain/river flow level conditions. All standard procedures were followed for analysis. The results indicated that mean soil TP for each land use type was cultivated land 442.5 mg kg-1, grasslands 434.9 mg kg-1 and unmetalled roads 257.7 mg kg-1, respectively. The contribution of runoff events to TP and PP was more prominent throughout the study period, and ranged between 0.115 to 4.89 mg L-1 and 0.092 to 4.84 mg L-1, respectively. A high inter annual variability in TP and PP loss was observed, however the maximum losses were recorded in NT soil under tobacco cultivation. The base flow SP showed high concentration during months of low water flux. The SS exhibits high mean TP 2825.6 mg kg-1 in the NT catchment in December months in both years. In contrast the TOP was maximum 584.86 mg kg-1 in SS from non-treated city effluents monitoring point. Generally, across the different anthropic pressures the TP content of SS showed 4-7 fold increase when compared to respective soil TP. The IP content was maximum in NT catchment and average across the monitoring points IP showed as much as 95 to 99% of the TP. The BAP content of SS ranges from 18.7 to 84 mg kg-1. The maximum index of rainfall erosion (EI30), runoff coefficient (C), and sediment yield (SY) was observed during month of July in both years and under NT tobacco catchment. The study explains seasonal variations for TP concentrations and for the concentrations of IP, TOP and BAP in all the study catchments, but no consistent seasonal patterns is established. Maximum and minimum concentrations of the individual fractions occurred during different months in each of the monitoring point, suggesting that multiple factors regulate the P dynamics in the individual catchments.

Keywords：*Phosphorus, sediments, catchment,land-use, management sysytems, quantification, release pattern*

P4-51

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Impact of Anaerobic Bacterial Activities on the Dynamic and Speciation of Mercury in Tropical Soils in French Guiana

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Mercury (Hg) is one of the most toxic heavy metals due to its high reactivity with the surrounding environment. Its compounds differ in their toxicity and environmental mobility. For example, the organic form, monomethylmercury (MMHg), is easily bioaccumulated in organisms and biomagnified along food webs. Therefore, dynamic of Hg and its speciation represent a major environmental and health preoccupation.

French Guyanese soils (South America) contain high concentrations of Hg due to biogeochemical background, and anthropic activities, especially gold-mining. In dominant tropical oxisols poor in organic matter, Hg has accumulated in association with iron oxyhydroxides. These could affect probably the dynamic of Hg and its speciation by bacterial activity. According to the literature, sulfate-reducing bacteria (SRB) and recently, iron-reducing bacteria (IRB) have been demonstrated to have the capacity to methylate Hg. The purpose of this study was to determine, for the first time, the impact of bacterial activity under anaerobic conditions on the dynamic and speciation of Hg (in particular its methylation) in soils, especially tropical soils. Moreover it aimed to describe the relationship between different anaerobic metabolisms and Hg methylation.

The study area is situated in the watershed of Combat creek; located 10 km from the village Cacao in French Guiana. Gold-mining activity has occurred at this site in the past. Soil distribution, is related to its position along the slopes, this is typical in French Guiana. Two types of soils have been compared. The first type, oxisol, dominates on the upslope. It is well-drained, rich in ferruginous nodules and under aerobic conditions. The second one, gleysol, in the lowland, with dominant sands, is drained by a permanent aquifer.

To reach our goals, we have created anaerobic conditions by setting up different types of microcosms studied during one month (soil + liquid culture medium flushed with N2), and incubated at 28°C. Different carbon sources were respectively added to the microcosms (glucose, acetate, or lactate) in order to promote different metabolisms (fermentation or anaerobic respiration). Moreover, inhibitors or stimulators of SRB or IRB were added respectively to microcosms to investigate which microbial guilds were involved in iron-reduction and/or Hg methylation activities.

Many samplings were realized to evaluate different parameters during one month: bacterial metabolism (CO2 evolved, carbon source consumption, and organic acids production), pH, concentrations of several forms of Hg (total and soluble Hg using an atomic absorption method, MMHg using an isotope dilution method by GC-ICPMS), analysis of iron Fe(II) and total Fe by a colorimetric method and ICP-OES respectively, sulfide and sulfate's concentrations using colorimetric methods...

Our first results with oxisol showed that the highest global bacterial activity and reduction of iron were found in microcosms containing a fermentable source of carbon (glucose). Although, MMHg concentrations in these microcosms were lower than those reported with acetate or lactate (used by anaerobic respiratory bacteria). This Hg methylation activity detected in oxisol shows that the production of MMHg could occur in situ on the upslope under anaerobic conditions. These could take place in many situations: oxisol particles could be transported to the lowland by surface erosion from deforestation due especially to gold-mining activity. Moreover, anaerobic conditions could occur temporarily on the upslope when the pores in soils are saturated with water after heavy rains. Our results also showed that Hg methylation could be associated to anaerobic respiration process in these soils. In order to define the respective impact of different bacterial guilds or species involved in Hg methylation, these results will be omplemented by ongoing analyses: using inhibitors for SRB or IRB, and a molecular biology method (T-RFLP, Terminal-Restriction Fragment Length Polymorphism).

Keywords：*Mercury , Monomethylmercury, Iron-reducing bacteria, Sulfate-reducing bacteria, Tropical soil, French Guiana*

P4-52

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Determination of Plant-Available Cadmium in Cacao Plantations in Southern Ecuador: Chemical Extraction and Fractionation Analysis

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The determination of bioavailable pools for emerging contaminants in soils and the factors controlling their bioavailability is a continuous effort in scientific community worldwide. Cacao (Theobroma cacao L.), and more specifically cacao bean, has been reported to accumulate high levels of cadmium (Cd), which may enhance the risk of Cd exposure in cacao-based products. The concern of Cd in cacao beans was also reported in some South America countries including Ecuador. The objectives of this study were: a) to understand the accumulation of Cd in cacao beans relative to soil Cd availability, and b) to determine chemical speciation and other factors that may control plant-available Cd in soils. Nineteen cacao farms were sampled; leaves, cacao pods and soils were collected; soils were sampled at 0-5 and 5-15 cm (depths 1 and 2) to pinpoint vertical distribution of available Cd. Cacao tissue and beans were pulverized and digested with concentrated HNO3. Single extractions using 1 M NH4OAc, 0.1 M HCl, or Mehlich 3 extractants, and soil Cd fractionation with a sequential extraction method (Tessier et al, 1979) were performed. Plant analysis showed low concentration of Cd in leaves but much higher in beans, which ranged from 0 to 2.9 mg kg-1, twelve out of nineteen sites surpassed the critical level of 0.5 mg kg-1. The analysis of variance (ANOVA) showed a significant difference ($P< 0.001$) among the single extraction methods, with extractable Cd decreasing in the order of 0.1 M HCl > Mehlich 3 >> 1 M NH4OAc. Available Cd estimated with single extraction varied significantly with depth of soil, higher in depth 1 than depth 2 ($P<0.01$); however there was no significant interactions between methods and depths. Bean Cd concentration was significantly correlated with both total recoverable Cd and extractable Cd in soil, but more closely related to extractable Cd, $r = 0.77$, 0.79 and 0.40 ($P< 0.0001$, < 0.0001, and < 0.0002), respectively for 0.1 M HCl, Mehlich 3 and 1 M NH4OAc.

Soil Cd fractionation showed that organically bound Cd is the dominant fraction of the total recoverable Cd, which is significantly correlated with available Cd estimated by chemical extraction. The results from this study indicate that the high concentrations of Cd in cacao bean are related to Cd accumulation in soil. The constant litter accumulation and decomposition in cacao plantations and other potential anthropogenic activities such as irrigation may have contributed to Cd accumulation in the soils, which tends to decrease with soil depth. Extractable Cd estimated by Mehlich 3 or 0.1 M HCl appears to be a good indicator of available Cd in the soils. The high percentage of organically bound Cd in the soils merits further study for improving soil remediation management.

Keywords：*Cacao, cadmium, single extraction, sequential extraction, bioavailable Cd*

P4-53

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Batch and Column Methods Comparison on Sorption and Desorption of Zinc in a Sandy Soil

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Batch and column methods are common methods to study heavy metal sorption and desorption in soils. The batch method is most widely used because it is cheap and rapid but column method is expensive and time-consuming although it resembles field conditions better. The aim of this study was to measure sorption and desorption of zinc by two methods and then compare them. For batch method, five different ratio of soil: solution (RSS) (1:2.5, 1:5, 1:10, 1:20 and 1:50) and 10 levels of initial concentrations of Zn2+ (10, 20, 30, 40, 50, 60, 70, 80, 90, and 100mg L-1) was performed. Suspensions were shaken in incubator for 5 different times to reach equilibrium. Previously examined amounts of Tri Ethanol Amine added to buffer pH through sorption and desorption times. Zinc desorption was done for all RSS after equilibrium times. At the end of shaking periods, the suspensions centrifuged at 3000 rpm then the supernatants filtered. In column method, the experiment carried out with solutions containing 10, 50 and 100 mg L-1 Zn2+ at different flow rates (0.5Ks, 1Ks and 1.5Ks). The soils sieved and filled to each column up to 40 cm height to reach 1.3 g.cm-3 bulk density.Zinc desorption in this method was carried out with 0.01M Ca(NO3)2 as a matrix solution and then break-through curves were obtained using HYDRUS-1D software.Several kinetic models and isotherm equations fitted to data toidentify characteristic difference between two methods. Results obtained from batch method showed sorption rates were fasten early times and also were faster in high RSS (such as 1:2.5) compared to smaller RSS (1:20 and 1:50). Amount of sorption sites in the soil solution and competition over sites are the main factors in achieving equilibrium and affect the amount of sorption at different RSS.Among the eight kinetic equations, a diffusion equation had highest fitness (r2=0.97**) and theoretical equations (zero, one, two and three order equations) had lowest values of fitness (r2=0.32ns).Results showed that the type of isotherm sorption changed from I to II when RSS changed from 1:2.5 to 1:50 that indicates sorption process changed from chemisorption to physiosorption. Freundlich (r2= 0.99**) and Two-site Langmuir (r2=0.96**) equations best fitted to isotherms data respectively. Some equation parameters had significant relation with changes at RSS even with the theoretical equations. A significant relation was found between the amounts of maximum sorption capacity and RSS. Furthermore the hysteresis was increased with decreasing RSS. Significant correlation (r2=0.886**) was found between Kd and RSS values in batch method. In column method the flow rate was not found to influence Kd and β in a well-defined manner but increasing inlet concentration tended to decrease Kd and increase β. Results showed that for estimation of Kd and β values in column method from batch method, soil: solution ratio should be more than 1:2.5 (e.g. 1:1).

Keywords：*Batch,column,zinc,sorption*

P4-54

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Effect of Temperature and Sewage Sludge on Macro and Micro Nutrient Availability in Different Soils of India

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Temperature is one of the important factor in availability of nutrients .Present study was undertaken done to study the effect of temperature on nutrient availability in sludge amended soil The dried sludge were added with the red ,black and alluvial soils at the rate of 0, 25 and 50 g kg-1 soil and mixed thoroughly. The sludge amended soil was thermally treated at 50°C, 100°C and 200°C and availability of macro and micro nutrients were analyzed. Nitrogen availability increased with the increase in temperature, because due to higher temperature mineralization of nitrogen increased. Phosphorus availability also increased because high temperature decomposition of organo-phosphorus was increased that ultimately increased availability of phosphorus. But potassium availability was not significantly increased with increase in temperature, because potassium is mostly bounded with the mineral lattice, so at 200°C temperature no change was possible in lattice structure and it was only element that 100% present in mineral form. Organic carbon content decreased significantly with increase in temperature, because high temperature resulted the exhaustion of organic carbon occurs as carbon di-oxide. On the other hand application of sewage sludge in the soil improves the micronutrient availability. Iron availability in sludge amended soil increased with the increase in the rate of sludge application. In black soil, the Fe content is increased about 37.49%, 79.71% and 65.70% at 50°C, 100°C and 200°C respectively from the preceding temperature. Because at higher temperature the organically bound iron and loosely bound mineral Fe are released due to decomposition of organic and mineral matter. With the increase in rate of sludge application the rate of increase in iron content decreased from 39 – 35.58% as the sludge rate increased from 50 – 100 ton/ ha. There is a 50% increase in iron content due to higher temperature treatment and 20% increment due to increased sludge rate. In alluvial soil, similar pattern was found. The Fe content increased with the increase in temperature and rate of sludge application. About 20% increase in Fe content due to increase in sludge rate. The availability of Fe content increased from 24.60 – 89.46 mg/kg soil by the thermal and sludge treatment . Manganese (Mn) content also increased in three types of soil with the increment of temperature and sludge application. There is a marked rise in Mn availability at higher temperature at 200°C, at lower temperature thermal treatment and sludge application did not significantly increase Mn content because low temperature is not able to release organically and minerologically bound Mn. At lower temperature the Cu content did not significantly increase with the increase in sludge content but at higher temperature 100°C and 200°C the Cu content significantly increased. So at low temperature the Cu is strongly bound to the organic compound of the sludge and soil. As the temperature increased to the level of 100°C and 200°C, decomposition of organic matter and organic compound takes place and release the bound Cu in available form.

Keywords：*sludge, micronutrient,red soil, alluvial soil,and black soil*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Mobility of Cu and Co in Metalliferous Ecosystems of Katanga: Comparison of Soil Profiles And Experimental Results

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Numerous soils in Katanga have been contaminated by mining activities. Research are conducted in natural ecosystems of the copper hills to evaluate mobility of Cu and Co in soil-plant systems (Kaya et al., 2012).

This paper compares the results of soil profile characterization and lysimeter experiment. Typically, the relief in metalliferous hill of Katanga is driven by differential erosion of folded formations of the Mines and RAT subgroups of Roan group (Kampunzu et al., 2009). The more resistant silicified dolomites which host Cu and Co deposits outcrop in the upper part of the hills over less resistant argillaceous dolomitic siltstones. Cu and Co are transported along the slope as solid particles inside rock clasts by gravity and surface erosion. These contaminations have created a stressful environment for vegetation and only steppic or lawn species have been able to survive on the hills while the surroundings are occupied by the miombo forest (Duvigneaud et al., 1963).

Up to now, it is not known if the contaminations are limited to the soil surface and what impacts pedogenesis and biological activity can have on Cu and Co mobility in the entire soils. Fourty-two soil profiles were described and sampled in copper hills in order to evaluate the vertical and longitudinal distributions of Cu and Co along the slopes. The characterization of soil samples included pH, Total Organic Carbon, Texture, CEC, total contents of Al, Fe, Mn, Cu and Co, available and mobile contents of Cu and Co.

Additionally, a typical forest soil has been artificially spiked with rock fragments from five outcrops of Fungurume hills. These rocks outcrop at the upper part of the hill and are mixed to surface soil horizon along the slope through colluvial processes. Cu and Co contents of these rocks range between 470 (Siliceous Rock) and 140,000ppm (Shale) and between 450 (dolostone) and 5,300ppm (Shale), respectively. Rock fragments were mixed with two horizons (Hemiorganic A and mineral B) of an acid (pHwater<4,5) acrisol under forest. Mixture was installed in 1L-lysimeters and left in outdoor conditions during the rain season (1210mm). Percolating water has been collected at six periods and the content in Cu and Co has been analyzed. At the end of the experiment, the soil from the lysimeters was removed for analysis of pH, TOC, available nutrient and trace elements, CaCl2-extractable Cu and Co. The soil capacity to adsorb Cu and Co was also evaluated by batch exchange experimentation.

Results show strong differences (i) of Cu and Co profiles in soils according to the position in the landscape and (ii) of Cu and Co release in the percolating solutions according to the nature of rock. The quantities released were correlated to the quantities originally present in the unweathered rocks. Differences were also found between horizon A et B sorption capacity and composition of percolating solutions which indicate that the physico-chemical properties of the soil do influence the reaction with

the rock. Among the differences between both horizons are mainly the organic content, the cationic exchange capacity and the nutrient content which were higher in the A horizon, and the pH which was more acid compared to B horizon.

All the results converge to evidence of transformation and migration of Cu and Co in soils of the metalliferous sites. Moreover biological transportations (worms, ants, moles…) have not been taken into account. This might be important in order to deepen the understanding of relationships between soil constituents and plants.

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Keywords：*Copper, Cobalt, ecosystems, mobility, lysimeter*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Formation Mechanisms for Chromium Hydroxide Precipitation on Mineral Surfaces: the Impact on Contaminant Mobility in the Soil Environment

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In order to understand the long-term bioavailability of inorganic pollutants in the environment it is essential to quantify their cycling, stability, and sorption state. Together these parameters define the exposure and mobility risk of metals in natural systems. This investigation focuses on chromium which exists in both an innocuous and carcinogenic oxidations state. Nontoxic chromite [Cr(III)] is the preferred species, however, manganese(IV) oxides can serve as a redox catalyst to transform the nontoxic chromite [Cr(III)] into carcinogenic chromate [Cr(VI)]. Manganese oxides can also help immobilize chromium as surface precipitates, resulting in surface passivation of the manganese oxides and a reduction in redox capacity. The manganese oxides then take on the properties of the chromium sorbent. This process has profound implications to reduce the formation of chromate, sequester free chromium, and minimize the risk of environmental contamination. Despite the significance of chromium in the environment, the current understanding of these reactions is very limited.

Our research addresses these deficiencies by elucidating the mechanisms of chromium precipitation on manganese oxide surfaces. Synchrotron-based spectroscopy suggests both chromite [Cr(III)] and chromate [Cr(VI)] form complexes on the mineral surface, whereas previously only chromite [Cr(III)] was thought to sorb. This alters the structure, composition, and morphology of bound chromium on the manganese oxide surface, and impacts stability and desorption rates. While chromite is bound in a tightly sorbed inner-sphere complex, chromate interacts through a more weakly sorbed outer-sphere complex, which is subject to desorption and release into the surrounding environment.

Synchrotron-based spectroscopy also questions the accepted view that an alpha phase or uniform chromium surface precipitate orms on the manganese oxide surface. Instead a clustered gamma phase precipitate, which grows away from the surface, formed on hydrous manganese oxide (HMO), acid birnessite (AB), and random-stacked birnessite (RSB). This gamma phase precipitate is weakly sorbed in the interfacial region of the minerals, and leaves areas of the manganese surface available to oxidize more chromite [Cr(III)] to chromate [Cr(VI)]. This is unlike the alpha phase precipitate whose formation blocks further chromate [Cr(VI)] production. Furthermore, we showed that manganese oxides of the same oxidation states and similar structures have different potentials to oxidize chromium, whereas previous research had found no differences in the oxidation potentials of these minerals.

We characterized the oxidation of chromium using a host of manganese oxides: HMO, AB, and RSB. These manganese oxides were reacted in batch, stirred-flow, and replenishment methods. Concentrations were kept below the chromium precipitate concentration and at a pH 2.5, 3, and 3.5 which is below the precipitate pH of 3.84. By varying the concentration of chromium and the manganese mineral we were able to use a variety of techniques to decipher key differences in chromium oxidation to elucidate reaction mechanisms and precipitate formation. The structure and elemental composition of the oxidized chromium oxides was analyzed via synchrotron based bulk X-ray absorption fine structure spectroscopy (XAFS) and transmission electron microscopy energy electron loss spectroscopy (TEM-EELS). Surface structures were examined using transmission electron microscopy (TEM). Using these methods we were able to determine the distribution, sorption type, and oxidation state of chromium on the mineral surface. These parameters ultimately define the long term stability of sorbed chromium as well as the reactivity of the mineral. With a detailed understanding regarding formation, desorption experiments will also carried out to quantify retention rates. Together these parameters provide a powerful tool to model chromium retention in environmental systems through gauging the risk of remobilization.

Keywords：*manganese oxides, chromium, synchrotron, environmental contaminant mobility*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Kinetics of Arsenic Oxidation by Manganese Oxide Minerals: The Influence of Origin and Structure on Reactivity

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Manganese(IV) oxides are one of the main redox catalysts in the subsurface environment. Their highly reactive surfaces allow manganese minerals to oxidize trace metals such as arsenic from the mobile and toxic phase arsenite [As(III)], to a less mobile and toxic form, arsenate [As(V)]. Arsenic contaminated drinking water is an increasingly important global issue from legacy industrial processes, pesticide residues, and mine tailings. Additionally, developing countries like Bangladesh with naturally high levels of arsenic in groundwater struggle to find clean water. Understanding manganese oxidation of arsenic is critical to ameliorate this global health hazard.

In order to understand the many roles of manganese oxides in the natural world, it is essential to characterize the differences in their reactivities. Abiotic and biogenic manganese oxides are the two primary forms of manganese minerals found in natural systems. Four abiotic Manganese oxide minerals -- manganese oxide (HMO), hexagonal birnessite, random-stacked birnessite, and acid birnessite, and one biogenic manganese oxide were reacted under identical conditions. Batch reactions using equal concentrations of manganese and arsenic [As(III)] were conducted to determine arsenic oxidation kinetics. Samples collected from the experiments were analyzed by liquid chromatography inductively coupled plasma-mass spectrometry (LC-ICP-MS) to determine arsenic [As(III)] and arsenic [As(V)] concentrations. All five manganese oxides exhibited a biphasic oxidation reaction, with biogenic manganese oxides having the slowest initial reaction kinetics.

Manganese oxide minerals are composed of MnO6 octahedra, which can be arranged in a variety of ways. Many naturally occurring manganese oxides are difficult to characterize because they are small and exhibit poorly crystalline structure. Manganese oxides fit into two broad structural groups: tunnel and layer structures. The manganese oxides tested in these batch reactions exhibit layer structure and tend to be more reactive than those with tunnel structure. Among the layered manganese oxides, minerals similar to hexagonal birnessite, including biogenic manganese oxides, are the most reactive and thus important in the environment.
Random-stacked birnessite (RSB) exhibits a triclinic birnessite structure, while all the other manganese oxides in this study have hexagonal birnessite structure. The hexagonal birnessite structure is more reactive and less crystalline than triclinic birnessite. Within the hexagonal birnessite structural group the reactivity was measured based on the crystallinity of the mineral. This was determined by x-ray diffraction (XRD) and transmission electron microscopy (TEM).
The two synthetic manganese oxides, acid birnessite and HMO, oxidize arsenic(III) more rapidly than biogenic manganese oxide. This could be caused by interactions between the arsenic(III) and residual microbial biomass present in biogenic manganese oxide. Finally, arsenic concentration, pH, and temperature were varied with the two most reactive manganese oxides, HMO and acid birnessite. Under these conditions, high arsenic concentrations decreased reactivity due to surface passivation. The reactions were temperature dependent and changes were reflected through altered kinetics. Understanding the reactivity of naturally occurring manganese oxide minerals provides key insight to the chemical processes that regulate manganese oxidation in the environment. This knowledge is invaluable in understanding how arsenic is naturally attenuated by manganese oxides in contaminated ecosystems.

Keywords：*manganese oxides, arsenic, drinking water, environmental contaminant mobility*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Evaluation of Heavy Metals Concentration in Shoormast Lake

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This study was done in the spring of 2013, to the knowledge of the pollution of Lake Shoormast to heavy metals (lead, copper and cadmium) were performed. Surface sediment samples, deep blue water and aquatic buttercups, Ranunculus fluitans, were harvested from four stations. For extracting metals from samples of wet digestion and chemical methods to determine the concentration of heavy metals by atomic absorption spectrometer (AAS) was performed. Data analysis software Spss and ANOVA was performed. The results showed that the mean levels of lead, copper and cadmium in surface sediment samples collected from different stations, respectively, 117, 8 and 11 ppm on a dry weight basis, and the deep sediments, respectively, 30, 14 and 7 ppm on a dry weight basis, and aquatic plants, aquatic buttercups, Ranunculus fluitans, respectively, 60, 10 and 16 ppm dry weight, and water samples, respectively, 1, 0.01 and 0.04 ppm is. Statistical comparison of metals, lead, copper and cadmium in deep sediments, surface water, and aquatic plants showed no significant differences. In this study, the average concentration of heavy metals in surface sediments than in the water is minimal. The results showed that the metals lead and cadmium in water samples compared to the standard World Health Organization (WHO) standard and America Environmental Protection Agency (EPA), was higher.

Keywords：*Heavy Metals, Pollution, Shoormast Lake*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Effects of Halogenation and Nitrogen(n)-Heterocyclic Aromatics on Estimating the Persistence of Future Pharmaceutical Compounds in the Sub-Surface

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The effects of halogenated aromatics/aliphatics and nitrogen(N)-heterocyclic aromatics on estimating the persistence of future pharmaceutical compounds were investigated using a modified half life equation. The potential future pharmaceutical compounds investigated were approximately 2000 pharmaceutical drugs currently undergoing the United States Food and Drug Administration (US FDA) testing. EPI Suite (BIOWIN) model estimates the fates of compounds based on the biodegradability under aerobic conditions. While BIOWIN considered the biodegradability of a compound only, the half life equation used in this study was modified by biodegradability, sorption and cometabolic oxidation. . It was possible that the potential future pharmaceutical compounds were more accurately estimated using the modified half life equation. The modified half life equation considered sorption and cometabolic oxidation of halogenated aromatic/aliphatics and nitrogen(N)-heterocyclic aromatics in the sub-surface, while EPI Suite (BIOWIN) did not. Halogenated aliphatics in chemicals were more persistent than halogenated aromatics in the sub-surface. In addition, in the sub-surface environment, the fates of organic chemicals were much more affected by halogenation in chemicals than by nitrogen(N)-heterocyclic aromatics.

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Plant Toxicity and Uptake of Rdx and TNT by Sweet Sagewort (Artemisia Annua)

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Military shooting range soils are often contaminated with explosives such as TNT (2-methyl-1,3,5-trinitrobenzene) and RDX (1,3,5-trinitroperhydro-1,3,5-triazine) and their byproducts; 2,4-DNT (2,4-dinitrotoluene), 2,6-DNT (2,6-dinitrotoluen), TNB (1,3,5-trinitrobenzene) and HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine). Currently no information is available on the risk assessment of explosives- contaminated military shooting range soils in Korea. In this study, bioaccumulation of explosives (TNT and RDX) onto a plant was conducted using sweet sagewort (Artemisia annua), one of dominant species in Darakdae shooting range. To assess phytoxicity and bioaccumulation of RDX and TNT, a non-contaminated natural soil collected from a local horizon was used. Artificially contaminated soil samples were prepared by spiking with RDX (48.91 to 1093 mg/kg) and TNT (122.9 to 2628 mg/kg), respectively. A 4-week exposure to the explosives showed hazardous effect on sweet sagewort (Artemisia annua). LC50 value was calculated from the dose-response results; LC50 of RDX was 949.41 mg/kg and TNT was 238.49 mg/kg, respectively. The amount of bioaccumulated to the plant was highly related to pore water concentration of spiked soil (RDX, R2 = 0.8602). Our results showed that TNT and RDX can accumulate in the plant and influence on plant growth. Sweet sagewort (Artemisia annua) could be used as an indicator for the risk assessment of explosives-contaminated soils.

Keywords：*bioaccumulation explosives, plant uptake, RDX, shooting range soil, sweet sagewort (Artemisia annua)*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Optimizing Concentrations of Hemoglobin and Hydrogen Peroxide for Remediation of Benzo(a)pyrene (b[a]p) Contaminated Soils

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Storage or disposal of waste railroad ties often results in soil contamination with PAHs (polycyclic aromatic hydrocarbons) and other toxic compounds. According to soil conservation regulations in Korea, one of the PAHs of most concern as related to carcinogenicity is benzo(a)pyrene (B[a]P). In this study we used a laboratory approach to investigate the efficiency of B[a]P removal from B[a]P-contaminated soils using an biocatalytic reaction. The experiment used varying concentrations of hemoglobin and hydrogen peroxide to quantify the efficiency of abiotic B[a]P degradation. The experimental soil was collected from a site previously used for waste railroad tie storage. The contaminated soil had B[a]P concentrations ranging from 7.4 to 32.95 mg/kg soil (average, 15.1 mg/kg soil). The soil at the site is a sandy loam with organic carbon content about 19.6 %, pH 6.3, and Fe concentration of 69,072 mg Fe/kg. The experimental design used a range of hemoglobin (Hb) concentrations from 0.010 to 0.050 g Hb/2g soil and H_2O_2 concentrations ranging from 0.020 to 0.120 g/2 g soil. Samples containing either Hb and H_2O_2 alone were used as controls. Soil samples and the reactants were mixed in glass vials and the treatment proceeded for 24 hours. After 24 hours, a solution of the enzyme catalase was added to stop the reaction. Soil samples were extracted using a 1:1 mixture of n-hexane and acetone and later analyzed for B[a]P concentrations using GCMS. For control samples no significant decrease in soil B[a]P concentration after 24 hours was indicated. For samples containing both Hb and H_2O_2, the efficiency of B[a]P degradation (percent removal) varied with the H_2O_2/Hb ratio. A H_2O_2/Hb ratio between 2 and 4 showed B[a]P percent removal ranging from 40 to 70. Addition of greater amounts of H_2O_2 did not show a significant increase in B[a]P percent removal. We found two optimum ranges of H_2O_2 and Hb concentrations for optimum B[a]P remediation. H_2O_2 and Hb concentrations of 0.08 and 0.02 g/2g soil and 0.10 and 0.045 g/2g soil, respectively, both resulted in B[a]P removal of approximately 60 percent. Overall, these results show that B[a]P remediation using this biocatalytic reaction can be successful. More detailed studies will be needed to understand the kinetics of reaction for the two zones of optimal B[a]P removal efficiency.

This subject is supported by Korea Ministry of Environment (MOE) as GAIA Program.

Keywords：*Hemoglobin, Hydrogen peroxide, Biocatalytic reaction, Benzo(a)pyrene, Contaminated soil*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Leaching of Metallic Elements from Abandoned Mine Soils Depending on Various Flow Conditions

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It is essential to predict the environmental impact of contaminants, such as the migration of metals from mine soils to agricultural soils and watershed. The impact of mine soils on surrounding areas is considerable because the concentration of metals in leachate from abandoned mine soils is usually higher than the regulatory level. Leaching behavior of metals form mine soils is highly affected by flow condition, such as velocity and flow interruption. Especially after intensive rainfall, it is possible that mine soils are saturated for a while, and the chemistry in mine soil system can be changed, which influences the reaction between metals and soils. Therefore, the objective of this research is to elucidate the effects of flow condition on leaching properties of metals in mine soil systems.

o do this, 1) two mine soils (i.e., DY soil containing mining tailings, BS soil) were collected from across abandoned mine sites located in Korea. 2) Batch sequential desorption experiments were conducted to examine the maximum capacity of leaching of metals from mine soils. 3) 1-D transport experiments were carried out with various flow velocities (i.e., slow and fast flow velocities) and flow interruption for 48h in saturated mine soils. In addition, 4) sequential extraction of mine soils was conducted to interpret the relationship between leaching of metals and soil characteristics.

For each batch sequential desorption experiment, the equilibrium solution pH increased slightly compared to the initial value during repeated batch desorption. Aqueous concentrations of As increased slightly, while significant decreases in concentrations of other cationic metals (e.g., Zn, Cu, Cd and Pb) were observed. From 1-D column experiments, unlike nonreactive Br^-, all breakthrough curves of metals showed the sharp concentration drop and longer tailing, which means that extreme chemical nonequilibrium condition controlled transport of metals though the mine soils in columns. Initial sharp concentration drop of metals was greater at fast velocity than slow velocity, which means the faster velocity, the higher nonequilibrium condition. After flow redemption, concentration disturbance followed by concentration drop was observed. pH and Eh values of effluents also fluctuated depending on flow conditions. The results of this study will be applied to predict the impact of leachate on surrounding areas and to ensure the proper remediation and management of abandoned mines.

Keywords：*abandoned mine, leaching, flow velocity, flow interruption*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Role of Recycled Water Sources in the (im)mobilization and Bioavailability of Copper in Soils

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The aim of the paper was to investigate the impact of various recycled water sources (treated sewage, storm water, dairy, winery and piggery effluents) on the (im)mobilization and bioavailability of copper (Cu) in soils. Recycled water can act both as a source and sink for heavy metals. When used for irrigation the concentration of metal content in soils may increase depending on the level of treatment. But the presence of dissolved organic carbon (DOC) in recycled water are likely to (im)mobilize Cu by forming complexes thereby affecting the bioavailability. This work reveals that Cu-DOC complexes decreased the adsorption and bioavailability of Cu to plants and soil organisms which were evidenced by microbial respiration, earthworm toxicity and plant growth experiments. While the mobility of Cu increased with increasing levels of Cu, it depended on the extent of Cu adsorption and formation of soluble Cu-DOC complexes.

Keywords：*Recycled water, bioavailability, copper, dissolved organic carbon, immobilization*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Enhanced Bioavailability of Hexabromocyclododecane (hbcd) Diastereoisomers to Plants by Humic Acids

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The additive flame retardant hexabromocyclododecane (HBCD) has been extensively used all over the world for thermal insulation building material since 1970s.Three diastereoisomers (10.28%, 8.72%, and 81.01% for α-, β-, and γ-HBCD, respectively) are primarily composed of technical mixtures (Saytex○R, mp=168-184 °C) and its high Kow value (i.e., γ-HBCD) is highly related with potential bioaccumulation. However,stereoisomerization from γ- to α-HBCD caused by thermal rearrangement, biological persistence, metabolizing capacity, and bioaccumulation potential has resulted in dominance of α-HBCD in biota.For this reason, the distribution patterns of HBCD diastereoisomers indicate that biotransformation enzymes (e.g., cytochrome P450) have metabolized γ-HBCD to α-HBCD. Unlike previous studies in biota, the results showed the similar distribution pattern of techanical mixtures, which meant that the stereoisomerization of HBCD diastereoisomers in biota living in the terrestrial environment, such as plants,had different aspects from those of aqueous environments.We also investigated the enhancement of HBCD uptake using humic acids (HAs) which are complex organic mixtures produced from biodegradation of vegetation, animals, fungal, and bacterial residues. It plays an important role in terrestrial environments by increasing resistance to stress, such as drought, floods, and fungal diseases, enriching uptake of nutrients, stimulating bacterial activity and plant enzymes.

Nicotiana tabacum was used as the test plant and cultured for approximately 30 days. The contaminated soil was made with 10 mg of HBCD technical mixtures/kg soil. After 30 days, the plants were harvested and separated into shoots and roots. Compared to the control group without humic acids and HBCD, an experimental group with humic acids and HBCD quantitatively increased the uptake of HBCD diastereoisomers about 2 times without stereoisomerization.Consequently, biotransformation enzymes secreted by nicotiana tabacum also did not metabolize γ-HBCD to α-HBCD as much as expected, thus indicating that the stereoisomerization of HBCD could be greatly influenced by adsorption to soil rather than enzymatic metabolism. The effects of humic acids for plant growth were examined by adding 0.01% of total soil weight. Identification of HBCD diastereoisomers was performed using Agilent 1100 series HPLC coupled with an API 2000 triple quadrupole mass spectrometer from Applied Biosystems/MSD Sciex with an electrospray source (ESI) in negative ion mode. MS detection of native and 13C12-HBCD isomers was based on [M-H]- → [Br]- transition at m/z 640.6 → 79/640.6 → 81 and m/z 652.6 → 79/652.6 → 81, respectively.

In conclusion, the results suggested that humic acids could enhance the phytoremediation potential in HBCD contaminated soils, in other words increased the HBCD bioavailability.

Keywords：*HBCD, bioavailability, humic acids*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Effect of Liming on Chemical Speciation of Phosphorus in a Deforested Soil

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Phosphorus (P) is a major plant nutrient, and reacts sensitively to changing soil pH. Deforestation primarily affects soil chemical properties such as soil pH. It is well known that liming increases soil pH that in turn affects changes in soil chemical P speciation. To investigate the effect of liming on soil pH and chemical P speciation in a deforested soil, soil samples were collected and split into three treatment groups: control and two calcium carbonate treatments (triplicate x 7 destructive sampling times). Calcium carbonate treatments incorporated two levels of CaCO3 application [1 g CaCO3 ㎏-1 (LCC) and 4 g CaCO3 ㎏-1 (HCC)]. Each soil was incubated at 25±2℃ during 50 days. Soil samples were analyzed for pH, total-P, organic-P, available-P, inorganic-P, exchangeable Ca. Inorganic P was partitioned into three following chemical forms according to the fractionation procedure of Chang and Jackson: (i) Fraction A (Soluble- and loosely-bound P + Al-bound P + Fe-bound P) (ii) Fraction B (Reductant soluble P: redox sensitive P), and (iii) Fraction C (Ca-bound P). During incubation, soil pH was higher in CaCO3-treated soils than in control soils, and was higher in soils treated with higher rate of CaCO3 application. However, at the end of incubation the pH of LCC soils dropped to the level of control soils. Available-P decreased from 0.67 ㎎ ㎏-1 to the level of control soils in CaCO3-treated soils at the end of incubation. During incubation, total-P and organic-P of CaCO3-treated soils were virtually the same as those of control soils, except the value (20 ㎎ ㎏-1) observed for CaCO3-treated soils at the end of incubation, while inorganic-P Fractions varied. In both soils, Fractions A and C decreased, while Fraction B increased. However, all Fractions were not changed in control soils. To our current knowledge, Ca-bound P fraction increases with liming. However, in this study, Ca-bound P fraction (Fraction C) was lower in CaCO3-treated soils than in control soils. Because the Ca-P fractions consisted of various kinds of calcium phosphates, concentrations of Ca-P fraction should be determined by the solubility of each calcium phosphate compound. Therefore, this unexpected result requires further investigation on the changes in chemical P fractions following the application of limes.

Keywords：*Deforestation, Liming, Phosphorus, Chemical speciation*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Establishment of Efficient Sample Pre-Treatment Method for the Analysis of Pesticide Residue in the Soil Using with Hplc-Ms/ms

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Analysis of the Residual Pesticide in the soil has been applied liquid-liquid extraction methods. However, it needs many organic solvents, analysis instruments, complex analysis process for sample preparation and takes long time for the analysis. Therefore, the development of new method using LC-MS and QuEChERS (quick, easy, cheap, effective, rugged and safe) methods that extracts and refines pesticide components by directly adding solid sorbent into the sample is need on multi-residue pesticide analysis in soil. In order to establish the cost effective and easy to handle pesticide residue analysis, this study carried out a comparative experiment on the existing analytical method with a analytical methods modified QuEChERS sample pre-treatment method. For this experiment, 91 pesticides spiking soil was prepared as 5, 10, 20, 100 ㎍/kg concentration level. Prepared soil was immersed with 0.2N NH4Cl for 1 hour, and then they were extracted by acetonitrile. In the modified method, 87 pesticides were within recovery rates (spiked at 10 ng/g) ranged from 70% to 120%, and RSD values were under 10% for most compounds. The results showed that the modified QuEChERS sample preparation and LC-MS/MS analysis can be applied to multi-residue analysis of pesticides in soil.

Keywords：*Residual pesticide analysis, QuEChERS*

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[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Changes in Gene Expression under the Controlled Exposure on Soil Nematode Caenorhabditis Elegans

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Caenorhabdtis elegans is a free-living nematode that lives in the interstitial liquid phase of soil. Therefore, they are frequently used in soil ecotoxicological studies utilizing various exposure media, including soil, water and agar. C. elegans is a good model species for the study of soil ecotoxiology using molecular level biomarker, because they have much biological background, such as, genetics, molecular biology and cell biology. In this study, the gene expression was used as a biomarker to identify the toxic response against chlorpyrifos under a constant exposure condition. Chloropyrifos (O,O-diethyl-O-[3,5,6-trichloro-2-pyridinol] phosphoro thionate; CP), an organophosphorus insecticide is widely used in agriculture and in the home because of its safety relative to other organophosphorus pesticides. Chlorpyrifos is known to be oxidized by the CYP450 monooxygenases, therefore, cytochrome p450 family protein 35A gene series (cyp35a1-5) extracted from C. elegans, was analyzed using a real-time PCR. The concentration of CP in the assay medium was stable until the end of experiment on the constant exposure condition using passive dosing method. In addition, the level of gene expression increased linearly both with the exposure time up to 8 h and with increasing concentration. The observed increased gene expression at low concentration of CP could be explained by increasing body residue concentration of CP with exposure time.

Keywords：*Caenorhabditis elegans, Chlorpyrifos, Gene expression, passive dosing*

P4-68

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Assessment on the Content of Cu and Zn in Citrus Orchard Soils in Jeju of Korea

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The management of heavy metals in soil is important for environmental-friendly agriculture and healthy ecosystem. Cu and Zn can be accumulated in soils of plastic film house by long-term application of agricultural materials. In this study, we examined the concentrations of heavy metals(Cu, Zn) in 40 soils sampled from Jeju Province. Sampling sites were 20 in general agriculture plastic film house(GA) and 20 in organic farming plastic film house(OF). Soils were collected from four depths types, 0 to 10, 10 to 20, 20 to 30 and 30 to 40 ㎝ from September to October in 2013. Total contents of heavy metal were analyzed by ICP-OES after acid digestion(HCl : HNO3 = 3 : 1), whereas extractable contents were measured after successive extraction of 0.1 N-HCl and 0.01 M-CaCl2. The average contents of Cu and Zn were highest in 0 ~ 10 ㎝ depth, and gradually decreased with the deeper soil depth. The average total contents of Cu and Zn were higher in the organic farming than those in the general agriculture. The average content of Cu in the extractant with 0.1 N-HCl was higher in the general agriculture than one in the organic farming, but Zn was no difference. But the average contents of Cu and Zn in the extractant with 0.01 M-CaCl2 were no difference. The total concentrations of Cu and Zn to threshold values (Cu 150, Zn 300 ㎎ ㎏-1) in Soil Environmental Conservation Act in Korea(2011) were low in the citrus orchard soils. The ratios of extractable of 0.1 N-HCl Cu and Zn to total content ranged 5.90～7.52% for GA, 2.34～3.16% for OF, 15.9～30.4% for GA, and 15.2～30.4% for OF, respectively. The ratios of extractable of 0.01 M-CaCl2 Cu and Zn to total content ranged 0.225～0.258% for GA, 0.243～0.283% for OF, 0.590～1.18% for GA, and 0.758～1.29% for OF, respectively. Consequently, the citrus orchard soil was safe because the Cu and Zn contents of citrus orchard soil were very low as compared to its threshold value in the Soil Environmental Conservation Act. However, we are careful of the input of agricultural materials with farming practices for assessment of Cu and Zn.

Keywords：*citrus, soil heavy metal*

P4-69

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Effect of Various Stabilization Additives on the Cationic and Anionic Metal Stabilization in Contaminated Soils

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Heavy metal pollution in agricultural fields near abandoned mine areas was a serious problem in South Korea. For the rehabilitation of contaminated lands and ensuring food quality and safety, various technologies have been applied. Among different remediation technologies, the stabilization method has been widely applied in contaminated agricultural fields in order to minimalize the adverse impacts on the soil structure and fertility. As a stabilization additive or binder reagent, however, lime-based materials such as Ca(OH)2, CaMg(CO3)2, and CaCO3 and partly steel slags were mainly used, focusing on cationic metal contaminants. The stabilization treatment of anionic metal contaminants such as arsenic has not been widely carried out. Therefore, this study was conducted to evaluate the effect of various additives on the stabilization of both cationic and anionic metal contaminants in soils using a batch and an incubation experiment. Soils were collected from an agricultural site in Danyang and contaminated with As (total content: 197 mg kg-1), Cd(total content: 8.56 mg kg-1), Pb(total content: 463 mg kg-1), and Zn(total content: 635 mg kg-1). Lime, steel slag, and acid mine drainage (AMD) sludge in different mixing ratios were determined as stabilization additives. The batch experiment was conducted by mixing 1, 3, 5, and 10 g of each additive to 100 mg L-1 of each As, Cd, Cu, Pb, and Zn solution. After different shaking time from 1 minute to 24 hours the solutions were analyzed for pH, EC, and soluble metals. The Incubation experiment was carried out with 1 kg soil mixed with 3 % of each stabilization additive (w/w). The mixtures were saturated with distilled H2O (water content about 35%), incubated in room temperature, and analyzed for pH, EC, and soluble metals after 1, 3, 5, 7, 14, 28, 56, 112, 365 days. Additionally, SEM-EDS analysis was carried out to investigate the surface precipitation. The results of batch experiment showed that all additive with mixing ratios of 3% (w/v) stabilized the cationic metals effectively. However, only 5% of AMD sludge stabilized effectively arsenic. Cadmium and arsenic precipitations on the surface of AMD sludge were observed. The results of incubation experiment indicated that the cationic metal stabilizations by all additive occurred with 7 days, but after it the solubility of the metals increased slightly with the time. For example, Ca(OH)2 showed the stabilization efficiency of 85%~99% within 7 days, but the stabilization efficiency decreased up to 49~11% after 365 days. CaCO3 appears as the most effective and everlasting additive for cationic metal stabilization. Only AMD sludge successfully stabilized arsenic. The stabilization efficiency for arsenic also decreased after 56 days. On the basis of these results we could conclude that 3% of CaCO3 represented the most effective additive for cationic metal stabilization and 5% of AMD sludge for arsenic stabilization.

Keywords：*AMD sludge, arsenic, contamination, lime, metal stabilization*

P4-70

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Efficiency of Stabilization Methods Applied to Paddy Soil for Stabilization Cadmium in Soil and Crop Safety

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Over the past several decades, industrial development throughout the world has resultant in the contamination of soil with heavy metals. Especially, mining and metallurgical industrial areas which when dumped necessarily result in soil contamination. These metal contaminated soil occurrence a risk to humans, animals and environmental. There are many physical, chemical and biological methods to remediate the organic and inorganic pollutants in soil. These among, conventional physicochemical methods have been frequently applied to remediate contaminated soil, but its expensive and can be destructive to soil function. The treat of chemical amendment in a beneficial way may lead to the application of an environment-friendly soil remediation technology. Therefore, objective of this research was to evaluate the effectiveness of chemical amendments and soil layer engineering methods on the mobility of Cd in contaminated paddy soil near to a mining site. Field experiments were conducted in order to assess the effects of chemical amendments and soil layer engineering methods on the Cd stabilization in paddy fields near the abandoned metal mine where paddy soil was contaminated with Cd. Soil samples were taken with different time interval and Cd concentration (0.1 N HCl extraction) in soil were monitored accordingly. After harvest, Cd concentration in rice grains were determined. Result showed that soil pH was increased compared to control (6.1-6.7) after mixing with amendments and ordered as dolomite (7.2~8.3) > steel slag (6.7~8.1) > agriculture lime (6.6~7.4) > zeolite (6.2~6.9) > compost (6.1~7.1). Among other amendments, agriculture lime, steel slag, and dolomite showed the highest immobilization efficiency of Cd in soil. Stabiliztion efficiency of chemical amendments was 49~72%, 51~83%, and 0~36% for agriculture lime, steel slag, and dolomite respectively. In addition, efficiencies of amendments inhibiting Cd translocation to rice grains were evaluated by the bioavailability parameters, such as Cd concentration in rice grains and the biological transfer factor (BTF). Bioavailability of Cd to rice grains was significantly decreased by treatments such as amendments (agricultural lime and steel slag), winter crop (hairy vetch) and amendment-winter crop combinations. The soil layer engineering methods were effective in inhibiting the uptake of Cd by rice grains. The concentration of Cd in rice grains was 0.95 mg kg-1 in the control which exceeded both KFDA (Korea food and drug administration; 0.2mg/kg) and CODEX guideline (0.4 mg/kg). Layering the ZVI and lime between the non-contaminated surface layer and contaminated subsurface layer was effective in retardation of Cd uptake by rice grains.

Keywords：*heavy metals, remediation, amendments, soil layer, paddy rice*

P4-71

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Phytoaccumulation of Veterinary Antibiotics with Varied Cultivation Condition

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Consumption of veterinary antibiotics (VAs) was increased within last decades in Korea and concerns about adverse effects of released VAs in the environment have been increased due to possible production of antibiotic resistance genes (ARGs) and phytoaccumulation. Especially, compost or liquid manure is applied in soil and residuals of VAs can be transported from soil to crops. Therefore, main objective of this research was to evaluate uptake of VAs into crops. Total of 3 VAs including chlortetracycline (CTC), sulfamethoxazole (SMX), and tylosine (TYL) were selected because of high demanded VAs in Korea. Two sprouts, Brassica oleracea L. var. capita f. rubra and Raphanus sativus were cultivated for 10 days in growing chamber with spiked concentration of 5mg/L for each VAs in water. Another crop, lettuce (Lactuca sativa), was cultivated for 2 months in cultural media spiked with same concentration (5 mg/L) of each VAs. Growing condition for two sprouts was as following: 16 hrs light and 8 hrs dark, temperature was kept to 22-23℃. Analysis of VAs was conducted with HPLC/MS/MS. Result showed that 3 VAs were uptaken in two sprouts at the range of 0.04 - 13.2 mg/kg depending on VAs. However, much lower concentration of VAs was uptaken in lettuce at the range of 0.02 - 1.87 mg/kg. Calculated amount of each VAs in crops was ranged with 0.89 - 15.98% depending on VAs. Our result clearly showed that introduced VAs in the environment can be transported from soil to crops causing adverse effect on human health. Therefore, best management practice should be conducted to minimize adverse effect of VAs in the environment.

Keywords：*Veterinary antibiotics, Sprouts, Lettuce, Phytoaccumulation, Manure*

P4-72

[C2.2-3] Behavior and Fate of Pollutants Entering the Soil Environment

Soil Toxicity of Titanium Dioxide Nanoparticles and Arsenic in the Nematode Caenorhabditis Elegans

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The use of Caenorhabditis elegans in toxicology has increased greatly in recent years due to several particularly interesting attributes such as short reproductive life cycle, large number of offspring, and ease of maintenance, and well established genomics and functional genomics information. C. elegans can be cultured either on solid or in liquid medium, using either highly controlled media or more natural, complex media, such as soils or sediments. Although recent work has shown that C. elegans is often found in decaying plant material in nature rather than being principally a soil nematode as frequently suggested in earlier literature, it can nonetheless be conveniently cultured in soil and exposed to environmental stressors such as NPs or metals. Several toxicity studies have been conducted in C. elegans exposed to soil/sediment contaminated with metals or organic contaminants, however, perhaps due to the complexity of the soil matrix, few nanotoxicity tests have been conducted in soil/sediment exposure conditions so far. Here we conducted titanium dioxide nanoparticles (TiO2 NP) and arsenic toxicity tests on C.elegans via soil exposure condition. Nanotoxicity test was conducted using artificial soil containing sea sand, Kaolin clay, sphagnum peat moss and calcium carbonate. Mortality was not observed over a 48 hr exposure to TiO2 NP in soil media at any concentration up to 50 mg/kg, with or without ultraviolet radiation (UVR), while survival rate decreased significantly when nematodes were exposed to 10 mg/L of TiO2 NP in moderately hard reconstituted water under UVR. To gain an insight of mechanism of toxicity of TiO2 NP and arsenic, we conducted toxicity test using various stress response mutants, such as, pmk-1, cep-1, sod-1, -3, ctl-2, mtl-2 and hsp-16.2 for screening of TiO2 NP toxicity, whereas, gcs-1, abts-1, aip-1, asna-1, hasp-16.2, mtl-2 and fmo-2 for arsenic toxicity. Further studies evaluating the toxicity of NP and metals to C. elegans in different natural soils focusing on endpoints more sensitive than mortality will be required to better understand the toxicity of NPs and metals in soil media.

Keywords：*Caenorhabditis elegans, soil toxicity, titanium dioxide, arsenic, stress response mutants*

P4-73

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Clay Mineral Transformation Controlling the Availability of Cr and Ni in Paddy Soils

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Serpentinities are relatively unstable in near-surface conditions and weather easily into other layer silicates. Serpentinitic soils display strong chemical fertility limitations because of low Ca/Mg ratios and Cr and Ni enrichments. Significant contributions to the understanding of serpentinite weathering are found in environmental applications of soil mineralogical study. However, limited reports have investigated the mineral composition and genesis of serpentinites in the paddy fields. An unresolved question is whether primary mineral alteration and secondary mineral formation vary with horizon in a paddy soil derived from serpentinites. This study evaluated the hypothesis that mineral composition in the soils varies with differences in impact of the flooding associated with serpentinite weathering. The aims of present study are to: (1) identify minerals and their alteration in a paddy soil profile from serpentinites in eastern Taiwan, (2) explore the transformation of clay minerals through serpentinite weathering, and (3) link the mineralogical characteristics to lability of Cr and Ni in the soil. The parent materials of soils in the study area contained serpentinitic alluvium, which are from exotic blocks of serpentinites that crop out in the eastern section of the Central Ridge of Taiwan. One pedon was selected from a paddy field in the study area. The relative abundance of elements in the bulk soils was as follows: Si > Fe > Mg > Al, indicating the typical geochemistry of ultramafic soil. The Mg/Ca ratio decreased substantially from 32 in the C horizon to 3.3 in the Ap horizon based on the total analysis of elements. The variability in the Mg/Ca ratio was attributed to the degree of soil weathering. The natural backgrounds of Cr and Ni in the agricultural soils of Taiwan are approximately 50 and 60 mg/kg by using the method of aqua regia digestion. The soil control standards (SCS) of Cr and Ni contamination are 250 and 200 mg/kg in the Soil and Groundwater Pollution Remediation Act of Taiwan. However, total contents of Cr and Ni contents in this study considerably exceeded the background levels and SCSs in Taiwan. Regarding the integraded analyses with micromorphology, XRD, and FT-IR, relative abundant serpentine and chlorite occurred in the pedon. Pyroxenes, amphibole, talc, and chromite were also present in the bedrock. These minerals represent the characteristic of serpentinites. However, more vermiculite and smectite were found in the clay fractions of Ap horizon than those of AC and C horizon, whereas C horizon contained a higher amount of serpentine and chlorite. The Ap horizon is in a state of reduction and the AC and C horizons are relatively oxidized in the profile during the rice growing season. Therefore, the differences in composition and relative abundances of the various clay minerals between horizons can be largely attributable to redox status. These clay mineral characteristics were corrresponding to the potentially available concentrations of Cr and Ni with 0.1 N HCl extraction, suggesting the metals from serpentine minerals were released into the soils during weathering and were further fixed by clay minerals such as vermiculite and smectite. Additionally, the Ap horizon with artificial flooding for rice production generated more active Fe oxides which sequestrated more Cr and Ni than the subsurface soils. Therefore, the labile pool of metal increased from C horizon to Ap horizon.

Keywords：*Clay mineral, chromium, nickel, paddy soil, serpentine*

P4-74

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Bio-Based Polymer Composites Derived from Corn Stover and Feather Meals as Double-Coating Materials for Controlled-Release and Water-Retention Urea Fertilizers

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In this paper, we synthesized a bio-based polyurethane using the liquefied corn stover (CS), isocyanate (PAPI) and diethylenetriamine. The synthesized polyurethane was used as a coating material to control nitrogen (N) release from polymer coated urea (PCU). A novel superabsorbent composite was also formulated from chicken feather protein (CFP), acrylic acid (AA) and N,N'-Methylenebisacrylamide (MBA), and used as an outer coating material for water retention. We studied the N release characteristics and water-retention capability of the double-layer polymer coated urea (DPCU) applied in both water and soils. The Ear yields, dry matter accumulation, total N use efficiency and N leaching from a sweet corn soil-plant system under two different irrigation regimes were also investigated. Comparison of DPCU treatments with conventional urea fertilizer revealed that DPCU treatments reduced N release rate and improved water retention capability. Evaluation of soil and plant characteristics within the soil-plant system revealed that DPCU application effectively reduced N leaching loss, improved total N use efficiency, and increased soil water retention capability.

Keywords：*double-layer polymer coated urea, corn stover, feather meal, nitrogen release rate, water retention,*

P4-75

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Phosphorus Speciation in Poultry Litter during the Composting Process Determined by P K-Edge Xanes, 31p-NMR and Sequential Fractionation

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Poultry litter contains high levels of P and can be an alternative to chemical fertilizers. Prior to the application of poultry litters to soils, composting should be performed to ensure sanitization and stabilization of carbon (C) and nitrogen (N) ratio. There are few studies focusing on P in the composting process. Detailed knowledge of dynamic changes in P speciation during the composting process of poultry litter is essential to provide useful information for the improvement of composting systems and P availability in manures. To understand availability and chemical speciation of P in manure and soil samples, macro- and molecular-scopic techniques have been employed. Solution 31P NMR is a powerful tool for determining organic P (Po) in multiple phosphorus compounds with a minimum pre-treatment of sample. Phosphorus K-edge XANES spectroscopy is a non-destructive method and can distinguish inorganic forms of Al, Fe and Ca phosphates (Pi) in manure samples. For precise identification of inorganic and organic P species in poultry litter, therefore, the combination uses of sequential fractionation with solution 31P NMR and XANES spectroscopy are essential. It has been reported that water soluble P is decreased by composting of poultry litter. This seems to be attributable to the transformation of original P species into less soluble P species during the composting process, although the exact mechanisms associated with the changes of chemical speciation remained unknown. A hypothesis may be drawn from thermodynamic chemical equilibria that labile P in fresh poultry litters could be transformed into less soluble forms such as apatite- and inositol-like P during the composting process. The objective of this study was to investigate the quantitative and qualitative changes in organic and inorganic P compositions in poultry manure during composting process using sequential fractionation in combination with P K-edge XANES and solution 31P NMR spectroscopy.

Poultry litter samples were collected from a closed composting system in a layer chicken farm in Mie Prefecture, Japan. This compositing system enables litters to complete composting in 7 days under 70oC, and the composted product has commercially been available. Litter sampling was periodically conducted every day in 7 days from the beginning to the end of composting period (K0 - K7, 8 samples in total). Litter samples were collected from 5 different positions at the depth of 70 cm from the top of composting system and composited by thoroughly mixing equal weights of samples. The samples were frozen and freeze-dried and stored until chemical analyses. Sequential fractionation of P in poultry litter samples was performed based on the Hedley method, and inorganic and organic P concentrations in extracts were determined. Phosphorus extraction from poultry litter samples and following procedures of solution 31P-NMR analysis were conducted based on previous studies. The XANES spectroscopy of P analysis was conducted at Photon Factory (Ibaraki, Japan) using the Beamline BL11B equipped with Si(111) monochromator.

The sequential fractionation recovered over 91% of total P. At the end of composting process, the H2O-extractable Pi in poultry litter was decreased by 55%, whereas the HCl-extractable Pi and Po was 1.6-fold greater than that in the fresh litter. X-ray diffraction results for poultry litter samples showed three distinct peaks indicative of hydroxyapatite. Phosphorus K-edge XANES confirmed the increase of hydroxyapatite during the composting process, which corresponded to the increased HCl-Pi determined by the sequential fractionation. The NaOH-EDTA extraction for solution 31P-NMR revealed the decrease of inorganic orthophosphate (72 to 63%) and the increase of orthophosphate monoesters (28 to 37%) during the composting period, which was consistent with the increased Po and decreased Pi quantified spectrophotometrically in NaOH-EDTA and sequential fractionation extracts. Inositol-hexakisphosphate (IHP) constituted about 80% of orthophosphate monoesters and was increased by up to 12% during the composting process. Our study illustrated that water soluble P in poultry litter was transformed into less soluble phases, primarily hydroxyapatite and IHP, during the composting process.

Keywords：*phosphorus, manure, speciation*

P4-76

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Change in Availability Of Phosphorus, Cadmium and Zinc Applied in Monoammonium Phosphate after Termination of Fertilizer Application

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Cadmium (Cd) and zinc (Zn) are both present as contaminants in phosphate (P) fertilizers and repeated fertilizer applications may increase P, Cd, Zn concentration in crops and soils. However, the long-term availability of these elements may change over time, due to crop removal and reactions with soil constituents. Field studies were conducted at seven sites across the Canadian prairies from 2002 to 2012, to determine the influence of repeated applications of monoammonium phosphate (MAP) fertilizer on accumulation of P, Cd and Zn in crops and soils. At each location, a control and three rates of P fertilizers (0, 20, 40 and 80 kg P ha^{-1}) from three different sources varying in Cd and Zn concentration (0.38, 70 mg, and 210 mg Cd kg^{-1} and 115, 860 or 3,500 mg Zn kg^{-1}) were applied annually from 2002 to 2009 and sites were seeded following a durum wheat-flax-durum wheat flax crop sequence. Treatments were applied to the same plots each year so that the cumulative effects of P fertilizer applications could be assessed over time. Treatments were arranged at each location in a randomized complete block design with four replications. From 2010 to 2012, the cropping sequence continued, but no further MAP fertilizer was applied. Soil samples were collected in the fall of 2009 and 2012 from the 0 to 7.5 cm depth for each treatment, air-dried, and ground to pass through a 2 mm sieve, using a grinder that had been previously shown to be free of Cd contamination. Soil samples were extracted using a 0.005 M DTPA extraction for Cd and Zn and 0.5 mM sodium bicarbonate for P. Cadmium concentration of the extract was measured using a graphite furnace with deuterium correction and P and Zn ICP-AES. Reliability of the analysis was assessed by including standard reference soils with values confirmed by 'round-robin' analyses in each set of samples. Statistical analysis was conducted using Proc Mixed of SAS with differences among treatments being considered significant at the $p< 0.05$ level.

Extractable P, Zn and Cd increased with increasing input over time, with availability varying considerably with soil characteristics. Both extractable Cd and Zn decreased with increasing soil pH. On several of the soils, pH decreased significantly with MAP application, which may have further increased Cd and Zn availability. When fertilizer input was terminated, extractable P decreased substantially between 2009 and 2012, with the amount of the decrease being greater with higher total P input. Decrease in extractable P presumably reflects crop off-take and conversion of readily soluble P fractions to less soluble calcium and magnesium phosphate forms. In contrast, extractable Cd and Zn did not decline significantly over the three years without fertilizer input with the exception of the site with the lowest soil pH, where both Zn and Cd concentration declined over time at the highest input rate. Therefore, availability of Cd and Zn was not attenuated significantly on most soils over the three years of the study through crop off-take or conversion to different forms. Assessment of risk from long-term applications of MAP fertilizer must consider not only the total amount of elements applied but also the characteristics of the treated soil.

Keywords：*cadmium, zinc, fertilizer*

P4-77

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Evaluation of Integrated Use of Sewage Sludge and Fym with Chemical Fertilizers on Yield and Quality of Carrot(Daucus Carota)-Bhendi (abelmoschus Esculentus) Cropping Systems

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The present investigation entitled “Evaluation of integrated use of sewage sludge and FYM with chemical fertilizers on yield and quality of carrot - bhendi cropping systems” was carried out under field conditions at College Farm, College of Agriculture, Rajendranagar, Hyderabad. Sewage sludge is rich source of major and micronutrients as well as heavy metals, which causes toxicity in plants and pollute the soil. To study the effect of sewage sludge on performance of crops in terms of yield and uptake of nutrients and trace metals by crops and also to find out the safe limits of heavy metals for human consumption in sewage sludge applied crops, the present studies were conducted.

The experimental soil for bhendi-carrot cropping sequence (CS-I) was low in available N (205.8 kg ha-1), medium in available P2O5 (20.57 kg ha-1) and high in K2O (295.3 kg ha-1) where as for carrot-bhendi cropping sequence (CS-II) the experimental soil was low in available N (202.5 kg ha-1), medium in available P2O5 (20.01 kg ha-1) and high in K2O (291.5 kg ha-1). In order to know the mineralization pattern and to understand the changes in the status of heavy metals of organic manures and for organic matter fractions, an incubation study was also carried out. A laboratory incubation study was also conducted to know the transformation of heavy metals during decomposition of organic manures applied.

The treatments for bhendi crop in the kharif 2008 with four main treatments viz., 0, 50, 75 and 100 per cent RDF and five sub reatments viz., two levels of each sewage sludge, FYM (10 and 20 t ha-1) and control (without manure) and combination of fertilizer levels along with organic manurial levels, thus, total of 20 treatments, each in triplicate was laid out in a split plot design. The recommended dose of fertilizer applied to bhendi crop was 120 N, 50 P2O5 and 50 K2O ha-1, respectively. In the second season (rabi) carrot crop was grown to study the residual effects of organic manures applied to the previous season bhendi crop.

The highest fresh fruit yield (180.53 q ha-1) plant dry matter (1952 kg ha-1) and fruit dry matter (1538 kg ha-1) of bhendi (CS-I) were resulted in treatment with sewage sludge applied @20 t ha-1 along with 100 per cent RDF over control. In carrot (CS-II) also showed higher fresh root yield (201.75 q ha-1), leaves dry matter (3991 kg ha-1) and root dry matter (3574 kg ha-1) with sewage sludge applied @20 t ha-1 along with 100 per cent RDF.

The mean highest concentration and uptake of all heavy metals in bhendi crop resulted with the application of sewage sludge @20 t ha-1 followed by 10 t ha-1. Similar trend was observed under CS-II. Integrated application of manures and fertilizers also showed significant effect on all heavy metal (Pb, Ni, Co, Cr and Cd) concentration in plant and fruit than fertilizers alone. Highest concentration and uptake of all heavy metals were recorded in plant and fruit with the application of sewage sludge applied @20 t ha-1 along with 100 per cent RDF.

Accumulation of major nutrients were more in edible parts of bhendi / carrot than plant / leaves. Unlike major nutrients, all the micronutrients (Fe, Mn, Cu and Zn) were accumulated more in plant / leaves than edible parts of both crops. All the heavy metal concentrations in the plant as well as in the edible parts of both crops were below the safe limits. Except Ni and Cr in carrot root only.

Residual effect of manures either alone or in combination with fertilizers showed significant influence on quality parameters of carrot root at harvest but highest carotene content (5.55 mg 100 g-1), total sugars (8.36 per cent) and total soluble solids (13.17 per cent) were resulted in sewage sludge applied @20 t ha-1 along with 100 per cent RDF.

Keywords：*sewage sludge,FYM,fertilizers,cropping system,INM*

P4-78

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Arsenic and Cadmium Bioavailability to Rice Correlated with Silica Speciation in Paddy Soil

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It has been paid extensive attention that silicon could inhibit arsenic and cadmium accumulation in rice. However, most of the previous studies have been focused on the effect of the additional silicon on plant arsenic and cadmium uptake, or the related physiological mechanisms. Few studies have been carried out on the biogeochemical mechanisms of silicon speciation in soil and its plant availability, which could reduce arsenic and cadmium accumulation in rice. Generally, the bioavailability of silicon is low, and that of heavy metals is high in subtropical area, especially in paddy fields. Therefore, investigation of the relationship between silica speciation and the bioavailability of heavy metals in soil-rice systems should be vital to clarify the function and the biogeochemical mechanism of silica in relieving the toxicity of heavy metal for rice. We conducted a series of investigation to analyze silica speciation in soils, and the contents of silicon, arsenic and cadmium in rice. Six procedures were used to extract Si from 107 soil samples collected from Lianhuashan tungsten mine area, which was contaminated with arsenic (95.6±23.5 mg/kg) and cadmium (0.65±0.28 mg/kg). The contents of silica, arsenic and cadmium in plants and the responding soils were also analyzed. The results showed that (1) the content of extractable-Si in descending order as Citrate- Bicarbonate-Dithionite (DCB-Si) >> buffering Oxalate-Ammonium Oxalate (Ox-Si) > 0.025 M citric acid (CA-Si) > buffering NaOAc-HOAc (pH 4.0) (HAc-Si) > 0.19 M Na2CO3 (pH=11.8) > 0.5 M NaHCO3 (pH 8.5). (2) Six extractable-Si speciation in soils were significantly correlated with total-Si in both the root and straws of rice. Ox-Si and CA-Si were positively correlated with Si content in the root and straw ($P<0.01$). On the contrary, DCB-Si was negatively correlated with Si content in the plant ($P<0.01$), indicating DCB-Si might be not the available speciation for rice. (3) As accumulation in rice should be dependent to silica speciation in soil. The contents of arsenic in root and grain were negatively correlated with Ox-Si and CA-Si ($P<0.01$). On the contrary, the contents of arsenic in root and grain were positively correlated with DCB-Si in soils ($P<0.01$). That might be attributable to the competitive adsorption of arsenate with silica in crystallized iron oxides. DCB-Si might decrease the adsorption of arsenate and then increase the bioavailability of arsenate. (4) Similarly, Cd accumulation in rice should be also dependent to silica speciation in soil. The contents of Cd in root and straw were negatively correlated with Ox-Si and CA-Si ($P<0.01$), and positively correlated with DCB-Si in soils ($P<0.01$). (5) To be most important, the content of Cd in grain was negatively correlated with Ox-Si, CA-Si and DCB-Si ($P<0.01$). Here, a higher DCB-Si indicated a higher Cd immobilization.

In previous study, NaOAc-HOAc extraction was considered to be the classical method for assessing Si availability for the acid and neutral soils. In this investigation, both Ox-Si and CA-Si in soils were found to be suitable index for assessing Si availability in the subtropical paddy soil in south China. Moreover, comparing with CA-Si, Ox-Si was more significantly correlated with arsenic and cadmium uptake and accumulation in rice. Therefore, it can be confirmed that Ox-Si should the most suitable index to evaluate the effect of silica speciation on arsenic and cadmium bioavailability. The silica nutrition management could be one of the effective measurements to control the As and Cd pollution in paddy field. On the basis of this finding, we have developed an innovative product-Silica hydrosol, which can alleviate the toxicity of arsenic and cadmium in rice, and significantly decrease the contents of arsenic and cadmium in grain.

Keywords：*Arsenic, Cadmium, paddy field, availability, silicon, silica hydrosol*

P4-79

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

The Relationship between Plant Growth and Nutrients

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Uganda is blessed with a wide diversity of natural resources: soil, climate, water and vegetation, enabling it to grow a large number of adapted crops. However, most soils in Uganda are older than 500 millions years and are in their final stage of weathering. The predominant minerals in the soils are quartz and kaolinite that don't directly supply nutrients to soils. The soils are acidic and infertile with low cation exchange capacity (CEC). Nutrients such as phosphorus occur in inorganic and organic forms that are not readily available to crops. Phosphorus is fixed by oxides of iron and aluminum. Nitrogen that is low in most mineral soils can only be naturally supplied to the soil from the atmosphere by symbiotic biological fixation and slowly from organic matter. Potassium another essential element, is also limiting in these soils because there are no primary minerals that can supply it. Also, due to the low CEC, inorganic cations are easily leached out of the root-zone of most crops.

Over the years, food production has been characterized by subsistence farming. A subsistence production system usually focuses on a maximizing short-term profit, consuming natural stocks of plant nutrients. Such a farming system has resulted in soil fertility degradation through nutrient mining. In the past, when Uganda's population was still low, lost soil fertility was restored through long periods of fallows. With an average land holding of about 2 ha per household, fallows are no longer practical or the periods greatly shortened. Research has clearly demonstrated that fertilizer inputs and appropriate land management practices are important components of technology required to increase crop yields in Uganda.

Soil science is the study of soil as a natural resource on the surface of the earth including soil formation, classification and mapping; physical, chemical, biological, and fertility properties of soils; and these properties in relation to the use and management of soils.

Sometimes terms which refer to branches of soil science, such as pedology (formation, chemistry, morphology and classification of soil) and edaphology (influence of soil on organisms, especially plants), are used as if synonymous with soil science. The diversity of names associated with this discipline is related to the various associations concerned. Indeed, engineers, agronomists, chemists, geologists, physical geographers, ecologists, biologists, microbiologists, sylviculturists, sanitarians, archaeologists, and specialists in regional planning, all contribute to further knowledge of soils and the advancement of the soil sciences.

Soil scientists in Uganda has raised concerns about how to preserve soil with a growing population, possible future water crisis, increasing per capita food consumption, and land degradation.

In Uganda Science fair projects on soil and fertilizer are common due to their accessibility and low cost. These projects are a very useful way to teach practitioner and students the relationship between plant growth and nutrients for the purpose of helping them learn in an interactive way.

Comparison of Fertilizers is one of the simple science projects on soil and fertilizer which is mainly to compare different brands of fertilizer to see which one works best. There are three basic components of fertilizer: nitrogen, phosphorous and potassium. But each fertilizer brand has different percentage of these ingredients. Therefore, the packaging of soil and fertilizer needs to Take four pots and fill them equally with soil.

Fertilizer efficiency was not of great economic importance, and environmental concerns were not a high priority. More effort was devoted to high yield research. The period when more soil samples are analyzed by commercial laboratories than university laboratories and commercial laboratories began making fertilizer recommendations.

In Uganda Commercial soil testing laboratories didn't conduct further research into field verification of recommendations and generally did not emphasize soil testing.

Therefore, fertilization depends on many factors in Uganda. One of the most important is the farm manager's objectives for that field. Many ideas have been proposed to put fertilization in the context of a general management principle yet most various ideas commonly discussed on the issue of crop fertilization only

P4-80

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Redox-Related Role of Mineral Oxides on Zn Solubility Dynamics in Flooded Rice Soils

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Background: Zinc (Zn) plays a key role in the normal growth and production of rice plants. An inadequate amount of available Zn in the soil can reduce the yield and nutritional quality of the plant, causing Zn deficiency, which leads to malnutrition in rice plants and in human rice consumers. Flooding could alter the soil chemistry that affects Zn availability (Ponnamperuma, 1972). Mineral oxides, such as iron (Fe) and manganese (Mn) (hydr)oxides, are the structural components of most soils that can cause variation in the redox chemistry of flooded rice soils. In addition, Fe and Mn (hydr)oxides can retain trace metals in soils by providing adsorption sites (Schulz-Zunkel & Krueger, 2009). This study aims to identify the role of mineral oxides as a parameter that may be useful for predicting which fields are at risk of flooding-induced Zn deficiency in rice.

Methodology: Laboratory experiments were combined with equilibrium modeling to explain the interaction of Zn with mineral oxides and other redox-species in paddy soils at varying redox potentials (E_h). Four air-dried rice soils with contrasting properties were submerged and incubated in a reaction cell system under N_2 for four weeks with continuous stirring, and then purged with air for another week to reoxidize the system. The parameters measured were redox potential; pH; temperature; water-soluble sulfide; water-soluble sulfate; and water-soluble Zn, Fe, and Mn. Geochemical modeling was used to identify the major Zn species in the soil solutions. Soil samples were collected from 80 sites in Bangladesh as part of a multi-location trial of biofortification breeding lines. Soil background characteristics were assessed to help select which sites will be used for the biofortification experiment. These soil tests included pH (1:1 soil:water), DTPA-extractable Zn, EDTA-dithionite-extractable Fe- and Mn-oxide, ISE determination of distilled sulfide, and organic matter by dichromate oxidation.

Results: For all four soils in the laboratory experiment, it was found that by the first sampling point at 21 hours, most of the added 0.91 mg l^{-1} Zn had disappeared from the solution, and so a follow-up experiment confirmed that approx. 70% of the added Zn immediately became unavailable in the aqueous phase within 20 minutes of addition. The E_h of the soils started at 120 to 300 mV, decreased to -220 to -300 mV after 100 to 250 hours of reduction, and was maintained at this low plateau for about two weeks before increasing again upon reoxidation. Different patterns in Zn solubility were observed in the four soils, with two of the soils showing a decrease in soluble Zn, as the E_h became low, mainly because of ZnS precipitation. In contrast, the other two soils showed that Zn solubility was maintained during the reduced phase, primarily because of competition with Fe for precipitation with sulfide and Zn sorption to Mn oxide. The model predicted that Zn was bound mainly to Mn-(hydr)oxides in three of the soils, whereas in the soil with a high amorphous Fe (hydr)oxide content, sorption to Fe-(hydr)oxides was equally important. Analysis of the 80 Bangladesh samples indicated that soil Zn was 0.3-12 mg kg^{-1}, the range of Fe-oxide was 0.4-1.7 mg kg^{-1}, the range of Mn-oxide was 0.01-0.04 mg kg^{-1}, pH range was 4.7-7.8, sulfide was 0.01-0.08 mg kg^{-1}, and organic matter content was 0.6-1.7%.

Based on these soil characteristics, it was estimated that about 25% of the field sites would show a response to Zn fertilization.

Conclusions: In this study, it was found that that the primary cause of decreasing Zn availability in flooded (non-calcareous, non-contaminated) soils is the precipitation of ZnS. Sorption of Zn onto Fe and Mn (hydr)oxides decreased Zn availability, primarily during the oxidized phases. Fe (hydr)oxide sorbs some sulfate and prevented it from forming ZnS. This study provides an insight in identifying the Zn chemistry of 80 soil samples from the multi-location trial (MLT) experiment in Bangladesh by understanding the relative importance of mineral oxides, sulfides, sulfates and organic matter content in soils.

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Keywords：*iron oxide, manganese oxide, redox chemistry, Zn solubility, rice soil, paddy soil, flooded soil*

P4-81

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Investigation of Potassium Distribution in Agricultural Soils by Combination of Micro X-Ray Fluorescence and X-Ray Absorption Near-Edge Spectroscopy (xanes) Full-Field Imaging

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Potassium (K) is abundant in most soils but the majority of soil K is usually unavailable to plants; the available fraction corresponding essentially to K^+ in solution and to exchangeable K. Clay minerals such as smectite have the ability to retain water and cations, including K^+, in their interlayer spaces and to exchange them rapidly with other cations of the soil solution. The unavailable fraction corresponds to K in soil parent minerals such as feldspars and micas. However, under the action of plants, and when available K is insufficient, part of non-exchangeable K (Badraoui 1992) can be released from mica/illite interlayers. Clay minerals, including micas, thus play a pivotal role in K soil processes (Barré et al. 2008; Simonsson et al. 2009). Despite growing interest in K fate, no precise and quantitative information has been proposed so far as to the distribution and speciation of K in soils at a micron scale and on its relations with clays and soil elements like roots. To retrieve this information, X-ray fluorescence (XRF) and X-ray absorption near edge structure (XANES) spectroscopies were combined at the micron scale.

Soil samples come from the Morrow Plots (U. of Illinois at Urbana-Champaign), one of the oldest continuous agricultural experimental plots (~140 years). Samples were picked in fields cultivated with different crop rotations (continuous corn, corn-soybean 2 year rotation, corn-oats-hay 3 year rotation) and fertilizing inputs (no input, NPK, manure). X-ray diffraction analyses on separated clay evidence the presence of kaolinite, mica/illite and illite-smectite. Although chemical analyses indicate similar K contents for the different samples, amounts of extractible K increase significantly with the addition of fertilizing inputs.

To preserve soil organization, undisturbed mottles of soils were impregnated with resin and self-supporting 30 µm-thick thin sections prepared. µXRF and XANES full-field data were collected at the X-ray microscopy beamline ID21 (Salomé et al. 2013) at the ESRF, France.

Large XRF maps (300×300 μm^2) were collected at 3.7 keV using a beam focused down to 0.3×0.5 μm^2 to evidence the location of the K-bearing minerals and of quartz, based on K, Al and Si elemental distribution. The recently developed XANES full-field imaging station (Fayard et al. 2013) was then used to study K speciation over a full 2D field of view of a few hundreds of microns. A transmission image of thin sections is recorded with an unfocused beam at each energy step along the K absorption edge. Under these conditions, up to 4.10^6 XANES spectra can be recorded simultaneously, with a sub-micron spatial resolution.

After data processing, a XANES spectrum can be extracted from each pixel of the map presenting K. Spectra are compared to reference spectra collected on purified and K-saturated clays, micas and powdered feldspars. To account for orientation effects due

to the angle between crystallographic planes of the feldspars and the incident beam, reference spectra were also collected on oriented mono-crystals. Characteristic features of the XANES spectra (position and intensity of white line and oscillations) allow discriminating feldspar, mica, illite and smectite. If pure feldspar spectra are frequently recorded, clays can occur as phase mixtures even at the micron scale; linear combination fitting (LCF) are thus needed to determine the contribution of elementary contributions. Distribution maps of each K-bearing mineral are finally obtained by conducting LCF on each XANES spectrum of the K absorption map.

This new spatially-resolved approach allows deciphering the distribution of K-bearing clay minerals in soils. Study of specific areas, like root vicinity, allows unraveling the ability of plants to access the different K pools (in particular exchangeable and non-exchangeable K in clays), and gaining insights into the influence of fertilizing inputs on this availability.

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Keywords：*clays, potassium, nutrients, X-ray spectroscopy*

P4-82

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Effects of Active Aluminium and Iron on Phosphate Extractability with Special Reference to Soil Micro- and Meso-Pores

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We investigate the effects of active Al and Fe on phosphate extractability, with special reference to soil micro- and meso-pores. The sorption of phosphate into micro- and meso-pores is the most likely mechanism of slow phosphate release in soils, but there is only a limited amount of experimental data on the effects of the specific surface area (SSA) and micro- and meso-pores.
Thirty soils, with widely different oxalate-extractable Al and Fe concentrations (1.7–87 g kg–1) were used. We characterized phosphate extractability using modified Hedley's fractionation method and sequential anion exchange membrane (AEM) extraction after treating with their maximum phosphate sorption amount, determined from preliminary phosphate adsorption experiments. In the Hedley's method, soil phosphorus was sequentially fractionated into six components including phosphate removed by an anion exchange membrane (Resin-P), phosphate extracted with 0.5 mol L–1 sodium bicarbonate solution (NaHCO3-P), and phosphate extracted with 0.1 mol L–1 sodium hydroxide solution (NaOH-P). For NaHCO3-P and NaOH-P, inorganic and organic phosphate (Pi and Po) were determined. Applying the AEM extraction repeatedly allows the phosphate release rate to be determined from a regression curve, assuming first-order kinetics.SSA characterization was performed on soil samples using the N2 adsorption method. We measured the total SSA, the SSA of micro- and meso-pores, and the decrease in the total and micro- and meso-pore SSAs after phosphate sorption in which the soils were treated with their maximum phosphate sorption amount.
The Hedley's fractionation method showed that most of the added phosphate was extracted as Resin-P, NaHCO3-Pi and NaOH-Pi. The percentage of phosphate extracted in each fraction correlated significantly with Alo + Feo; the most labile phosphate (Resin-P) extract negatively correlated ($rs = –0.79$ $P < 0.001$), and the moderately and less labile phosphate (NaHCO3-Pi, NaOH-Pi) extracts positively correlated, with Alo + Feo. ($rs = 0.55$, $P < 0.01$ and $rs = 0.55$, $P < 0.01$, respectively). These results indicate that soils with higher Alo + Feo have lower proportions of labile phosphate and higher proportions of moderately and less labile phosphate. Sequential extraction by AEM showed the first-order rate constant was negatively correlated with Alo and Feo concentrations ($rs = –0.91$, $P < 0.001$) indicating the slow release of added phosphate from the soils with high Alo + Feo. The total specific surface areas before treatment (SSAtotal) correlated positively with Alo + Feo ($rs = 0.74$, $P < 0.001$), indicating that active Al and Fe, because of their large SSAs, contribute to the SSAtotal of the soils. The soil samples after phosphate sorption treatment had lower total SSAs than those before treatment. Although micro-pores were not detected in 15 samples, small meso-pores (2–4 nm) were present in all of the samples. The 0.7–4 nm pore SSA (SSA0.7–4 nm) to SSAtotal (SSA0.7–4 nm/SSAtotal) ratio, which indicates the micro- and small meso-porosity of the samples, positively correlated with Alo + Feo ($rs = 0.76$, $P < 0.001$), indicating that the soils with higher levels of active Al and Fe were rich in micro- and meso-pores. SSA0.7–4nm/SSAtotal also correlated significantly with the proportions of Resin-P, NaHCO3-Pi, and NaOH-Pi from Hedley's method extracts and the AEM sequential extraction rate constants ($rs = –0.72$, $P < 0.001$, $rs = 0.42$, $P < 0.05$, $rs = 0.46$ $P < 0.05$ and $rs = –0.70$, $P < 0.001$, respectively), indicating that phosphate was more difficult to be extracted for the samples with higher porosity of the soils.
We present experimental data showing that phosphate extraction from the soils that were rich in oxalate-extractable Al and Fe was more difficult because of phosphate sorption into micro- and small meso-pores.

Keywords：*phosphorus, acid-oxalate-extractable aluminum and iron, specific surface area, micropore*

P4-83

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Stable Cesium Uptake by Rice Plant with Different Amendments under Flooded and Temporal Upland Condition

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The distribution of stable cesium (Cs) in soils today represents the result of soil evolution under ambient natural conditions over recent geological time. The study of this trace element in soil-plant system can provide an insight that has relevance to long-term stewardship of radiocesium-contaminated farmland. Rice as Asian staple food is demanded to know the suppressive way of radiocesium uptake in order to prevent from internal exposure and useful countermeasures for farmer should be needed. In this study, field experiment of stable Cs uptake by rice plants (Oriza sativa; "Koshihikari" and "Kinuhikari") was carried out under flooded (FL) and temporal upland (TU) conditions to evaluate the suppression of Cs uptake by rice from Gray Lowland Soil (Haplaquest) in Ishikawa, originally containing 4.39 mg kg-1 dry weight of total Cs. 'Kinuhikari' has originated from 'Koshihikari'. Rice plants were grown under four kinds of plot with five replications to investigate the suppressive effect of Cs uptake using different amendments: (1) Control, (2) Original soil + Cs (9 kg ha-1), (3) Original soil + Cs (9 kg ha-1) + K (380 kg ha-1) and (4) Original soil + Cs (9 kg ha-1) + vermiculite (7000 kg ha-1). At harvest, rice plants were separated into different components; brown rice, leaf blade, leaf sheath, and root, and then Cs concentrations in these components were determined with ICP-MS. The Cs concentration in brown rice, leaf blade, leaf sheath and root of 'Koshihikari' and 'Kinuhikari' grown under FL-condition was 0.203 mg kg-1 and 0.217 mg kg-1, 0.377 mgkg-1 and 0.443 mg kg-1, 0.896 mgkg-1 and 0.845 mgkg-1, 1.41 mg kg-1 and 1.45 mg kg-1, for the original soil, respectively, while the Cs concentration in these components of 'Koshihikari' and 'Kinuhikari' grown under TU-condition was 0.0543 mg kg-1 and 0.0751 mg kg-1, 0.0611 mg kg-1 and 0.108 mg kg-1, 0.097 mg kg-1 and 0.178 mg kg-1, 1.91 mg kg-1 and 2.11 mg kg-1 for the original soil, respectively. The Cs concentration in the aerial components for all plots was in decreasing order; leaf sheath > leaf blade > brown rice. These components showed easier absorption of Cs under FL-condition than TU-condition for all plots after panicle formation stage. The root accumulation of Cs did not show significant difference between FL-condition and TU-condition. However, the transport factor (Tf) (transported from root to the aerial components) gave higher value under FL-condition than under TU-condition. The Cs concentration in each component was in the decreasing order; Cs amended plot > Cs + K amended plot > Control plots, except for Cs+ vermiculite amended plots. In comparison with the Cs concentration of the brown rice or leaf blade between 'Koshihikari' and 'Kinuhikari' under the same treatment, there was a trend that the Cs concentration in brown rice and leaf blade of 'Kinuhikari' was higher than that of 'Koshihikari'. The Cs concentrations of brown rice in Cs amended plots were 10.5 to 20.4 times as much as that in control. The addition of vermiculite to the soil provided a tendency to increase Cs concentration in rice plants grown under TU-condition. The K amendment of 380 kg/ha remarkably suppressed Cs accumulation in brown rice to 24.5-38.8% of Cs concentration in Cs amended plots.

Keywords：*Stable cesium; Rice plant; Root; Flooded condition; Temporal upland condition*

P4-84

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Remineralization, Remediation and Recovery: A New Route for Sustainability

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One of the greatest challenges of today is to reconcile food production and environmental preservation. In order to build a new route to sustainability this paper presents the results of a research that has as its objectives to demonstrate that re-mineralization of soils, through the use of crushed rocks is an excellent alternative to enable remediation of degraded areas as well as possible the production of food and income. The recovery process is through the addition of macro and micronutrients present in the rocks that alter positively soils fertility. To prove this capability, we implemented an agroforestry system or agroforestry, where the performances of five different kinds of rocks (shale, kamafugite, to types of basalts and amphibolites) were evaluated with regard to its potential as remineralizer (or agromineral). The agroforestry area was divided into plots (including one control and one with organic fertilization). Crops (vegetables, species agricultural, forestry and legumes) added in each plot were planted as seeds, seedlings or bulbs and have different development cycles. The management and monitoring of the plant's development were done monthly for two year so that we could measure the rates of germination, growth and productivity of each species. In parallel, the measure of changes in the soil (pH, available nutrients - potassium, phosphorus, calcium and magnesium), organic matter, and CTC in each plot was done. The results demonstrate that different types of remineralizers have the capability to supply, in a differentiated but adequate manner, the necessary nutrients for the development of various types of plants. The profile of soil fertility has changed positively. The pH increased from acidic to alkaline, depending on the supply of calcium and magnesium present in all rocks tested. These results show that the remineralization facilitates recovery of depleted soils, with the use of geological material widely available in the whole world. This ability can become a new technological route, simple and cheap, for remediation of degraded areas.

Keywords：*Remineralization, agroforestry, sustainability*

P4-85

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

The Diversity of Plants in Subalpine Meadows of Wugong Mountain in Jiangxi Province of China

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Using the method of combining of transect and sample band's in vigorous plant growth season (From June to September), the martial arts mountain meadow specimen collection, investigating vegetation and quadrat survey plant photo shoot, record along the meadow destruction of the situation of Wugong mountain. Finishing the literature data, the identification of specimens, quadrat data and analyzed to study the martial arts mountain mountain meadow plant diversity, tourism disturbance factors on plant diversity, the protection of the martial arts mountain meadow, recovery, and appropriate use of development scientific basis.The results of research are as follows:

1. There is a relatively abundant fiora in Wugong Mountain. 280 vascular plants represented in the meadows of Wugong Mountain, which belong to 44 families and 73 genera. Among these, the pteridophytes include seven families with seven genera and seven total species; the gymnosperms include one family with two genera and two total species; and the angiosperms include thirty-six families with sixty-four genera and eighty-two species.

2. According to the vegetation classification system of “Vegetation of China”(1995) and combine with the investigation of plant community types of meadows of Wugong Mountain, main communities in this area are divided into three meadow formation groups(grass meadows, carex meadows and forbs meadows). The forbs meadows included six meadows associations: Ass. Anaphalis margaritacea+ Pennisetum alopecuroides, Ass.Aster ageratoides+ Miscanthus floridulu , Ass. Spiraea japonica+ Senecio nemorensis, Ass. Eupatorium japonicum Thunb+ Miscanthus floridulu , Ass. Osmunda japonica Thunb+ Agrostis canina Linn. var. formosana Hack, and Ass. Polygonum caespitosum Bi+ Saluia plebeia R. Br .

3. There exist obvious differences among the eight meadow community types of Wugong Mountain. Species diversity of grass meadow is the highest, followed by carex meadow and Ass. Anaphalis margaritacea+ Pennisetum alopecuroides, plant diversity of Ass. Spiraea japonica+ Senecio nemorensis and Ass. Eupatorium japonicum Thunb+ Miscanthus floridulu are lower, and diversity of Ass. Polygonum caespitosum Bi+ Saluia plebeia R. Br is lowest.

4. Arrange these eight meadow communities in accordance with the Simpson index (D) from highest to lowest as follow: grass meadow> carex meadow> Ass. Anaphalis margaritacea + Pennisetum alopecuroides> Ass.Aster ageratoides+ Miscanthus floridulu> Ass. Spiraea japonica+ Senecio nemorensis> Ass. Eupatorium japonicum Thunb+ Miscanthus floridulu > Ass. Osmunda japonica Thunb+ Agrostis canina Linn. var. formosana Hack> Ass. Polygonum caespitosum Bi+ Saluia plebeia R. Br. Arrange these eight meadow communities in accordance with the Pielou index (E) from highest to lowest as follow: grass meadow> Ass.Aster ageratoides+ Miscanthus floridulu> carex meadow> Ass. Anaphalis margaritacea+ Pennisetum alopecuroides> Ass.

Osmunda japonica Thunb+ Agrostis canina Linn. var. formosana Hack> Ass. Eupatorium japonicum Thunb+ Miscanthus floridulu > Ass. Spiraea japonica+ Senecio nemorensis> Ass. Polygonum caespitosum Bi+ Saluia plebeia R. Br. Arrange these eight meadow communities in accordance with the Shannon-Wiener index (H) from highest to lowest as follow: grass meadow> carex meadow> Ass. Anaphalis margaritacea + Pennisetum alopecuroides> Ass.Aster ageratoides+ Miscanthus floridulu > Ass. Osmunda japonica Thunb+ Agrostis canina Linn. var. formosana Hack > Ass. Eupatorium japonicum Thunb+ Miscanthus floridulu > Ass. Spiraea japonica+ Senecio nemorensis > Ass. Polygonum caespitosum Bi+ Saluia plebeia R. Br . There is a significant difference between Ass. Polygonum caespitosum Bi+ Saluia plebeia R. Br and other seven meadows associations in the Simpson index (D), the Pielou index (E) and the Shannon-Wiener index (H).

Acknowledgement:The work reported here has been funded by IPNI (Jiangxi-29) and the National Natural Science Foundation of China (31260194）,(30960312),（31360177）and National Science and Technology Support Project (2012BAC11B06),The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Wugong mountain of Jiangxi Province , Alpine meadow, Plant diversity, Plant Resources*

P4-86

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Chemical and Mineralogical Characteristics of the Wonosegoro Clays Java Island Indonesia

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There are many sedimentary Clay-stone deposits in Wonosegoro District, Boyolali Regency, Central Java Province, Indonesia. Some people of this District consider that these clays are included in bentonite. There is not enough information on the chemical and mineralogical characteristics of the Wonosegoro clay materials as a quality assurance of these materials. The present study was aimed to identify the mineralogical composition and main chemical properties that determine the clay quality and kinds of it usage. Clay samples were collected from 12 locations, and they were then crushed using ball mill and these were sieved trough 200 mesh wire as a fine sample. Clay fraction (< 2 μm) was then collected by mechanical methods. Cation exchange capacity (CEC) of the Wonosegoro clay samples was analyzed by extraction using 1 molar pH 7.0 NH4O acetate. The extractable cationic bases (Ca, Mg, K and Na) on the NH4O acetate extraction were then measured using atomic absorption spectrophotometer. The results of the research showed that the Wonosegoro clays had variation in phyllosilicate and non phyllosilicate minerals. It is thought because the kind and composition of the phyllosilicate minerals in clay have more contribution in chemical properties, especially on the negative charge than the other one. The Wonosegoro clays that located in the wet tropical area are subjected to weather fast, especially from smectite minerals (as 2:1 type expandable minerals) that generally alter to form kaolin minerals. The Ketoyan clay had highest content of smectite minerals, while the Banyusari clay was in the reverse. There is a variation in the content of non phyllosilicate minerals in the Wonosegoro clays, and it is roughly grouped in three types of clay the Wonosegoro area, i.e.: (1) first type clay that containing quartz, (2) second type clay that containing calcite, and (3) third type clay that containing calcite and Na mineral. In the present study, it was shown that the plot of exchangeable sodium percentage (percentage of exchangeable Na to total bases) and pH of the clay had a positive correlation. It is suggested that the pH value is affected by all cationic bases in the exchangeable sites of the clay. From the results, it is showed that pH is not affected by a single cationic base of Ca, Mg, K and K, however the composition all cationic bases determines the chemical reaction of the clay materials. The presence of smectite minerals in the clay material may gives a negative charge at a certain value. By addition of the quantity of these minerals results an increasing of the CEC value, however there is a maximum CEC value of these minerals. Therefore, the relationship between the percentage of smectite minerals and the CEC is not linear regression, but in the logarithmic regression. There were Na-smectite mineral in Bandung 1 and 2, and Kauman Cekelan clay, while the other clays were Ca-smectite minerals. The composition all cationic bases determined the chemical reaction of the clay materials. According to the results of the study, it can be conclude that the Wonosegoro clays have variation in clay mineralogy. The Ketoyan clay has highest content of smectite minerals, while the Banyusari clay is in the reverse. The content of the smectite mineral in the clay material determines the CEC value. There are Na-smectite mineral in Bandung 1 and 2, and Kauman Cekelan clay, while the other clays are Ca-smectite minerals. The composition all cationic bases determines the chemical reaction of the clay materials.

Keywords：*the Wonosegoro clays, Ca-smectite, Na-smectite, three types of clay, CEC.*

P4-87

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Organic Inputs and Mineral Fertilizer Effects on Soil Chemical Properties, and Maize Productivity in Mbeere District, Kenya

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Farmers in central highlands of Kenya experience declining agricultural productivity majorly due to soil desiccation and soil fertility depletion. Low soil water availability is caused by low and unreliable rainfall, poor water harvesting techniques and unsuitable farming practices. Therefore, in order to increase crop productivity, and reduce production risks, better use of available rainfall and improved nutrient use efficiency is required. One way of reversing the trend of declining land productivity in smallholder farms in Kenya, is believed to be the combined application of organic and mineral sources of nutrients. In order to investigate this, field trials were established in a dry land environment in Central Kenya, at Machang'a. The objective of the research was to assess the effect of organic inputs on soil nutrients, soil water availability and maize (Zea mays) productivity in semi arid regions of the Central Highlands of Kenya. The study was carried out in Mbeere District, Kenya, representing a low potential area in terms of agricultural productivity due to low and erratic rainfall. The trial followed a randomised complete block design with three replications. The treatments consisted of four organic sources (Tithonia diversifolia, Lantana camara, Mucuna pruriens, and goat manure) combined with mineral nitrogen fertilizer, sole fertilizer and a control. Sole goat manure, Lantana camara + 30 kg N ha^{-1}, and sole Tithonia diversifolia recorded the highest maize grain yield. Generally the maize grain yields were lower with the sole fertilizer treatments compared to the organics across the seasons and this could be attributed to poorly distributed rainfall. Goat manure was superior in terms of improving soil chemical properties such as soil pH, magnesium, potassium, calcium and nitrogen. Soil pH declined in most of the treatments, more so with the combinations of organics and mineral fertilizers compared to the sole application of organics such as Lantana camara, Mucuna pruriens and manure. Calcium in the soil increased significantly in sole Lantana camara, sole manure and Tithonia diversifolia + 30 kg N ha^{-1} treatments (t-test, $p = 0.029$, $p = 0.022$, and $p = 0.0264$, respectively). Soil organic carbon decreased in all the treatments except in the sole manure treatment and manure + 30 kg N Farmers in central highlands of Kenya experience declining agricultural productivity majorly due to soil desiccation and soil fertility depletion. Low soil water availability is caused by low and unreliable rainfall, poor water harvesting techniques and unsuitable farming practices. Therefore, in order to increase crop productivity, and reduce production risks, better use of available rainfall and improved nutrient use efficiency is required. One way of reversing the trend of declining land productivity in smallholder farms in Kenya, is believed to be the combined application of organic and mineral sources of nutrients. In order to investigate this, field trials were established in a dry land environment in Central Kenya, at Machang'a. The

objective of the research was to assess the effect of organic inputs on soil nutrients, soil water availability and maize (Zea mays) productivity in semi arid regions of the Central Highlands of Kenya. The study was carried out in Mbeere District, Kenya, representing a low potential area in terms of agricultural productivity due to low and erratic rainfall. The trial followed a randomised complete block design with three replications. The treatments consisted of four organic sources (Tithonia diversifolia, Lantana camara, Mucuna pruriens, and goat manure) combined with mineral nitrogen fertilizer, sole fertilizer and a control. Sole goat manure, Lantana camara + 30 kg N ha^{-1}, and sole Tithonia diversifolia recorded the highest maize grain yield. Generally the maize grain yields were lower with the sole fertilizer treatments compared to the organics across the seasons and this could be attributed to poorly distributed rainfall. Goat manure was superior in terms of improving soil chemical properties such as soil pH, magnesium, potassium, calcium and nitrogen. Soil pH declined in most of the treatments, more so with the combinations of organics and mineral fertilizers compared to the sole application of organics such as Lantana camara, Mucuna pruriens and manure. Calcium in the soil increased significantly in sole Lantana camara, sole manure and Tithonia diversifolia + 30 kg N ha^{-1} treatments (t-test, p = 0.029, p = 0.022, and p =0.0264, respectively). Soil organic carbon decreased in all the treatments except in the sole manure treatment and manure + 30 kg N ha^{-1}. The decline in soil organic carbon was significant in sole Lantana camara, Lantana camara+ 30 kg N ha^{-1}, sole Tithonia diversifolia, Tithonia diversifolia + 30 kg N ha-1, sole Mucuna pruriens, Mucuna pruriens+ 30 kg N ha-1, fertilizer (60 kg N ha-1) and control treatments (t-test, p = 0.012, p = 0.033, p = 0.0224, p = 0.0166, p = 0.0349, p = 0.0129, p = 0.0004 and p = 0.0341, respectively). Goat manure needs to be promoted among farmers in the drier areas because of its good performance in improving soil properties.. The decline in soil organic carbon was significant in sole Lantana camara, Lantana camara+ 30 kg N ha^{-1}, sole Tithonia diversifolia, Tithonia diversifolia + 30 kg N ha^{-1}, sole Mucuna pruriens, Mucuna pruriens+ 30 kg N ha^{-1}, fertilizer (60 kg N ha^{-1}) and control treatments (t-test, p = 0.012, p = 0.033, p = 0.0224, p = 0.0166, p = 0.0349, p = 0.0129, p = 0.0004 and p = 0.0341, respectively). Goat manure needs to be promoted among farmers in the drier areas because of its good performance in improving soil properties.

Keywords：*Goat manure, Soil organic carbon, Tithonia diversifolia*

P4-88

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Proximate, Mineral and Vitamins

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Sample of the fruit of Cucums sativus plant was analysed for proximate analysis, vitamins and mineral constituents. The analysis was carried out in the laboratory. The results revealed that the cucumis sativus contained crude protein (1.12+0.0%), crude fibre (0.8+0.0%), Carbohydrate (15.19+0.0%), Moisture (74.79+0.0%), Ash (6.9+0.0%), and fat (1.2+0.0%). The fruit is also a good source of minerals such as Calcium, Potassium, Magnesium, Phosphorus, Iron and Zinc.

These minerals help in the transport of oxygen, hardening of the bone and teeth, acceleration of the wounds healing process, needed for body defense, help in cell division, helps in the control of diabetes too. The research also showed that cucumber contains vitamins such as A,B1,B2,B3 and C needed for proper functioning of the epithelial tissues and clearer vision. This research therefore showed that Cucumis Sativus is good for health and also has nutritive properties.

Keywords: proximate, Minerals, Vitamins, Composition, cumcumis sativus.

P4-89

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Effects of the Applications of the Clay Minerals on the Early Growth of Red Pepper in the Horticultural Bed Soil

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As the seeding technology through use of plug tray for good cultivation of seeds was developed, the use of bed soils has recently been increased. Its seedlings were cultivated in the bed soil normally used for horticultural purpose. In this study, the effects of the four clay minerals such as illite, phyllite, zeolite, and bentonite on the early growth of red pepper in the bed soil were investigated and furthermore proteome analysis for the samples of red pepper treated with only illite was performed. Of the seedling cultured, the healthy and regular size seeds were selected and cultivated in the pots, after they were treated with four clay minerals. The experiment was performed during the whole six weeks in the glasshouse of the Chungbuk National University. The growth lengths, fresh and dry weights of red pepper were significantly higher in the treatments of illite, phyllite, zeolite, and bentonite than in the control. In addition, the uptake of K+, Ca2+, and Mg2+ were higher in the treatment of illite, phyllite, zeolite, and bentonite than in the control. The 2-DE patterns for the red pepper by the applications of illite, phyllite, zeolite, and bentonite were similar to each other. Therefore, compared to the samples of control, the proteome analysis for the samples of red pepper treated by only illite were performed. Proteome analysis for red pepper showed that plastid fructose-1,6-bisphosphate aldolase class 1, aldolase, and glyceraldehydes 3-phosphate dehydrogenase were highly expressed in leaf tissue by illite treatment. In stem tissue, NAD-dependent formate dehydrogenase, potassium transport protein and GIA/RGA-like gibberellins response modulator were highly expressed. Based on the results obtained from the proteome analysis, it appears that the proteins specifically and differentially expressed on the illite treatment may be involved in the enhanced growth of red pepper. The identification of some proteins in the clay mineral response provides new insights that can lead to a better understanding of the molecular basis of vegetable crops.

Keywords：*bentonite, Capsicum annuum L., cations, identification, illite, phyllite, protein, zeolite*

P4-90

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Effects of the Additions of Clay Minerals Illite and Zeolite as Inorganic Materials on The Growth of Chinese Cabbage in Horticultural Bed Soil

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Since the 1990, as the seeding technology through use of plug tray for good cultivation of seeds was developed, the use of bed soils has been increased. Therefore, the bed soils should include the physical, chemical, and biological properties suitable for the growth condition of crop plants and the economic value. Organic materials, such as coir, peat moss, and sawdust, and inorganic materials, such as zeolite and vermiculite, are the world widely used materials of bed soil for the growing of seeds. Currently, the bed soils are properly mixed with organic and inorganic materials and are used to improve their physical and chemical properties. The inorganic four clay minerals such as illite, phyllite, zeolite, and bentonite, known as enhancing the structure of soil, were used to improve the chemical properties of bed soils. They are also known as neutralizing the soil acidity and providing some useful nutrients, resulting in the improvement of soil quality and root elongation. In this study, the representative two clay minerals illite and zeolite were used to evaluate their potentials which can be used as the inorganic materials in the manufacture of horticultural bed soil. Compared to zeolite, illite is reserved in a mass amount in the region of Yeongdong of Chungbuk province. It has a variety of trace elements essential for the growth of plants in agriculture. However, zeolite rather than illite is currently used in the domestic country as inorganic materials in manufacturing the horticultural bed soil. Similar to illite, the clay mineral zeolite is also resistant to high temperature of heat, sorbs the volatile gas and holds water in its pore space and has the high CEC value. In contrary to illte exclusively produced in the domestic country, zeolite is imported from the overseas. Therefore, it may be possible to save the expense spent in importing it from overseas, if zeolite can be replaced with illite. This study was initiated to evaluate the possibility of replacing zeolite with illite through the comparison of effects of inorganic materials added to the commercial bed soil. For the correct comparison of the effects of illite and zeolite in the experiment, the zeolite currently used as a component in the horticultural bed soil should be excluded in order to be used as a control bed soil. Therefore, the control bed soil is a bed soil excluding the zeolite from the commericial bed soil called Joeun bed soil. In the experiment, the illite and zeolite were added to this control bed soil, as necessary in the treatments. Chinese cabbage was used as a model vegetable crop in the study. The seeds of chinese cabbage sold from the N company were planted and grown and then their seedlings were transported and grown in greenhouse through the drip irrigation for the four weeks. The growth length of chinese cabbage during the three weeks from one

week of growth to three weeks of growth every one week. since the burgeoning of the plant. Total nine treatments include 1) the control bed soil(without zeolite from the commercial Joeun bed soil), 2) the control bed soil with 10% of zeolite added, 3) the commercial normal horticultural bed soil("Joeun bed soil" with zeolite), 4) the control bed soil with 5% of illite added, 5) the control bed soil with 10% of illite added, 6) the control bed soil with 15% of illite added, 7) the control bed soil with 20% of illite added, 8) the control bed soil with 5% of illite plus 5% of zeolite added, 9) the control bed soil with 10% of illite plus 10% of zeolite added. Compared to the control bed soil, the growth lengths of the leaves of chinese cabbage in the treatments of illite as a whole were increased by 15 to 30% in length, whereas its growth length in the commerical Joeun bed soil was increased by 20%. Also, their growth lengths in the treatment of control bed soil with zeolite added were increased by 10%. Their growth lengths in the treatment of control bed soil with the mixture of illite plus zeolite at the same ratio were increased by 25 to 35%. The amount of cations such as K, Ca, and Mg were higher in all the treatments of clay minerals, such as illite and zeolite than in the control, respectively. In the comparison of treatments of Joeun bed soil and control bed soils with illite added, the cations remaining in the part of bed soils were higher in the commercial Joeun bed soil than in the control bed soil with illite treatments, whereas, the cations of leaves and roots of the chinese cabbage were 15% and 20% higher in the bed soil with 15% of 1llite and 20% of illite treatments than in the Joeun bed soil, respectively. Especially, the cations of leaves part of the chinese cabbage were higher in the control bed soil with all the treatments of illite than the in the Joeun bed soil. The pH of bed soils with illite treatments (pH 6.3-6.5) was a little higher than that of control bed soil(pH 6.1), whereas, that of the commerical Joeun bed soil (pH 5.9) was lower than that of the control bed soil. Based on the experimental results from the study, it appears that the use of illite and the mixture of illite plus zeolite can contribute to the enhanced growth of chinese cabbage and to the savings of expense in the manufacture of the horticultural bed soil.

Keywords：*Clay mineral, Illite, Zeolite, Growth, Cations, Chinese cabbage, Horticultural bed soil*

P4-91

[C2.4-2] Roles of Minerals as Suppliers and Regulators of Plant Nutrients

Mineralogical Characterization of Tremolite Asbestos-Containing Soils of S. Korea

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Introduction

Asbestos-containing soils occur mainly at ultramafic rocks and hydrothermally altered carbnate rocks and Naturrally Ouccurring Asbestos(NOA) area in S. Korea. Remediation of asbestos-containing soils of asbestos exhausted mine and NOA area is considered a high priority by the Korean Government because these soils, if left untreated, represent a hazard to the environment and human health. The objective of this study was to show a priori physicochemical and mineralogical characterization of asbestos-contaminated soil can direct the development of remediation strategies.

Materials and Methods

Two sites (Seosan and Jaecheon, S. Korea) at abandoned asbestos mines were selescted for soil and mineralogical characterization. Parent rock of the two sites is hydrothermally altered carbnate rocks in S. Korea. At each site, samples were taken at soil surface. Soil preparation consisted of sieving air-dried soil through a 2 mm sieve. The sieved soils (< 2 mm) were used for soil characterization and mineralogical analysis. Following particle size fractionations, mineralogical characterization was investigated by TG-DTA, XRD, PLM, SEM and EDS analyses. Point counting was used to quantify asbestos in the whole soil and size fractionated samples.

Results and Conclusion

The soil color of the both sites was dark red (Seosan site) and dark brown (Jaecheon site). The soil texture of the Seosan and Jaecheon sites was loam and sand, respectively. XRD analysis showed mineral assemblages of the Seosan and Jaecheon site were tremolite-talc-vermiculite-quartz-diopside and tremolite-talc-vermiculite-quartz-dolomite, respectively. XRD, PLM, SEM and EDS analyses showed that the needle-shaped tremolite was observed and the typical chemical compositions(Si-Mg) was analyzed at both soils. Size fraction between 425 ㎛ to 2 ㎜ of the Seosan and Jaecheon soils contained 1.5 % and 2 % asbestos, respectively. Therefore, the soils of the both sites were designated as asbestos-containing materials (greater than or equal to 1%) according to the criteria of the U.S. EPA. In case of S. Korea, If the asbestos in residence area soil near asbesots exhausted mine is detected, the Ministry of Environment(MOE) will decide to remediate that area depend on the results of risk assessments. The remadiation will be the excauvation to the landfill and cover with a clean soil. In case of TG-DTA analaysis, the results showed that tremolite asbestos at both soils were transformed to diopside with the temperatures about 1,100℃ and indicated that thermal treatment of asbestos-containing soils was effective for phase transformation of the asbestos in soils of asbestos exhausted mine and NOA area. The results of this study shows that it is necessary to consider the thermal treatment of asbestos contained soil as one of the remediations and to test the toxic of phase transformated asbestos by thermal treatment in further.

P4-92

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Effect of Long-Term Spentwash Application on Soil Physical, Chemical and Biological Properties

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Spentwash, a distillery by product, is a plant extract and microbial residue. Spentwash is rich in plant nutrients and could be utilized in agriculture as liquid manure after biomethanation. Discharge of raw spentwash into the open fields or nearby water bodies results in environmental, water and soil pollution including threat to plant and animal lives.

In a replicated field experiment conducted at Main Agricultural Research, University of Agricultural Sciences, Dharwad (Karnataka). Spent was applied as a source of nutrients to maize in kharif and wheat in rabi for 9 years in permanent plots. The results on soil properties after harvest of 9th crop (maize) grown during kharif 2012 are presented and discussed in the this paper. The treatments consisted of T1- 1 N through spentwash (60,000 litre ha-1+ balanced P through SSP); T2 ? 1 ½ N through spentwash (90,000 litre ha-1 + balanced P through SSP); T3 ? 1 N through recommended dose of fertilizer (150:75:37.5 kg NPK ha-1); T4 ? 1 ½ N through recommended dose of fertilizer (225:75:37.5 kg NPK ha-1); T5 ? ½ N through fertilizer + ½ N through spentwash; T6 ? ½ N through spentwash + ½ N through fertilizer and T7 ? Farmer's practice (2 bags DAP + 1 bag urea= 41).

The soil of the experimental site was Typic Chromustert. Soil samples were collected from 0-15 cm and 15- 30 cm depths from all the replications and treatments before initiating and after harvest of the crop. The pH of the soil ranged from 6.58 to 7.40 in surface soil and 6.63 to 7.35 in 15-30 cm soil. The electrical conductivity was slightly higher in spentwash applied plots compared to fertilizer applied plots. The soil organic carbon in the surface layer ranged from 4.03 to 6.60 g kg-1. The available N, P, K and micronutrients were higher in treatments with fertilizer application.

Bulk density of the soil was significantly influenced by the long-term spentwash application. Application of spentwash to serve 1.5 times recommended nitrogen was high enough to bring significant reduction in the bulk density compared to equivalent dose of fertilizer. Spentwash application to supply 100 per cent RDN and 50 per cent RDN also reduced the bulk density compared to fertilizer application. Porosity, per cent water stable aggregates and maximum water holding capacity were also higher in the treatments that received 1.5 times recommended N through spentwash. The porosity was 1.15 times higher in treatment with 1.5 N through spentwash compared to farmers' practice. Higher easily decomposable organic matter content and enhanced microbial activities in spentwash applied treatments had improved all the physical properties of soil.

Application of spentwash continuously in the long run brought major changes in the chemical properties of soil. The highest pH (7.73) was observed in the treatment with 1 ½ N through spentwash. The ECe of the soil was higher in spentwash treated plots but was less than 4 dSm-1 (critical level for grouping into saline soils). The electrical conductivity was measured to be the highest (3.54 dSm-1) in the treatment that received higher dose of spentwash (1 ½ N through spentwash). There was no accumulation of salts in the deeper layers since the electrical conductivity decreased with depth in all treatments and soil salinity did not differ among treatments at 30-60 and 60-90 cm depth.

Organic carbon was the highest in treatments that was supplied with 1.5 times recommended nitrogen through spentwash. Addition of organic matter through spentwash and better crop growth with concomitant increase in the root biomass could be the probable reasons for the increase in the organic carbon content in the soil with higher quantity of spentwash application. Soil inorganic carbon was higher in the spentwash treated plots compared to the other fertilizer treatments. Organic carbon and potassium present in the spentwash improved the CO2 evolution by enhancing the microbial activity. The exchangeable cation, water soluble cations and anions increased with long-term spentwash application. Higher exchangeable sodium was noticed in soils irrigated with spentwash than fertilizer applied ones. Exchangeable potassium was higher in spentwash irrigated plots than the unirrigated plots. Exchangeable calcium and magnesium dominated over sodium and potassium in all the treatments. Water soluble bicarbonates, chlorides and sulphates increased due to long-term spentwash application. Dehydrogenase and phosphatase activities in the spentwash irrigated plots were found to be higher than the fertilizer applied plots. The highest dehydrogenase activity (55.56 µg TPF g-1 of soil day-1) was recorded in the treatment that was supplied with 1 ½ N through spentwash. Application 1N through fertilizer (31.5 µg TPF g-1 of soil day-1) had lower dehydrogenase activity compared to equal nitrogen application through spentwash (46.28 µg TPF g-1 of soil day-1).

Keywords：*Spentwash, physical properties, chemical properties*

P4-93

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Influence of Long Term Fertilization on the Evolvement of Soil Organic Matter Evaluated by Mid-Infrared Photoacoustic Spectroscopy

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The structure of soil organic matter (SOM) is usually characterized via analysis of SOM fractions extracted from the soil; however, the obtained SOM information from the isolated fractions may deviate since the extraction process may alter SOM structure. Fourier transform infrared photoacoustic spectroscopy (FTIR-PAS) was applied to in situ characterize the structure of organic matter collected from historic Sanborn Field, Columbia, MO, and a nearby native prairie. Non-destructive depth-profiling of SOM was performed using different modulation frequencies to characterize SOM structure as a function of distance (μm scale) from the particle surface. Here we showed that SOM profile were very heterogeneous, and three different layers were identified through the depth profiling FTIR-PAS spectra: (1) a outer layer (0-23 μm) that exhibits enrichment of C-O bonds; (2) a middle layer (23-43 μm) displaying enrichment of aromatic C=C bonds; and (3) an inner layer (43-99 μm) enriched in heterocyclic N moieties. The SOM's evolvement, especially in the inner layer, was accelerated from 123 years to 74.9 years under long term fertilization, but inversely, this evolvement, was remarkably retarded by the crop residue returning from 123 years to 937 years, which quantitatively demonstrated that long term fertilization combining crop residue returning offered pathway for sustainable soil management.

Keywords：*soil organic matter; evolvement; long term fertilization; photoacoutic spectroscopy*

P4-94

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Advances in Techniques to Study the Influence of Earthworms on Soil Structure

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The overall influence of earthworms on soil structure results on the balance between their ability to produce organo-mineral aggregates and galleries, and the lifetime of these structures in soil. The difficulty to recognize from which species belong soil biostructures, to quantify them when fresh and welded, and to determine their turnover rate, are the main obstacles for modeling the influence of earthworms on soil structure. Basically biogenic structures are recognized from surrounding aggregates through their shape, size, color, surface features, internal fabric and organization. Conventional methods used to quantify biostructures are manual sorting, point counting or 2D image analysis on soil thin section/photography. As a result they are experimenter dependent, laborious, destructive and finally give limited spatial and temporal resolutions on the dynamics of aggregation or disaggregation. Recently, the large awareness of soil ecologists for the near infrared reflectance spectroscopy and X-ray computed tomography should enable better understanding on the production, stabilization and degradation of the biostructures directly in the field. This presentation aims to evaluate both the advantages and the limitations associated with these techniques and to highlight challenges might be used to quantify earthworm biostructures.

Keywords：*soil structure dynamics; bioturbation; ecosystem engineers*

P4-95

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Characterization of Ethyl Acetate Extract of Neurospora Crassa Using Gas Chromatography- Mass Spectrometer

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Soil has been a free gift of nature that the creator has giving mankind for exploration, there is a world-wide effort by the pharmaceutical chemists to continue to search for new antibiotics, anti-viral, antiparasitic and host of other novel drugs as a result of the grave consequences posed by the current diseases that have developed resistance to many of the known drugs. Neurospora crassa from Fifty years old cocoa farm soil in Ikota, Nigeria was isolated, cultured to yield maximum bioactive compounds using locally designed and fabricated fermenter and bioactive compounds were extracted in ethyl acetate and purified through column chromatography. The fraction X5 was screened for antibacterial activities using agar well diffusion, it has strong zones of inhibition (mm) against S.aureus, B.substillis , and E.coli. The results were better than streptomycin standard. The strong antibacterial activities displayed may be connected to the presence of bioactive compounds revealed by the Gc-Ms and these are: 1H-indene,2,3-dihydro-4-methyl having retention time 5.485, height area 310344 and % total 8.267; 1H-Indene,2,3-dihydro-1,2-dimethyl with retention time 6.375, height area 99678 and % total 3.214 and 1H-indene,1-ethylidene having retention time 8.743, height area 134010 and % total 3.567.The pharmacognosy screening of the crude showed presence of saponin(+), flavonoid(+), steroid(++) ,terpenoid(+) and cardiac glycoside(++).From the research work, the cocoa farm soil is an eye opener for the pharmaceutical chemists where they can beam their search point into for the discovery of new and novel compounds that may have various biological activities.

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Keywords：*Keyword: cocoa farm soil fermenter, antibacterial, 1H-indene, 2,3-dihydro-4-methyl, 1H-Indene,2,3-di*

P4-96

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

The Fe Uptake Mechanisms of Paddy Rice in Different Concentrations of Fe (iii) and Fe (ii) Hydroponic Solutions

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When paddy soil is submerged, Fe (III) oxides undergo reductive dissolution and Fe (II) concentration is increased in the soil solution. In paddy soil, the concentration of Fe (III) and Fe (II) is changed dynamically due to the change in redox potential with time. Meanwhile, rice root can release oxygen to change the redox status and Fe chemistry in the rhizosphere. Therefore, temporal variations in the Fe speciation and concentration are expected to occur in the rhizosphere of paddy rice. However, it is unclear how rice root could regulates the uptake of Fe while the Fe (II)/Fe (III) distribution changes with growing time. In this study, rice plants were grown in hydroponic solutions with different concentrations of Fe (III) or Fe (II). The Fe contents, the radial oxygen loss and the production of hydrogen peroxides in different parts of rice roots were measured. Stable isotope analysis was conducted to determine the predominant reactions determining the uptakes of Fe. The results provide information for understanding the Fe acquisition process of rice root.

Keywords：*paddy rice, Fe(III), Fe(II)*

P4-97

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Electrochemical Analytical Method for Determination of Available Cadmium in Soil with Screen-Printed Carbon Electrodes

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The pollution of heavy metal ions such as cadmium (Cd) have been of major environmental concerns due to the chronic toxic effects in human body. Cd speciation play a key role in determining the fate and transport of Cd in soil. However, the conventional analysis methods, such as AA, ICP and ICP-MS, can only determine the total content of metal in a sample. In this study, the electrochemical methods, square-wave anodic stripping voltammetry (SWASV) and differential pulse anodic stripping voltammetry (DPASV), were applied to determine labile Cd in Cd-contaminated soils. Screen-printed carbon electrode (SPCE) was used to be the working electrode. The results showed that the determination limit of labile Cd using SWASV and DPASV is at the level of ppb. Therefore, the determination and quantification of Cd speciation in soil can be achieved by the use of SPCE with SWASV and DPASV methods.

Keywords：*SPCE, DPASV, SWASV*

P4-98

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

The Use of Soil Thin Sections for the Study of Organic Matter Stabilisation

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Soil thin sections offer a two dimensional glimpse at soils in their undisturbed physical form. As such they have long been used to study soil structure, aggregation and the physical relationships between soil components. More recently chemical analysis of soil thin sections has provided a means to study the interplay between soil structure and soil chemistry. Such an approach is valuable in the study of soil organic matter for three reasons: 1) soil structure is an important factor in the physical stabilisation of organic matter (SOM), 2) thin sections allow micro, and even nano-scale examination of organic matter with the physical soil context retained, and 3) by preserving the spatial relationships of soil components, the interactions between organic matter, soil aggregates and soil minerals in spatially heterogeneous soils can be studied in ways that traditional wet chemistry approaches do not allow. This presentation demonstrates the potential benefits of soil thin sections for SOM analysis by considering three separate studies that have employed this approach.

A study of the distribution of SOM in relation to soil structure from the Rothamsted Broadbalk experiment employed image analysis and SEM-EDS of undisturbed soil thin sections (Smith, 2010). This study demonstrated the potential of these techniques to distinguish SOM from the soil matrix and impregnating resin using their O:C ratios. Thus, particulate SOM distribution could be mapped within intact soil aggregates and changes in C concentration in the vicinity of SOM were recognised.

A study of the microfeatures and stability of SOM (Falsone et al. 2013) applied image analysis, SEM-EDS and NaClO oxidation techniques to thin sections in order to study the link between features, composition and lability of SOM in gleyic and stagnic soils. The results demonstrated that SOM feature was linked to composition with amorphous compounds having higher Si:C, Al:C and Fe:C ratios than organ features, clearly pointing to interactions with the soil inorganic phases, which contributed to SOM stabilisation. Following oxidative treatment organs were almost totally removed, while the amorphous organic compounds were less affected both morphologically and chemically.

A second study of the interaction between SOM and Fe-oxides in gleyic and stagnic soils applied micromorphology, SEM-EDS and sequential extractions by ammonium oxalate and dithionate-citrate-bicarbonate to the surface of thin sections (Wilson et al. 2013; Cloy et al. in press). In these soils the distribution of SOM and Fe-oxides is highly heterogeneous and is intimately linked with soil structure. This complexity is lost in bulk chemical analyses leading to uncertainties in our understanding of exactly how these interactions operate. As well as demonstrating the importance of iron / aluminium oxide interactions for SOM stabilisation, this study highlighted differences in the interactions of poorly and strongly crystalline phases with SOM. Poorly crystalline iron

(hydr)oxides were found in association with partially degraded tissue residues and amorphous fine organic matter, whilst strongly crystalline iron (hydr)oxides formed impregnative features within soil aggregates. Fe/C ratios suggested strongly crystalline Fe features had formed by precipitative processes rather than sorption, and at the core of many of these were well preserved, occluded organic tissues.

These studies individually showcase the potential offered by the use of soil thin sections in SOM analysis, as well as highlighting some of the technical and analytical difficulties imposed by the use of resin impregnated sections.

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Keywords：*Soil thin sections, SEM-EDX, Soil organic matter*

P4-99

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Soil Olsen-P Accumulation Models and Prediction Estimation of Soil Olsen-P Accumulation by Models in China

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Phosphorus (P) is one of the most important nutrients to improve crop yield. In an attempt to achieve higher yield, farmers have resorted to use higher than the recommended levels of fertilizer in many areas in China. Use efficiency of Phosphorus fertilizer was 10%-25% Normally, thus Phosphorus accumulation in the soil is a problem worthy of study. Influence factors on amount of Olsen-P(extraction by 0.5 mol L-1 NaHCO3) accumulation in soil were initial soil Olsen-Pi, surplus of P fertilizer and soil character (pH). And surplus of P was calculated by subtracting amount of yield uptake from amount of P fertilizer application. So The models of Olsen-P (extraction by 0.5 mol L-1 NaHCO3) accumulated in soils was studied by long-term experiments, which were established by soil pH, initial soil Olsen-Pi, amount of fertilizer application (Pm), yield, ratio of P contented in yield and cultivation time, and equation as: Olsen-P = Olsen-Pi + (D/pH) × (Pm - Cm×Ym) × t , where Olsen-Pi is the initial concentration of Olsen-P in soils (mg kg-1), pH is soil pH, P is application rate of P fertiliser (kg P ha-1), t is cultivation time (year), C is the apparent concentration of P in crop grains (g kg-1), Y is the total grain yield of crops per year (ton ha-1), D was constant under same cultivation management, the subscript m denotes the average of P, C and Y in the period of cultivation years, respectively. The model was validated by other long-term field experiments and investigated data, and which is helpful for accurate prediction of accumulation rate of Olsen-P in soil ,as well as for best management of P in soils for both agricultural production and environment protection. Also, application of models to predict the change of Olsen-P in soils can decrease the frequency of monitoring Olsen-P in soils and cut off the cost of soil testing.

Under different crop system and fertilizer type, the description of parameterized predictive model and predictive rate of Olsen-P accumulation in the soil as follows:

Model in paddy soil with chemical fertilizer application as:

(1) Olsen P (mg kg-1) = Olsen Pi + 0.0763 × (Pm 3.07 × Ym) × t, (R2 = 0.95, n = 17).

When P application rates ranged from 49.2 to 78.6 kg/ha in paddy soils with rice yields from 7.1 to 11.7 tons ha-1, the accumulation rates of Olsen P in paddy soils were estimated to be from 1.2 to 3.7 mg/kg/year.

(2) Model in wheat-maize cropping systems soil with chemical fertilizer application as :

Olsen-P (mg kg-1) = Olsen-Pi + (0.238/pH)(Pm-2.78Ym) t (R2 = 0.91, n = 58).

When P application rates were 70 and 80 kg P ha-1 year-1, the target yield of wheat and maize is 10 ton ha-1, in the soil with pH 8, the increasing rates of Olsen-P in soils as estimated by the model will be1.25 and 1.55 mg kg-1 year-1 respectively.

(3) Model in wheat-maize cropping systems soil with biosolids (sewage sludge or chicken manure) application as :

Olsen-P (mg kg-1)=Olsen-Pi+(0.234/pH)(Pm-2.79Ym)t (R2=0.94, n=21)

the increasing rates of Olsen-P in soils was 2.87 mg kg-1 in average in the plough layer treated with biosolids for every 100 kg P ha-1 surplus.

(4) Model in wheat-maize -cotton one crop a year systems soil with chemical fertilizer or organic fertilizer application as:

(R2=0.71, n=122) , If the target yield of wheat, maize and cotton were 5, 6 and 6 ton ha-1 respectively in soil with pH 8, the increasing rates of Olsen-P in soil as estimated by the model will be 0.11, 0.24, 0.36, 0.49 and 0.61 mg kg-1 year-1 when P application rates are 60, 70, 80, 90 and 100 kg P ha-1 3 yr-1, respectively. For every 100 kg P ha-1 P surplus can increase 1.13 mg kg-1 Olsen-P in Xinjiang grey desert soil.

Keywords：*Phosphorus, models , Prediction, soil*

P4-100

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Chemical Compositions of Iron Plaque and Root Exudates of Different Rice Cultivars Grown in Fe(ii) and Fe(iii) Hydroponic Solutions

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Paddy rice is grown in submerging condition, which results in spatial and temporal variations of Fe(II) and Fe(III) concentrations in paddy soil. Rice root absorbs Fe(III) through Strategy-II mechanism. However, the concentration of Fe(III) is significantly lower than that of Fe(II) in submerging condition for growing rice. It is therefore hypothesized that rice root can regulate the Fe chemistry in the rhizosphere by the secretion of oxygen and root exudates and control the uptake of Fe(III) by the root. Different rice cultivars were grown in hydroponic solutions of different Fe(II) or Fe(III) concentrations to investigate the Fe absorption efficiency as a function of root oxygen and exudate secretion. Microelectrode probe was used to determine the oxygen concentrations at different parts of rice roots. X-ray microscopy was applied to determine the spatial distributions of Fe precipitates on rice roots, and μ-XRD and μ-XAS were used to determine the mineral compositions of the Fe precipitates. As revealed by X-ray microscopy, the distributions of Fe precipitates on rice roots were heterogeneous. The formation of Fe precipitates was related to root exudates and ferrihydrite was found to be the major composition in Fe precipitates. As revealed by the results of stable isotope analysis, Fe(II) was oxidized and then absorbed by rice roots grown in Fe(II) systems. Therefore, the formation and subsequent dissolution of ferrihydrite on rice roots may play a key role in the Fe uptake process of rice roots.

Keywords：*iron, paddy rice, rhizosphere, X-ray microscopy*

P4-101

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Time Course Analysis of Fe Uptake and Translocation in Rice Plants

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Iron (Fe) is one of the essential micronutrients in plants. The mechanisms of Fe acquisition of higher plants can be grouped into two categories: Strategy-I and Strategy-II. Rice (Oryza sativa), which is a graminaceous crop using the Strategy-II mechanism to take up Fe(III)-DMA, is able to absorb Fe(II) at Fe deficient conditions as by nongraminaceous plants. However, there is limited information on Fe(II) uptake and transport in rice plant. The goal of this study was to investigate how rice root regulates the uptake of Fe with varying Fe(II)/Fe(III) concentration. Rice plants were grown in hydroponic conditions with different Fe(II) and Fe(III) concentrations. The concentrations of root exudates and Fe(II)/ Fe(III) in hydroponic solutions were analyzed as a function of growing time using LC-ESI-Q-TOF-MS and ICP-AES, respectively. The Fe contents in different parts of rice plant were determined. The results of this study revealed that the oxidation of Fe(II) to Fe(III) and the subsequent absorption of the resultant Fe(III) by rice root is the predominant mechanism of Fe uptake by rice root.

Keywords：*rice, Iron, oxidation*

P4-102

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Investigation of the New Soil Substitutes for Cultivation Legume-Rhizobia Symbiosis under Simulated and Real Microgravity

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The life of microorganisms essentially accompanies the life of plants in the natural conditions. The plant-concomitant microbocenosis includes both unfavorable and favorable representatives. The last of them are known to alleviate the broad spectrum of stresses in plants. The Man-made ecosystems are mostly characterized by the stress conditions for the higher plants nd animals. Here the stress conditions are to be more meaningful because of the lack of favorable soil microorganisms. To solve this problem one must choose the parameters, suitable for productive plant-microflora interaction.

In the Earth conditions we attempted to simulate how the legume-rhizobia symbiosis will develop under the space greenhouse conditions. The state of microgravity was achieved by means of 3D-clinostats. The next task was to create the model of the soil and the associated processes, appropriate to a space flight.

Granular materials aren't allowed in the space technologies because of hazard to the life of the space-craft personal. It made us test some fibrous materials and perlite, cemented with agar (0,8%). The fibrous monoliths, such as Grodan (Netherland), are widely used in the agricultural and floricultural glasshouses, but they are characterized by the considerable cost for the utilization for the purposes in the large-scale space missions. Taking this into account we decided to get the data about the parameters of the unusual soil substitutes – textile productions such as ground capronic, acrylic and polyestheric fibers (synthetics); lavsan-enforced flax (semisynthetic); viscose (artificial); cotton and coarse flax (natural fibers); wool and silk (proteins). The three parameters measured were the acceptability for the growth of plants (A.Grodzynskyy, 1983), N-fixing bacteria (Roizdin, 1964), and the water retention capacity (WRC).

In the analyses with bacteria the pure droplet of the Azotobacter chroococcum suspension served as the control. In the experimental variants the soil substitutes were soaked in the same amount of the suspension. The wool showed the best fouling by the colonies (235% comparing with the control). It was followed by Grodan (208%), flax (191%), acrylic fibre (157%), and cotton (139%).

The biggest increment of the cress roots was observed on the extractions from flax (137% comparing with the control), Grodan (134%), lavsan-enforced flax (126%), silk (121%), and cotton (117%).

The WRC of acrylic fibre was fixed on the level of 775%, Grodan – 760%, wool – 600%, caprone – 590%, cotton – 580%, flax – 560%, viscose – 470%, silk – 420%, polyester – 390%, lavsan-enforced flax – 380 %. The listed materials are more dispersive than the natural soils and this explains why the meanings of their WRC are considerably higher as compared with the natural soils.

Consequently Grodan can be considered as the most suitable soil substitute for the cocultivation plants and N-fixing bacteria. We rejected the rest of the tested variants while taking the next steps of the work.

On the second stage of the investigation we studied the ability of the soil substitutes to withstand clinorotation and alfalfa cultivation was. Here two substitutes, such as Grodan and agar-cemented perlite, were tested. It was shown that perlite+agar was able to retain the moisture, required for the plants, for months. The same time parameter for Grodan was only 7-10-days.

Nevertheless perlite+agar failed under utilization in high-volume containers (more than 0,1 l), because sometimes it fell out while turning of clinorotated containers. This might be explained by the following. Adhesion between the perlite+agar and container walls is proportional to container perimeter. The weight of the soil substitute squarely correlates with container's diameter, and the perimeter of walls only linearly. Thus, the increasing of weight exceeds the increasing of adhesion.

Overall, our investigations showed that good conditions for the cultivation of the legume-rhizobia symbiosis in the real or simulated microgravity responded the utilization of Grodan with moisture from 400 to 700 %. The last could be achieved by the periodical moistening of the soil substitutes for 700 % every 5-8 days.

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Keywords：*soil substitute, water retention capacity , suitability for plants, suitability for N-fixing bacteria, clinorotation*

P4-103

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

The Role of Total and Active Calcium Carbonate Equivalent in Availability of Some Soil Micronutrients

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Carbonates are among the most common soil constituents in arid and semiarid. Considering the soil productivity, in spite of their high carbonates most of calcareous soils do not show sever limitations compared to the other arid zone soils. This may cause some difficulties in interpretation of actual roles of soil carbonates. Carbonates, especially active carbonates may cause different problems including micronutrients deficiency in soils. This study investigates the effects of carbonates on the availability of some micronutrients amounts in four soil orders including: Inceptisols, Aridisols, Alfisols and Mollisols. Active calcium carbonate equivalent was measured according to ammonium oxalate method, and the available concentrations of the studied micronutrients were measured using DTPA extraction method. The results did not show any regression between the available concentrations of micronutrients with CCE content. However, strong regression coefficients were observed between them and ACCE at ACCE contents less than 2.5 %. After a sharp decrease at the range of 2.5 % ACCE, except for available Cu similar trends with limited tolerances were obtained for the relationships between ACCE and available Fe, Mn and Zn contents.

Keywords：*Calcareous soils, Active calcium carbonate equivalent, Available iron, Micronutrints.*

P4-104

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

The Effect of Incremental Acidification on the Solubility of Phosphorus in Alkaline Vertisols

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Vertisol soils often have large reserves of phosphorus (P) that are considered unavailable to plants in the short term. However, these phases provide P for plant over several seasons and possibly late in a season, though the circumstances under which this happens is not known. Acid soluble phosphates, thought to be mainly various calcium phosphates, appear to be a large store of the reserve P in these soils. We investigated the release of reserve P in alkaline Vertisols during incremental acidification. The six soils investigated had moderate or high pH buffering capacity, and low, high or very high reserve P concentrations. The reserve P concentrations, assessed as the difference between P concentrations in bicarbonate and H2SO4 extracts, were <20 mg/kg (low), 350 mg/kg (high), and 1400 and 6800 mg/kg (very high). The soils with high pH buffering capacity contained carbonate and were acidified to pH 6; other soils were acidified to pH < 5. The P released was recovered with anion exchange membranes and iron oxide paper strips. The highly buffered low reserve P soil did not release as much P as contained in a single assessment of labile P (via bicarbonate extract) through the acidification process. In the moderately buffered low reserve P soil, 73% of the reserve P was released between pH 5.1 and 4.8. In the soils with high to very high reserve P, there was a consistent pattern of large amounts of reserve P being released at certain stages during incremental acidification. In the two moderately buffered, very high reserve P soils, P release increased 50% to 100% as the pH fell below 6.2. In the soil with the highest P concentration, the P release rate increased further at lower pH values until 68% of the reserve P still remained in the soil below pH 4.6. In the second of these two soils, the P release rate decreased below pH 4.8 and only 10%of the reserve P remained at pH 4.4. Of the two additional high reserve P soils the P release increased from 50 to 70% at pH 6.8 and increased again at pH 6.3. Seventy percent of the reserve P remained in the soil below pH 5.3 in the moderately buffered soil, and 90% remained in the highly buffered soil below pH 6.3. The dissolution of reserve P into a plant available form is strongly affected by pH buffer capacity and the total reserve P available. Very high reserves of P appear to be proportionally more readily soluble, indicating a gradient in solubility in what is considered reserve P. In the moderately buffered soils, rhizosphere acidification may solubilise a large quantity of reserve P, yet the majority of the reserve P may only become soluble through slower dissolution as soil solution concentrations are maintained below the mineral solubility products. Further kinetic studies are required.

Keywords：*Phosphorus, rhizosphere, reserve supply*

P4-105

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Coupling Arsenic Mineralogy to Seasonal Arsenic Mobilization in Groundwater in Southwest Taiwan

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In southwest Taiwan, high levels of As occur naturally in groundwater and have raised serious public concerns due to the toxic effect of As in human. The distribution of arsenic species in vadose zone is determined by redox potential, pH, and microbial activity. The change in the water table of groundwater may result in change in the redox condition and consequently As mobility in the corresponding vadose zone. The goal of this study was to investigate the mechanism of As mobilization in southwest Taiwan. The depth profiles of As minerals were characterized using X-ray diffraction and X-ray absorption spectroscopy for two bole hole sites, which were selected based on the groundwater As levels determined in previous surveys. The water-table levels of groundwater of these two sites were monitored weekly. Groundwater samples were also collected weekly for the analyses of pH and Eh, and chemical compositions, including As, Fe, Mn and S. The seasonal change in the As concentration in groundwater will be attributed to the mechanisms of Fe-hydroxide reduction and/or sulfide oxidation. The information acquired in this on-going work will assist in developing strategies for reducing health risk of As in groundwater in southwest Taiwan.

Keywords：*arsenic, X-ray diffraction, X-ray absorption spectroscopy, Fe-hydroxide reduction, sulfide oxidation*

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[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Fog Ii - A New Innovative Portable Instrument for the Total Calcium Carbonate Soil Testing

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An automatic portable and digital calcimeter was used for the determination of the total carbonates in soil samples. The soil calcimeter consists of a multi-sensor for precision measurement of pressure and temperature, control keys, a portable digital analyzer with a built-in unit for communication and determining the geographical position (GPS), a liquid crystal display, a microprocessor, a flexible polyurethane hose, a plastic screw cap with a hole through which pass hoses, a glass reaction cartridge (head) into which the sample reacts with hydrochloric acid, a host reagent vial containing hydrochloric acid and rechargeable batteries. The major advantage of this invention is the use of a multi-sensor, which combines simultaneous measurement of pressure and temperature. In addition to the measurement of temperature, the instrument has a built-in module for automatic temperature compensation, so that performs measurements with higher accuracy. Other important advantages of the instrument are its ability to communicate and tracking the geographical location (GPS) and save this in a special memory, especially when the use of the instrument is in the field. In addition, the portable instrument can host up to six heads for sequentially measurement of six samples providing to the end-user the advantage of the measurement of high volume of samples in a very short time. For testing purposes of this innovation, soil samples were analyzed for their total carbonates content. The instrument has a typical mean error of ± 0.3% calcium carbonates content of the soil sample and a recovery more than 98% comparing to certified inter-laboratory soil samples (proficiency tests) for quality assurance.

Keywords：*soil testing, total carbonates, agricultural technology, innovation*

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[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Predicting Soil Lime Requirements Using Agro-Informatics Practices

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Precision farming technologies are well known, but the combination of site-specific machinery and portable devices is still regarded as a major innovation in agriculture. For soils of downstream Acheloos plain in Western Greece which presents low pH, an advanced information system was developed, for rapid estimation of lime requirement (LR) that should be added for the increase of pH value, using a previously proposed pedotransfer function LR (Mg ha-1) = ((pHt ? pHa)/b) ´ 0.495 ´ CaCO3 and factors bw=0.2496 for soil samples whose pH value is determined in suspension soil:water (pHw) and bCaCl2 = 0.1840 for soil samples whose pH value is determined in suspension soil:0.01M CaCl2 (pHCaCl2), using user's global position (geographic coordinates), via portable devices. Related applications and ICT solutions have already been applied in other cases, where the use of portable devices leverages business processes and other operational needs. An approach like this is applied for the first time in Greece and our work provides a successful know-how transfer example, in agriculture.

Keywords：*soil lime requirements, agro-informatics*

P4-108

[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

The Role of Particle Shape and Texture in Amplifying Hydrophobic Behavior at the Soil-Water Interface

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Events at the interface between soil and water are critical in determining soil hydrological processes and its implications for plant growth. Where the affinity between soil and water is limited (soil water repellency), surface runoff can be enhanced and water availability for plant growth be reduced. This phenomenon is caused not only by the chemical properties of the soil (i.e. the presence of a hydrophobic coating) but also by surface structure, a feature which has only recently been considered as a major factor affecting water repellency in the field of soil science. Moreover, the surface texture of particles has not been fully considered in the overall structural effect yet.

In this study, the role of particle shape and texture on the behavior of the soil-water interface was investigated using various standardized hydrophobic surfaces. Hysrophobized glass slides, beads, shards and naturally occurring sand were used as simplified models for soil surfaces with increasing surface texture, as confirmed by optical microscopy. Contact angles were measured on a layer of closely packed particles, which were fixed on a microscope glass slide using double-sided adhesive tape. The same chemical modification procedures were applied to all materials and the particle sizes were limited to small ranges. This standardization allowed effective isolation of the roles of particle shape and texture by direct comparison between different surfaces, minimizing the influence of heterogeneity of the particles.

All particle-based surfaces showed larger contact angles than a smooth, flat surface. The contact angles, and hence water repellency, increased in order of glass beads < glass shards < sand. These results confirm that the same chemical properties can result in more severe water repellency on rough surfaces compared to smooth. The role of particle texture in soil water repellency was evident by the result that the sands showed significantly more severe water repellency than the smoother glass materials with the same particle size. The role of particle shape was not as significant as the texture. Overall, these results suggest that the surface structure is important for understanding the behavior at the soil-water interface.

Acknowledgement: This study was funded by UK Engineering and Physical Sciences Research Council (EP/H000747/1 and EP/H000704/1).

Keywords：*soil hydrophobicity, soil-water interface, contact angle, soil water repellency, surface structure*

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[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Nutrient Expert® - A Nutrient Management Decision Support Tool For Smallholder Cereal Farmers Of South Asia

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Nutrient management is a key challenge for smallholder cereal farmers in South Asia. With limited access to soil testing facilities, farmers use blanket fertilizer recommendation that do not take into account for high spatial variability of available nutrients, typical in smallholder systems. Otherwise, farmers apply fertilizer based on perceived importance of nutrients that is often highly skewed towards nitrogen application. Such ad-hoc application of nutrients had very limited success and farmers' yields rarely reach more than 60% of the attainable yield of crops.

Site-specific Nutrient Management (SSNM) has been proposed as a strategy to synchronize nutrient application with the spatial and temporal variability of soil available nutrients and crop productivity. This approach (SSNM) has been able to address many of the issues of ad-hoc nutrient prescriptions. However, SSNM is a knowledge-intensive process and its large-scale implementation is a major challenge, particularly in smallholder cereal farm fields of South Asia.

Nutrient Expert®(NE)-a recently developed nutrient decision support tool for South Asian smallholder production systems, provides the capability to easily implement SSNM in farmers' fields. The NE decision support tool for maize and wheat are easy-to-use, interactive computer-based decision tools that can rapidly provide nutrient recommendation for individual farmers' field in presence or absence of soil testing data. The tools estimate the attainable yield for a farmer's field based on the site specific soil characteristics, determines the nutrient balance in the cropping system based on yield and fertilizer/manure applied in the previous crop, and combines such information with expected N, P and K response in the concerned field to generate a location specific nutrient recommendation. The validation studies of NE Wheat and Maize showed that the NE tool-based recommendation produced better yield and farm economics as compared to existing nutrient management practices across different agro-climatic zones of India.

Resource endowment of smallholder farmer is a key issue that influences nutrient management decisions. Improved fertilizer recommendations are often not adopted by farmers, as recommendations do not match farmer resources. The NE tool is capable of providing farmer resource based fertilizer recommendation. The tool determines an appropriate yield target for a particular farmer's field based on several soil and climatic factors. However, the user has the discretion to override the estimated attainable yield target

suggested by the tool for a particular farmer and provide a different set of yield targets to suit the farmer's resource availability. It then logically distributes available resources of the farmer to match nutrient limitation/requirement in individual fields.

We used the Nutrient Expert® tool for ex-ante analysis of agronomic and economic benefits of fertilizer use in maize in different farm typologies of smallholder systems in eastern India. Results from West Bengal state showed that the additional seed and fertilizer cost in the NE based fertilizer recommendation ranged from -50 to +22 USD/ha, -36 to +36 USD/ha and -88 to +46 USD/ha for average incremental yield targets of 0.7 t/ha, 1.7 t/ha and 2.3 t/ha over the farmers' practice, respectively. For Odisha state in Eastern India, the range of extra seed + fertilizer cost in the NE based recommendation for the average incremental yield targets of 1.7 t/ha and 2.3 t/ha over farmer's practice was -134 to +62 USD/ha and -92 to +78 USD/ha, respectively. This suggests that the NE recommended fertilizer + seed for higher yield targets often costed less than the farmer's practice. The extra benefits achieved through NE recommendation over farmer's practice ranged from 30 to 1095 USD/ha across two locations and forty participating maize farmers.

The present study suggests that NE can improve the yield and economic return of the smallholder farmers in South Asia. South Asia is one of the most populated geographies in the world. Nearly 70-80% farmers in South Asia cultivate less than 1 hectare of land. Food and economic security of the smallholder farmer will depend on how well they manage their inputs, particularly nutrients and Nutrient Expert® is a step forward in that direction.

Keywords：*Nutrient Expert®, Nutrient Management, Smallholder Systems, South Asia, Maize, Wheat*

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[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Soil Attributes and Arboreous Vegetation Characterization in the Biologycal Reserve of Pindorama, Sao Paulo State, Brazil

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The Pólo Regional Centro Norte in Pindorama, São Paulo State, Brazil, has a 120 hectares area constituted of forest remainders transformed into Biological Reserve by the law nº 4960/86 since a great diversity of regional occurrence species was withhold. These forest remainders are classified as seasonal semi-deciduous tropical forest of the Atlantic Forest biome. This work aimed carry out a phytosociological survey of two toposequences in different remainders and its possible soil attributes due variation and relief. To such work two transects were demarcated with sequential parcels of 20 m x 20 m. A topographic survey was carried out using the following variables: slope, height and localization of the plots throughout the profile. A quadrant of 10 m x 10 m was chosen randomly in each parcel and in its area an evaluation of the physical and chemical soil attributes using samples in the 0-20 cm depth composed of 20 sub-samples. In this quadrant the individuals with breast height diameter (DBH) ≥ 5,0 cm were identified, marked, classified and their phytosociology describers calculated: relative and absolute frequency and densities, value of importance (VI), Shannon Diversity Index (H `), Equability (J) and the Jaccard Similarity Index (ISJ) between the two areas. For each parcel the degree of weeds was evaluated adopting ten classes according the infestation percentage varying from null to very high. The hierarchic grouping test based on the soil physical and chemical attributes allowed a division in five groups of parcels. For each group the average values of each characteristic were determined, as well as recalculated the diversity species index, equability and the similarity between the groups index. It could be concluded that the hierarchic method grouping analysis showed efficient to separate groups of phytosociology sampling parcels in seasonal semi-deciduous tropical forest when it was used the physical and chemical soil attributes variability. For both evaluated areas the families that presented greater number of individuals were the Meliaceae with nine identified species and the Myrtaceae with six species. The higher value of importance species were for Astronium graveolens Jacq to both areas followed by Acacia polyphylla DC. and Ceiba speciosa A.St.-Hil. to area 1 and Guarea khuntiana A. Juss and Guarea guidonia (L.) Sleumer to area 2. The presence of weed reduced the basal area and height of the trees species evaluated, the number of species and individuals in the parcel and caused a high presence of lianas in the four bigger trees of the parcel. This situation was observed when the distance from the edge to the remainders was smaller. The pioneering and not pioneering species occurrence and growth varied according to the soil attributes and fertility, relief and weeds presence.

Keywords：*Soil and forests, Tropical soils, trees and soil*

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[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Which Vineyard Practices in Order to Assure Sustainable Champagne. Results from the Vitiecobiosol Programme, a Long Term Study (25 Years)

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Conventional vineyard practices have lead in many environmental disturbances as soil erosion, soil compaction, loss of organic matter and soil biodiversity, water contamination,…. Therefore, there is an increasing interest to develop sustainable viticulture in the famous Champagne vineyard since 20 years: a huge program called “VITI 2000” has been developed since 1986 by CIVC (Inter-professional Committee of Champagne Wine) in collaboration with researchers. This program aims are i) to assess the impact of vineyard practices on soil functioning environmental properties and wine quality, ii) to advice sustainable practices to winegrowers. One strength of this program is to allow a long term field experiment. In this program, earthworm communities, microbial biomass, soil and vine parameters were followed during 25 years in 19 plots representing 66 treatments which tested the impact of pesticides applications (nematicides, fungicides, herbicides), or organic matter inputs, or vine management (organic vineyard vs conventional vs integrated). This program ended in a huge data collection e.g. the data table of earthworm communities (species, body mass, sexual stage) presents more than 39 000 lines. A database, compatible to others soil fauna databases developed by the laboratory EcoBio (University Rennes 1), has been developed. First results indicate that i) grass strip between the vine rows and compost, quickly stimulate biological soil processes, while dried organic matter inputs have a slow positive impact, ii) fungicides containing copper alter in the same pattern, earthworm and microorganisms, iii) integrated management could be as positive as organic practices. Statistical treatments are still going on and further results will be discussed.

Keywords：*Vineyards, Biostimulation, Ecological engineering, Sustainable agriculture*

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[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Research on Magnetic Field Strength of Electromagnetic Soil Conductivity Meter and Correlation Coefficient Between Electromagnetic Response and Soil Analysis Value on Main Reclaimed Land Polder Soil

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Main issue of crop cultivation in the reclaimed land is soil salinity. The salt content of soil in the reclaimed land changes by environmental factors such as precipitation, sunlight, wind, and temperature. Large scale cultivations are planned in newly constructed reclaimed lands located on the west coast of Korea such as Saemangeum and Yeongsangang; therefore, rapid measurements of soil salinity in a timely manner are needed.

This study presents the magnetic field of the transmitter, correlation coefficient between electromagnetic detection and lab analysis of the reclaimed land soil, and data for soil salinity mapping. The results of this study are as follows:

1. In the vertical mode, the strength of the magnetic field showed a power function (y = 8940.5x-2.123). It was inversely proportional to the distance; i.e. it decreased by 50mG, 18mG, 10mG, 6.6mG, and 4.2mG with increasing distance in the vertical direction by 10 cm.
2. In the horizontal mode, the strength of the magnetic field showed a power function (y = 4503.2x-1.971). It was inversely proportional to the distance; i.e. it decreased by 35mG, 12mG, 7.8mG, 4.5mG, and 2.6mG with increasing distance in the vertical direction by 10 cm.
3. In the vertical mode, sum of the magnetic fields based on the distance from the transmitter was larger than the one in the horizontal mode by 23%.
4. The correlation coefficient R2 between the measured electromagnetic fields and analyzed electrical conductivity with the soils from Yeongsangang reclaimed land collected on June 13th was 0.51 (topsoil) and 0.58 (subsoil). And The R2 with the soils collected on October 18th was below 0.1.
5. The correlation coefficient R2 between the measured electromagnetic fields and analyzed electrical conductivity with the soils from Iweon reclaimed land collected on June 19th was 0.64 (top soil) and 0.50 (subsoil). And The R2 with the soils collected on October 18th was 0.56 (top soil) and 0.72 (subsoil).
6. The correlation coefficient R2 between the measured electromagnetic fields and analyzed electrical conductivity with the soils from Hwaong reclaimed land collected on May 31st was below 0.1 both in the top soil and subsoil. And The R2 with the soils collected on October 16th was 0.23 (top soil) and 0.13 (subsoil).

Keywords：*reclaimed land, electromagnetic field,soil salinity*

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[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Pyrosequencing-Based Assessment of the Bacterial Community Structure along Different Crops in Upland Fields

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Pyrosequencing provides taxonomic information about the overall bacterial community. The present study evaluated the soil bacterial communities in soil samples collected from 25 upland fields in South Korea by using the pyrosequencing method. The operational taxonomic units, with an average read length of 566 bp, were assembled using a 97% similarity cut-off. Of the total bacterial sequences assessed, the most abundant phylum was Proteobacteria (37.8%), followed by Acidobacteria (17.1%), Unclassified (9.9%), Bacteroidetes (9.3%), Actinobacteria (8.3%), Firmicutes (4.9%), Chloroflexi (3.9%), and Gemmatimonadetes (2.7%). The Cyanobacteria community in soil of potato (5.3%) was significantly higher than that in soil of bean (1.3%), red pepper (0.8%), and garlic (0.5%) cultivation. In addition, the Firmicutes community in sandy loam (8.2%) was significantly higher than that in loam (4.4%) and silt loam (3.9).

The Cyanobacteria community should be considered as a potential factor responsible for the obvious soil bacterial community difference that was observed between crops of cultivation in the upland fields.

Acknowledgment : This work was carried out with the support of 'Cooperative Research Program for Agriculture Science & Technology Development (Project No. PJ009198252013)' Rural Development Administration, Republic of Korea.

Keywords : *Bacterial community, Pyrosequencing, Cyanobacteria, Firmicutes, Upland*

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[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Long-Term Monitoring of Chemical Properties from Upland Soils in Gyeongnam Province

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The monitoring of fertility changes in upland is very important for agricultural sustainability. Field monitoring was performed to evaluate the soil chemical properties of 170 upland soil samples in Gyeongnam province every 4 years from 2001 to 2013. Soil chemical properties such as pH, electrical conductivity, amount of organic matter, available phosphate, and exchangeable potassium, calcium, magnesium, and sodium were analyzed. The amount of exchangeable calcium, sodium, and soil pH were significantly increased as cultivation year increases. In 2013, the frequency distribution for values of pH, organic matter, available phosphate, and exchangeable potassium, calcium, and magnesium that were within the optimum range was 16.5%, 31.8%, 4.7%, 5.9%, 7.1%, and 27.1% respectively. Especially, available phosphate, exchangeable potassium, and exchangeable calcium were excess level with portions of 61.8%, 58.2%, and 78.2%, respectively. These results indicated that a balanced management of soil chemical properties can reduce the amount of fertilizer applied for sustainable agriculture in upland fields.

Acknowledgment : This work was carried out with the support of 'Cooperative Research Program for Agriculture Science & Technology Development (Project No. PJ009198242013)' Rural Development Administration, Republic of Korea.

Keywords：*Chemical property, Upland soil, Soil fertility, Available phosphate, Exchangeable calcium*

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[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Biomarker Discovery Using Seldi-T of Ms In Environmental Nanotoxicology

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Biomarker discovery using surface-enhanced laser desorption/ionization time-of-flight mass spectrometry (SELDI-TOF MS) has been introduced to analyze protein patterns and find biomarkers specific to human diseases, especially cancers, for diagnosing them (van Gorp et al., 2012). Profiling intact proteins using SELDI-TOF MS has made possible for the selection of biomarkers and rapid to determine certain environmental contamination affecting to the ecological systems (Lee et al., 2013; Mo et al., 2013). Two main advantages in biomarker discovery using SELDI-TOF MS are lower loss of sample than MALDI-TOF MS and time and labor efficiency because it does not need to use complicated analytical procedures. Recently, my lab has employed SELDI-TOF MS to find presumable biomarkers to detect possible toxic effects of nanoparticles. Nanoparticles exhibit their effects on protein expression in terrestrial plants and animals determined by SELDI-TOF MS and my lab has found possible biomarkers for rapid detection of nanoparticle exposure in the environment.

Keywords：*SELDI-TOF MS, terrestrial animals and plants, nanotoxicology*

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[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

A Rapid Bio-Assay Technique for Phytotoxicity Assessment Using Photophenomics and Rhizospheric Imaging

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The objective of this study was to develop a rapid bio-assay technique through the photochemical parameter analysis. To test phytotoxicity of herbicide, glyphosate the young seedling of lettuce were sawn on the agar plate with different pH. The rhizospheric pH changes were detected Using pH indicators. Simultaneously, the photochemical responses were photographed by a chlorophyll fluorescence camera (handy-cam, PSI) and the photochemical parameters as like as the maximum quantum yield of photosystem Ⅱ (Fv/Fm) and the steady-state quantum yield (ΦPSⅡ) were analyzed.

The Fv/Fm ratio was already reduced to fifty six percentage within twenty four hours after glyphosate treatment. The ΦPSⅡ was more significantly retained only to fifteen five percentage.

In conclusion, we could rapidly detect the herbicidal phytotoxicity in the photosynthetic tissue and non-photosynthetic root using the chlorophyll fluorescence imaging and the rhizospheric pH indicating.

Keywords：*bio-assay, glyphosate, pH indicator, photosynthetic efficiency,chlorophyll fluorescence*

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[C2.5-1] Advances in Techniques to Investigate Chemical, Physical and Biological Interfaces in Soils

Photochemical Assessment of Rice (oryza Sativa L.) Seedlings Grown under Abiotic Stresses Using Photophenomics Technique

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The main objective of this study was to assess the effects of abiotic stresses on performance and vitality of rice plants. Three rice cultivars from South Korea were used in the study. Drought experiment was carried out for 4 days after which the drought specimen was re-watered. The polyphasic OJIP fluorescence transient was used to evaluate the behavior of Photosystem II (PSII) during the entire experiment period. In drought stress the maximum florescence (Fm) level is reached earlier when compared to the controls. Analysis of the photosynthetic performance Index (PI) of the 3 cultivars show that they are heavily affected by drought stress. For the first 4 days of treatment there was a decline in PI of between 60 and 90 percentage. There was also a large decline of the maximum photochemical activity of PSII (Fv/Fm) as shown in the trend lines graph of this parameter. Re-watering had a significant effect on the rice plant recovery from drought as shown by rapid rise in (Fv/Fm) after re-watering. For the screening of drought stress tolerance the Drought Factor Index (DFI) of each variety was calculated as follows: DFI = log(A) + 2log(B). All the three cultivars show DFI ranged from -3.42 to -5.03, meaning less useful in selection of drought tolerant cultivars. Performance Indexes and Fv/Fm values of three cultivars were to indicate reduction of plant photosynthetic performance during the early vegetative stage under drought stress.

Keywords：*chlorophyll fluorescence, Rice, Abiotic Stresses, Photophenomics Technique*

P4-118

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Role of Surface Reactivity in Kinetics of Soil Chemical Process

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1. Cadmium sorption in calcareous soils

The relative activity of soils is intimately related to their specific surface area as well as by their mineralogy, which largely determines the chemical behavior of the surface chemistry and its kinetic reactions. This work aimed to evaluate the contribution of specific surface area of some calcareous soils (Typic calcids), varied in their total and active CaCO3 content on the kinetics of cadmium (Cd2+) sorption reactions. The obtained results revealed according to highest coefficient of determination R2 and the lowest standard error SE values; data was best described by empirical modified Freundlich (power function) and Elovich models. The rate constants of used models indicated that Cd2+-sorption on calcareous soils was highly positive correlated with soils specific surface area through the calculation of simple correlation coefficient (r), multiple and stepwise regression analysis. For other soil parameters, results showed that percent of clay content, organic matter (OM) and total Cd2+ content of these soils, these properties largely controlled the variations of kinetic parameters describe the rate of cd-sorption, the intensity factor and also capacity factors of used models. Active CaCO3 content of used soils, which is largely correlated with surface area, was negatively correlated and significant controlled the variations in kinetic parameters of Cd reactions in soils i.e. rate, and capacity factors. The study suggest that Cd sorption followed by surface precipitation on active CaCO3 surfaces is the main mechanism of Cd2+ retention which controlled Cd release in such systems.

Keywords：*surface area, heavy metals, kinetic models, calcareous soil*

P4-119

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Dependence of the Electron Transfer Capacity on the Kinetics of Quinone-Mediated Fe(iii) Reduction by Iron/humic Reducing Bacteria

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The effects of a series of quinones on goethite reduction by two types of iron/humic reducing bacteria (Shewanella decolorationis S12 and Aeromonas hydrophila HS01) were investigated in this study. The results showed that the quinones with redox potentials (Eh0) in the range of -344 to -137 mV (vs. SHE at pH 7) can significantly accelerate Fe(III) reduction by S12 and HS01. Plots of the electron transfer capacities (ETC) of the quinones (including the electron accepting (EAC) and donating (EDC) capacities determined using chronoamperometry) vs. Eh0 were similar to those of the ratios of the iron reduction rates (kcell+Q/kcell) vs. Eh0. The UV/Vis diffuse-transmittance absorption spectra of S12 and HS01 suggested the presence of outer membrane c-type cytochromes, which are responsible for the extracellular reduction of iron and quinones. The Eh0 of the different types of cytochromes varies within a broad potential window, which might influence the electron shuttling capacity of various quinones from microorganisms to iron. The nominated Fe(III) reduction rates in the presence of quinones had a good linear relationship with their ETC, and the difference of the redox equilibria among the different quinones might correlate to their different performance of ETC and mediating microbial iron reduction. This work can help researchers understand the influence of redox properties of quinone compounds on microbial iron transformation in anoxic environments.

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[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Iron Cycles Link with Arsenic Availability in Rice for Food Safety from South China

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Iron is the fourth most abundant element on the Earth. As a recognized physiological requirement for life, its role extends well beyond a nutritional necessity for many microorganisms. Owing to its higher chemical activity and microbial activity, iron cycle should be a perfect model system to study the interaction among minerals, dissolved organic matters and bacteria. Iron biogeochemical cycles have great potential to couple contaminant transformation as well as to support various microbial populations in soil and sedimentary environments.

In south China, rice, as most important crop has been suffering from extensively heavy metals pollution, especially arsenic and cadmium. It is difficult to remediate polluted paddy fields with millions hectare by engineering techniques. On the view of biogeochemical process, we have been long focusing on the linkage between iron cycles and bioavailability of heavy metals in subtropical paddy soils. For example, arsenic is mainly present as arsenate and strongly absorbed on iron (hydr)oxides under oxidized conditions, while Fe(III) (hydr)oxides can be reduced by dissimilatory Fe(III) reducing bacteria under reducing environment, causing the release of the sorbed As into soil solution and arsenate can be reduced to more mobile species of arsenite. In those processes, Fe oxides play important roles in controlling As biogeochemical cycling and bioavailability.

Lianhuashan tungsten mine is one of the biggest tungsten mines in the southern China, which lies in Guangdong province. Rice paddies downstream of the mining areas receive substantial input of As. 73 pair samples of soils and corresponding rice plants were collected from paddy fields. A sequential As fractionation scheme was employed to determine the following operationally-defined As fractions: (F1) extractable with 0.05 M (NH4)2SO4, (F2) extractable with 0.05 M NH4H2PO4, (F3) 0.2 M NH4+-oxalate buffer-extractable (amorphous Fe and Al oxides bound phase), (F4) 0.2 M NH4+-oxalate buffer + ascorbic acid-extractable crystalline Fe and Al oxides bound phase, and (F5) extractable with HNO3/H2O2.

1. The Fe(III)/Fe(II) speciation link with As bioavailability

Our results showed that amorphous Fe showed a significant and negative correlation with As contents in brow rice and in strew. DCB-extractable Fe was also found to be significantly and negatively correlate with As contents in brow rice and strong negatively correlate with As in strew. Multiple regression analyses were performed to identify the most significant soil properties that regulate As bioavailability for brown rice. Approximately 83% of the As content in brown rice could be explained by the following equation:

AsBrown rice=0.575-0.60×FeO+0.021×As-F2-0.04×As-F3 (r2=0.832, P<0.01)

These results demonstrated that with the increasing of amorphous Fe or DCB-extractable Fe, more As fractions would be found in amorphous/ crystalline Fe and Al oxides bounded fractions, resulting in decreasing of highly available As fractions. Amorphous Fe oxide content in soil played a vital role in reducing As availability for uptake and loading into the rice grain.

2. Microbial community structure links with As bioavailability

Microbe is believed to be associated with ferric hydroxide precipitates (Fe-plaque) formation on the root of plant. However, the microbial community structures of Fe-plaque on rice root and their relationship with arsenic accumulation in mature rice plants have not been explored before. In this study, high-thoughtput next generation sequencing and real-time quantitative PCR were applied to explore the microbial composition and diversity of Fe-plaque biota on rice root. Combined with arsenic analyses in different parts of rice, our goal is to clarify the relationship between the microbial community on root and the arsenic accumulation of rice. The results showed: (1)The pattern of microbial community structure of Fe-plaque was markedly different with topsoil and rhizosphere soil. (2) aoxB gene clone library showed that the arsenite-oxidizing bacteria were dominated by members of Acidovorax, Hydrogenophaga and Pseudomonas at genus level. (3)The number of arsenite-oxidizing bacteria on Fe-palque has a significantly negative relationship with As concentration in rice root. In summary, we demonstrated that the Fe-plaque is a unique microbial biota and the arsenite-oxidizing bacteria on Fe-plaque may control the arsenic mobility on root. This investigation shinned light on the important role of microbe as a mediation in Fe-As transformation on root, which has influence on arsenic uptake of rice. It also provide a novel effective way to reduce the arsenic uptake of rice in contaminated soil thought regulating Fe-plaque microbial community.

P4-121

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Soils as Interfacial, Low Entropy Systems with Resilience Based on Maximum Entropy Production

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Soils are resilient, low entropy, natural bodies governed by non-equilibrium thermodynamics through the creation and function of an array of abiotic and biotic interfaces that can produce entropy at maximum rates when disturbed. The entropy state of soils is based on solar, gravitational, orogenic, and anthropogenic energy inputs and flows, with the last being the most variable in time and space through the use of fossil fuels.

The capture of solar energy and its transformations in photosynthesis and subsequent abiotic and biotic processes are the primary reasons for changes in the entropy state and its production in soils. Soils transfer entropy to their surroundings; and in the process, restore or lower their entropy state in the course of pedogenesis and in response to disturbances that may occur on a cyclical basis and over a range of temporal and spatial scales from seconds to millennia. Entropy is produced by chemical polymerization and microbial degradation of organic matter, soil processes directed by DNA transcription and translation to form proteins. Furthermore, this information is expressed by changes in the genomics, proteomics, and metabolomics of microorganisms. Chemical, physical, and biological processes also influence variations in soil salinity at the colloid-water interface level; and thereby produce and export entropy.

All of these entropy-producing processes can be changed by human uses, management, degradation, and restoration of soils. Furthermore, we posit that the dynamics of soil organic matter, microbial communities, and colloid-water interfaces can be studied experimentally and related to entropy changes in soils over time. Finally, we are exploring the idea that a knowledge of entropy change in soils can be used to define operationally a concept of "soil resilience."

Dynamic entropy changes across soil interfaces are related to three components of soils that distinguish them from natural waters and the atmosphere at the Earth's surface:
(1) colloidal clay mineral and oxide formation with high surface area and charge governed by their crystallographic structures and interfacial processes between colloid surfaces and the aqueous and gaseous phases,
(2) organic matter accumulation and degradation in the presence of atmospheric oxygen through catabolic and anabolic biochemical reactions; modified by chemical reactions governing polymerization, pH-dependent charge formation, and redox reactions, and
(3) microbial community formation and function, principally in biofilms that encode and archive genetic information, and that act as key producers of entropy through metabolic processes releasing water, a key entropy-maximizing compound. The archived genomic information for a soil may be a measure of the biotic potential of a soil to produce entropy in response to disturbance.

The “resilience of soils” (SR) can be viewed conceptually as the difference between the magnitude of a measurable change in a soil property caused by a disturbance (Ds) to a “less desirable” state (based on human preferences and soil functions), and the new state of the soil after a response of the soil has occurred naturally or due to human inputs, Rs, on a time scale defined by humans. Therefore, SR = Rs Ds. When SR = 0, the soil has “recovered” to its previous state; if SR < 0, it has become “degraded;” and if SR > 0, the soil has “improved” as a result of going through a cycle of disturbance and recovery. Soil resilience can be linked to entropy and interfaces, and we hypothesize that soil entropy and the magnitude and rate of its production are integrated variables for assessing soil change.

Operational definitions of SR require the choice of one or more soil functions of interest (especially those related to ecosystem services: biomass production, nutrient and pollutant transformations, and microbial gene reserves), and what soil properties are of concern to users of the soil for that function. Given the wide range of soil properties that could be measured for each of these three soil functions, assessing soil degradation, recovery, or improvement; and thus resilience, is a daunting task.
In light of this conundrum associated with the quantification of soil resilience, we propose that qualitative and semi-quantitative evaluations of entropy status and maximum entropy production may provide a functional, common metric for soil resilience for all three soil functions (separately or together) and for a range of properties used to measure soil change.

Keywords：*soil organic matter, soil salinity, microbial genomics*

P4-122

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Effect of Some “live” And “mixed Dry Organic” Mulches on Selected Soil Physical and Chemical Properties and Yields of Two Cocoyam (xanthosoma Sagittifolium (l.) Schott) Cultivars in Akwa Ibom State, N

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The effects of some “Live“- and “Mixed Dry Organic”- mulches on selected physical and chemical properties and yields of two cocoyam cultivars the old cocoyam (Colocasia esculenta) and new cocoyam (Xanthosoma sagittifolium) were studied in Akwa Ibom state, Nigeria. The treatments comprised melon (Citrullus vulgaris), fluted-pumpkin (Telfairia occidentalis),, dwarf okra (Abelmoschus esculentus), groundnut (Arachis hypogeae), cowpea (Vigna unguiculata), and soybean (Glycine soja), as live mulches; and mixture of dry vegetative parts of various grasses, as mixed dry vegetative mulch, and bare-surface plots, as control. The eight treatments were arranged in a randomized complete block design and replicated three times. As expected and regardless of the type of crop variety, the mixed dry organic and live mulches generally lowered soil temperatures, while the temperatures rose considerably in the control plots. The mean moisture contents of the control plots dropped slightly at the termination of the experiment while there were general increases in the mean moisture contents of soils under the various mulching treatments, but excepting the trends obtained in plots covered with Okra crops. Organic carbon contents decreased significantly in the control plots (mean value of 10.2 g kg-1) compared with the pre-trial values of 14.0 g kg-1; while it increased in varying degrees in the plots that received either various live or mixed-dry mulches compared with the values in the control plots. Both live and mixed-dry mulches increased soil total nitrogen in the old and new cocoyam plots. Similarly, mixed dry and live-organic mulches increased yields of corms and cormels compared with the yields in control plots, but yield increases over the control were higher for cormels than for corms. Melon, cowpea, and groundnut crops, in decreasing order of contributions, have shown great promise as live mulch crops in cocoyam fields, compared with the mixed-dry organic materials commonly used to mulch cocoyam farms by farmers of the area. To encourage adoption of this practice, however, the farmers would need to be sensitized and trained.

Keywords：*Keywords: Mulches, Soil properties, Cocoyam yield, Akwa Ibom State, Nigeria.*

P4-123

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Toposequence for Distribution and Transformation of Phosphorus Fractions in Humid Subalpine Forests

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Phosphorous is one of the most important elements in reforestation and forestry management. However, knowledge about phosphorus (P) fractions in humid subtropical subalpine forest soils is scarce and patchy. We aimed to determine how pedogenesis changes the translocation and transformation of inorganic and organic P (Pi and Po) along a topographic gradient of seven pedons of subalpine forest soils. We used both chemical sequential extraction of P and electron-probe micro-analysis (EPMA) of soils. The vertical distribution of P and transformation among P fractions were strongly influenced by soil weathering degrees. The higher the weathering degree, the greater the total P (TP) and the higher the fraction of labile P (KCl-Pi + NaHCO3-Pi + NaHCO3-Po) and Po (NaHCO3-Po + NaOH-Po) were in soil. The formation of an iron pan (Bsm horizon) was a major barrier limiting the leaching of P and further influencing the transformation of P. Accumulation of TP in the surface soils was enhanced by the presence of a Bsm horizon. Besides TP, organic P fractions were accumulated in the surface horizons of the pedons with the Bsm horizon. With increasing weathering degree, Po pools gradually transformed to Pi pools in the surface horizons, whereas fractions of Po and Pi were transformed to a residual P fraction below the Bsm horizon. By comparison, Po fractions were the major form of P presented in all soil horizons (O, A and Bw horizons) in profiles without the Bsm horizon. EPMA element mapping in the soil matrix revealed that P was mainly co-illuviated with iron oxides in the Bsm horizons, so leached P was strongly absorbed by iron oxides. The depth distribution function of TP further indicated that the presence of the Bsm blocked the downward mobilization of TP in this forest. The effect of the topographical factor might be masked by soil moisture regimes, because an epiaquic condition resulting from the Bsm horizon at upper slope positions tended to result in more TP content in soil profiles.

Keywords：*Available phosphorus ,Inorganic phosphorus (Pi), Organic phosphorus (Po), Placic horizon, Subalpine*

P4-124

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Modified Bentonite Assisted Bioremediation of Pahs in Mixed Contaminated Condition: Microbial Viability and Biodegradation of Phenanthrene

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Organic contaminants, such as polyaromatic hydrocarbons (PAHs), whether having acute or chronic toxicity, are of concern given their potential adverse impact on environmental quality and public health. It is of greater concern if they coexist with other inorganic contaminants, such as heavy metals. Bioremediation is considered as a cost effective method compared to physical and chemical remediation. However, remediation of PAHs from a mixed contaminated site can be challenging in the presence of toxic metals (e.g. Cadmium (Cd)) which can adversely impact microbial activity. For example, while Cd reduces the enzyme activities of bacteria, the presence of PAHs, such as phenanthrene increases its toxicity to the soil bacteria (Lu, et al., 2013). Sorbents that reduce Cd toxicity through its adsorption while at the same time increases the bioavailability of PAHs can be used as it can enhance biodegradation. Clay and modified clay minerals (e.g. organoclays) are good adsorbent of both PAHs and heavy metals (Sarkar, et al., 2012). Clay-based chelating agent has already been shown to be potential adsorbent of heavy metals (Malakul, et al., 1998). However, the efficiency depends on the types of clay minerals, mode of modification and the target contaminants. Moreover, the microbial agents employed to degrade PAHs are largely specific to those adsorbents. The degradability by the microbial cells critically depends on the complex environment of clay based chelates, toxic metal, organic contaminant, microbial agents and their biotic and abiotic interaction. The answer to the following questions is therefore inevitable to reveal the most efficient functioning of biodegradation: (a) what is the functional relationship between metal concentration and the adsorbents, (b) what fraction of organic contaminants is bioavailable, and (c) how the microbial cells behave in terms of their viability. On the way to addressing these questions, we have developed a clay-based chelating agent followed by its compatibility assessment through the biodegradation of phenanthrene coupled with Cd toxicity.

Natural clay mineral, bentonite (termed as B) (CEC, 85.8 cmol [p^+] kg^{-1}) from Western Australia was used as parent clay. We followed the modified protocol of Malakul, et al. (1998) to develop a chelating agent. In summary, two step treatments were applied: bentonite was treated with alkyl ammonium surfactant Arquad® 2HT-75 (termed as AB) followed by palmitic acid treatment (termed as ABP). For the biodegradation experiment, a PAHs degrading bacterium Mycobacterium gilvum VF1 (DSM) was employed in 20 ml of aqueous suspension after allowing it to reach equilibrium with 20 mg l^{-1} of phenanthrene as sole carbon source (≥98% pure, Sigma-Aldrich), different concentration of Cd (2.5, 5, 7.5 and 10 mg l^{-1}) and 0.5% of B, AB and ABP. All possible controls were kept. The pre-grown culture (Media: nutrient broth) was washed with 0.02% PBS and ca. 1.7×10^9 cells were

inoculated from its late log phase. The newly inoculated vials were incubated at room temperature on an orbital shaker at 170 rpm at dark to prevent photodegradation. After 7 days of incubation, the samples were taken to measure the concentration of phenanthrene by HPLC and Cd by ICP-MS. A comparison of microbial growth was estimated by counting CFU after 4-7 days of incubation in nutrient agar. The clay-microbe aggregation was observed by SEM.

We found that M. gilvum shows higher proliferation in clay-based adsorbent (ABP) followed by AB and B. This indicates that the ABP binds more Cd, which reduces the toxicity to microbe. Even after 12 days, ABP with 10 mg l^{-1} Cd gives four times more microbial proliferation than unmodified bentonite with 0 mg l^{-1} Cd. However, this growth reduces with the increase of Cd concentrations. For instance, in ABP treatment, CFU was 4-5 folds lower while Cd concentration was 10 mg l^{-1} than that of no Cd. The HPLC results also show that phenanthrene was degraded at higher rate in ABP added suspension. The aggregation of microbes and adsorbent was clearly visible in SEM image in which ABP gives prominent microbial clump in the system. However, the fraction of active and inactive cells in those systems still remains under investigation.

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Keywords：*Mixed contaminants, PAH degradation, clay-based chelates, microbial viability*

P4-125

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Influences of Soil Active Particles on Bacterial Activities

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Substantial interactions of microorganisms with soil particles impose fundamental effects on microbial activities governing a series of biogeochemical processes. However, how soil active particles modulate the activities has rarely been studied and the mechanisms remained poorly understood. This work examined that influences of soil colloids and minerals on the thermal activity, glucose degradation and cell biomass accumulation of three Gram-negative strains Pseudomonas putida, Escherichia coli TG1, Paracoccus sp. 169 and a Gram-positive strain Bacillus subtilis 168. The results showed that soil colloids from a Red soil and a Brown soil, kaolinite and goethite inhibited cell activities of P. putida and Paracoccus sp. while promoted the activities of E. coli and B. subtilis. The results suggest that the promotion or inhibition is predominantly determined by bacterial types rather than the solid particles. The presence of naturally occurring humus in soil colloids usually enhanced the metabolic activity of E. coli, B. subtilis and P. putida regardless of negative or positive effect on bacterial activity by the soil colloids. The impact of humus was possibly through the interfacial interaction instead of nutrient supply. Compared with inorganic Brown soil colloid, the greater suppression on the metabolic activity of P. putida by inorganic Red soil colloid was probably due to its higher content of kaolinite. The adsorption amount and affinity of bacteria and the detoxification of metabolic inhibitors by soil components may control the effects of soil particles on bacterial activity.

P4-126

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Adhesion to Kaolinite and Goethite of Pseudomonas Putida at Different Growth Phases

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Bacterial adhesion to minerals in soils and sediments is of fundamental importance in mineral weathering and formation, soil aggregate stability, organic matter degradation, transport of pathogens and bioremediation of contaminants. Bacterial surface properties that changes with growth phase are considered to govern the adhesion process. However, it has never been addressed how growth stage influences bacterial adhesion to clay minerals and iron oxides. This work examined the role of growth phase of Pseudomonas putida in adhesion to kaolinite-coated coverslips. Fluorescence microscopy and a cell viability dye were used to directly quantify surface cell density and viability of P. putida adhered to kaolinite. In situ attenuated total reflectance Fourier transform infrared spectroscopy was applied to depict the molecular information of bacteria, the adsorption kinetics on kaolinite and goethite films in controlled flow systems. Stationary-phase cells presented larger surface adsorption density on kaolinite surfaces than mid-exponential-phase cells under static deposition conditions. For the phyllosilicate, stationary-phase cells displayed higher saturation coverage fitted by a pseudo-first-order kinetics equation than the other phase cells in continuous flow systems. However, for goethite, the result of the saturation coverage was reversed for different growth phase cells. The greater adhesion of stationary-phase cells to kaolinite was probably ascribed to their deeper secondary energy minima and lower energy barriers. The larger adsorption of mid-exponential-phase cells to goethite was possibly assigned to the stronger electrostatic attraction and deeper primary energy minima. The data suggest that growth phase and mineral compositions play vital roles in cell transport and biofilm formation in a variety of aqueous geochemical environments.

P4-127

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

The Forms and Surface Availabilities of Soil Iron and Aluminum Minerals Influence their Adsorptive Stabilization on Litter-Derived Dissolved Organic Carbon

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Dissolved organic carbon (DOC) leached from litters constitutes an important flux of organic carbon into forest soils, and can be stabilized characterized by adsorption to soil iron and aluminum minerals, influencing its biodegradation. Iron and aluminum minerals in soil are distributed heterogeneously and vary in forms of crystalline and amorphous, thus the surface availability and the form of minerals would influence the adsorptive stabilization. We detected the biodegradation of the DOC adsorbed by minerals in crystalline and amorphous forms at various mineral-DOC solution ratios in incubation experiments, to investigate the adsorptive stabilization of iron and aluminum mineral on DOC under various surface availabilities as well as in various forms conditions. Results showed that, independent of mineral types, the biodegradation of DOC was sharply reduced after adsorption to minerals; however, the extent of biodegradation differed as mineral surface availability varied, indicating different stabilization of minerals on DOC at varying surface availabilities. The minerals strongly stabilized DOC under large surface availability conditions whereas relatively weaker stabilization was observed under low surface availability conditions, implying mineral content plays an important role in controlling the behavior of mineral stabilization on DOC in soil. Under low mineral surface availability conditions, DOC adsorbed by aluminum minerals was more stable against microbial decomposition than by iron minerals, and crystalline minerals exhibited stronger stabilization than amorphous minerals. These results do help in making a better understanding of the fate of litter-derived DOC after adsorption to soil iron and aluminum minerals in forest ecosystems.

Keywords：*Adsorption; Forest litter DOC; Iron mineral; Aluminum mineral; Stabilization*

P4-128

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Influence of Soil Humic Substances on Point of Zero Net Charge

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The effects of soil humic substances and in comparison with different inorganic fertilizers on the pH dependent surface charge properties of two different types of soil are estimated in this study. Two different soil samples haplaquept (forest soil) and fluvaquent (agricultural soil) is incubated with humic acid, fulvic acid and four different inorganic fertilizers urea, ammonium sulphate, di-ammonium phosphate and single super phosphate. pH dependent charge characteristics are estimated at every 30 days interval up to 90 days by ion adsorption methods. These soil samples bore net negative charge at their native pH, but variability in the magnitude of this charge was attributed to the effect of Al-blocked exchange sites or from strongly acid functional groups. These soils also bore significant amount of pH dependent positive charge at their natural acidic pH values, which is more in forest soil compare to agricultural soil. This investigation supports the agreement which is attributed to dissolution reaction of minerals and organic matter at high and low pH, which contribute overestimates surface charge. The ion adsorption method showed net charge to be a nearly linear function of pH. From the data analysis it was observed that with increasing percent of organic matter the point of zero net charge (ZPNC) value increases. Amount of net charge decreases with rise in pH, and it become negative from neutral to alkaline pH. Net charge sharply increases at pH 2 from 1.2 to 2.17 cmolckg-1 on agricultural soil, where as reverse trend observed in case of forest soil, it is depressed from 5.2 to 2.17 cmolckg-1,when humic acid adds to research sites, this is due to the presence of huge amount of exchangeable cations in forest soil. The net charge during the 30 days incubation in forest soil were 41.57,45.71,45.95,45.96,46.46,44.77 and 50.83 cmolckg-1 in soil, urea, diammonium phosphate, ammonium sulphate, single super phosphate, fulvic acid and humic acid respectively. Humic acid play major role on pH dependent surface charge properties, which indicates humic acid contribute higher charge densities to soil system, which is a favorable condition for higher cation and anion exchange capacities that has a relation for enhancement of soil fertility.

Keywords：*humic substances, pH dependent surface charge, point of zero net charge, soil fertility.*

P4-129

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Evaluation of Macro Soil Fauna as Bioindicator of Environmental Quality in Forests Remnants in the City of Sao Paulo- Brasil - Preliminary Results

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Soil quality is particularly through composition and structure, as well as by, measured by physical and chemical indicators, as well as by living organisms contained therein, which play the most varied ecological functions. The abundance and diversity of soil macrofauna in ecosystems can be affected by many factors, precisely because these organisms are sensitive to environmental changes, whether induced or natural. Thus, soil populations can be measured as bioindicators, since changes in the community may indicate possible changes in soil functioning.

This research aims to survey the biodiversity of macro soil fauna environments with remaining Atlantic Forest (Cientec Cantareira Park and Park) in order to detect specific features and significant changes in ecological function performed by these soil communities. The project aims to develop an overview of multivariate understanding about soil, especially the relation of variation of pedofauna with the occurring physical and chemical modifications in order to be able to prove the adaptation of soil fauna with variations in temperature, humidity, sunshine, influence of vegetation, soil genesis and topographic gradient.

According to Lavelle Spain (2001), the temperature and humidity are the main factors that activate the metabolic regulation in subjects of soil fauna, which ultimately determine their spatial distribution, periods of increased activity, peculiarities and significant changes, the function of these communities in the substrate.

Two combining sampling will be performed, one in the rainy season, in January, and another in the dry season, in July, with the purpose of measuring the diversity of populations according to seasonality. Invertebrates associated soil interface burlap (MOREIRA et al, 2010) will be caught by pitfall traps, which will be distributed in three installments by park, containing a sampling gride with nine equidistant points 30 meters of each other. Through Provid method, idealized by ANTONIOLLI, ZI et al,. (2006) capture is the use of Pet Bottle 2l as a trap where her windows with dimensions of 6 cm are made powder 4 cm in height of 20 cm which will be buried in the ground. The solution 200ml placed inside the bottle is a mixture of water and a neutral detergent to 2.5 percent.

Identification of macro invertebrate fauna will be made as soon as possible to avoid loss of physiological characteristics or death of the animal, which complicates the identification. During the extraction place the soil or animals collected in a tray, and carefully, with the aid of forceps, pulls out all visible animals, which are passed on to a container containing 70% alcohol, properly identified. With the aid of microscope and are grouped taxonomically in the kingdom, phylum, class and order (Papavero, 1994).

n the environment, the tests of abundance and heterogeneity (Martin and Santos, 1999), Simpson dominance (Odum will apply , 1983), Tukey test 5% and multivariate analysis.

Soil surveys (EMBRAPA, 1997) will be conducted so that the plots overlap to the same kinds of soil stains. Soil samples will be collected near the sampling sites for analysis of some physical parameters (EMBRAPA, 1997), such as texture, structure, porosity, aggregation, field capacity and compaction ; chemical (EMBRAPA, 1997) as pH, fractional organic matter, phosphorus, potassium, calcium and magnesium and other mineral nutrients such as nitrogen, sulfur, boron, manganese, zinc, copper, cobalt, chlorinebecause these nutrients are some activators enzymes that perform specific functions in the environment such as: regulation of water balance, fixing and cycling of nutrients in soil, plant growth and development, but also interfere with the functioning of organisms of soil fauna. This analysis is very important in research because the shortage or excess of any of these nutrients cited, may cause changes in soil functioning (EMBRAPA, 1997).

Keywords：*Ecological Indicators ; forests remnants ; soil invertebrates*

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[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Adsorption Potential of Fine Fractions of Sandy Clay Loam Soil (natural Aluminosilicate) for Ammonium Ion from Aqueous Solution

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In this study, the adsorption potential of fine fractions of sandy clay loam soil (SCL), a natural aluminosilicate material for ammonium ion was investigated. SCL was characterized by x-ray diffraction, chemical analysis, infrared spectroscopy, specific surface area and also the cation exchange capacity (CEC) was estimated. The effects of contact time, pH and initial concentration on the adsorption capacity of ammonium ions on SCL were also studied. The result showed that optimal adsorption occurred at pH 7. Langmuir (two linear forms), Freundlich, Harkin-Jura, Halsey and Elovich isotherm models were fitted to the experimental data. The best fit to the data was obtained with the Freundlich isotherm model. Kinetic experiments showed that equilibrium was reached after 45 min and the data correlated best with the pseudo-second-order model. The presence of competing ions in solution significantly affected the adsorption capacity.

P4-131

[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Assessment of Persistence of Cry1ac Protein from BT Spray in Soil: Comparison of Field and Controlled Laboratory Applications

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The harmful effect of chemical pesticides to the environment as well as human health have led to the development of bio pesticides in agriculture. Nowadays, Bacillus thuringiensis is widely used worldwide because of its efficiency and absence of side-effects. These have been the most successful biological pest control products worldwide, and 95% of microbial pesticides sold contain this bacterial agent, with annual sales estimated at $100 million (Kaur 2002; Federici et al., 2006). Strains of Bacillus thuringiensis produce proteins, known as Cry proteins, that have highly insect-specific toxic properties. However, in contrast to the numerous studies of Bt toxins produced by genetically modified crops, there is almost no information available on the persistence of Cry proteins from biopesticide sprays.

Our aim was to follow the persistence of Cry protein from Bt spray in soil under field conditions. Various spray conditions are varied to take account of different pathways leading to soil contamination. In parallel, to allow a more detailed explanation of the underlying mechanisms, soil was sprayed and incubated under controlled laboratory conditions. The effects of moisture content, temperature and sunlight over a period of several weeks were studied. Protein was extracted from soil using a high pH buffer containing surfactant and assayed using an ELISA-microplate kit.

The results show that detectable protein degraded slowly during the first week and then more quickly. Small differences in the degradation of Cry protein was noted for soils sampled in the same field, with a time lag observed for one of the soils.

Small differences were observed between soils incubated at different moisture contents, but the contrasts decreased with time and were no longer significant after two weeks. However, there were significant effects of temperature and sunlight. When soil was exposed to sunlight, Cry protein degraded more quickly than soil incubated in the dark. Detectable Cry protein was lost more quickly at low temperature (4°C) than higher temperature (20°C). This trend is in marked contrast to observations made when purified Cry protein was added to soil. In that case decline of detectable Cry protein was slower at low temperature.

Keywords：*Bt toxin; insecticide; persistence; soil protein*

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[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Effects of Some Effluents on the Physical and Chemical Properties of Soils in Edo State, Nigeria

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The effects of four different effluents (Palm oil mill effluent, Cassava mill effluent, Rubber effluent and Abattoir effluent) on some physical and chemical properties were investigated in the Screen House of the Teaching and Research Farm of Ambrose Alli University, Ekpoma, Nigeria. Composite soil samples were used in the experiment. Each of the four different effluents was used in separate pot experiments. Five rates (0,200,400,800 and 1200ml) of the effluents were added to 10kg of soil. This is equivalent to the rates of 0,20,40,80 and 120ml/kg of soil respectively. The treatments were fitted into a Complete Randomized Block Design and replicated three times. The treated soils were incubated for eight weeks. The physical and chemical properties of the soil were determined before applying the effluents and at the end of the experiment. Application of these effluents to the soils led to rise in soil pH with the exception of Rubber effluent. The applications of Palm Oil Mill, Cassava mill and Abattoir effluents increased soil pH from 4.8 to 5.2, 4.8 to 5.3 and 4.8 to 5.7 respectively. On the other hand, Rubber effluent reduced soil pH from 4.8 to 4.0. In addition Abattoir effluent had significant influence on the availability of P, K, Na, Zn, Mn, Pb and exchangeable Al; Cassava mill effluent significantly influenced available P and Ca; Palm Oil mill effluent significantly influenced total N, available K, Na and Pb while Rubber effluent had significant influence on available K, Mg, Na and Cu in the soil.

Keywords：*Palm Oil, Cassava, Abattoir, Rubber, Mill, Effluent, Soil physical and Chemical properties*

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[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Spatial Variations of Soil Microbial Biomass P along an Elevation Gradients in the Upland Meadow of Wugong Mountain

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RESERCH PROBLEM:

The upland meadow of Wugong Mountain vertical vegetation band in east of china with typical and particular, for which it have wide area and distribute at the low altitude. Thispaper expounds the characteristics the spatialvariability of soil microbial biomass P in Wugong Mountain mountain meadow, analyzes the effect of soil organic matter to the soil microbial biomass P, as well as the influence of soil microbial biomass phosphorus ecological factors, which have important significance to the Jiangxi Wugong Mountain mountain meadow vegetation restoration.

METHOODS:

1.To understand the spatial variations of soil microbial biomass P along an elevation gradients in Wugong Mountain ,samples were determined plots along an elevation gradients in the Wugong Mountain, which were 1600m, 1650m, 1700m,1750m, 1800m, 1850m, 1900m.

2.Fresh soil fumigation with chloroform, After being killed microbial biomass phosphorus was quantitatively extracted by0.5mol ? L-1NaHCO3 solution and determined out, According to the differences (total phosphorus incremental)of fumigation and no fumigation results and extraction

efficiency (conversion factor KP), soil microbial biomass phosphorus can be determination and to estimated.

3.Use spss17.0 to analyze significance of soil microbial biomass phosphorus at different altitudes and different layers ,use linear regression analysis correlation between soil microbial biomass P and the soil organic matter.

RESULTS:

1.CV<0.1 is weak variability; 0.1 <CV <1.0 is moderate variability; CV> 1.0 is strong variability. From amount of the coefficient of variation view of the SMB-P(Table 2),The coefficient of variation of SMB-P has little difference, all are belong to moderate variability.

2.Fig.1 showed that soil microbial biomass P did not show significant variation along an altitudinal gradient direction and the soil microbial biomass P at 0~20 cm depth was significantly higher than that at 20~40cm soil depth. Analysis of variance showed that soil microbial biomass P were have significant differences significantly with altitudes and soil depth($p<0.05$).

3.As can be seen from Table3 organic matter is reduced with the soil depth, in 0~20cm soil organic matter and soil SMB-P was significantly correlated, indicating that this the SMB-Pin this layer more susceptible to soil organic matter, while the layer of 20~40cm's SMB-P and organic matter have weak correlation

CONCLUSIONS:

1.Soil microbial biomass P is thesum of the elements phosphorus in the body, in the organization of microbial,the content (mass fraction) of soil microbial biomass P is approximately 1.4% to 4.7%, where there is 1.5% to 2.5% soil microbial biomass P in bacteria, there is 4.8% in fungi. Microbial biomass P have a significant spatial variability, as it waw was an important part of soil microbial biomass,

2. Phosphorus is the essential nutrients for crop growth, the soil minerals have strong adsorption and fixation effect on it, plant availability of soil phosphorus is generally low. Soil microbial biomass phosphorus because of its turnover rate, and can release the active phosphorus ,it was regarded as an important source of plant available phosphorus supply. Influence factors of soil microbial biomass phosphorus was very complex, including soil types and properties, climatic conditions, cultivation and fertilization management system. Soil organic matter plays N, P, S and other nutrient carrier, and it is the energy source of microbial growth and reproduction of essential, so it is one of the important factors affecting the soil microbial biomass P. The results showed that, total soil organic matter may be the dominant factor regulated in 0~20cm soil microbial biomass phosphorus along altitude gradient variation, and the soil moisture, soil temperature, soil pH may be the regulation of 20 ~ 40cm soil ecological factors.

Acknowledgement:The work reported here has been funded by National Natural Science Foundation of China (30960312) 、（31360177）and National Science and Technology Support Project (2012BAC11B06),The Innovation Fund Designated for Graduate Students of Jiangxi Province（YC2013-B029）and the IPNI Project(JX-29).The authors want to take this opportunity to thank all of the supports.

Keywords：*Wugong Mountain; Upland meadow; Microbial biomass P; Spatial variations*

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[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Modified Bentonite Assisted Bioremediation of Pahs in Mixed Contaminated Condition: Characterisation of Modified Clays

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Naturally occurring clay minerals play important roles to control the bioavailability and toxicity of organic and inorganic contaminants to soil microorganisms. The properties of clay minerals can be altered by a range of surface modifications in order to enhance contaminant adsorption and/or degradation (Sarkar et al, 2012). For example, surfactant modified clay minerals are excellent adsorbent of hydrophobic organic contaminants such as polyaromatic hydrocarbons (PAHs). If modified by certain organic molecules following appropriate steps, the resulting clay products can adsorb heavy metals too. Such modified clay minerals might be employed to enhance bacterial degradation of organic pollutants in a mixed contaminated environment (Olaniran et al, 2013, Malakul et al, 1998). For example, at a mixed contaminated site where bacteria cannot perform degradation of an organic contaminant to its fullest extent due to the toxic effect of heavy metals, a modified clay mineral might be applied in order to reduce the heavy metal toxicity through adsorption. To test this hypothesis, an investigation was conducted in a mixed contaminated system of phenanthrene and cadmium (Cd) in the presence of phenanthrene-degrading bacteria (Mycobacterium gilvum VF1) and organically modified bentonite products. This particular study presents the surface characteristics ofthe modified bentonite clays which were applied to assist the biodegradation of phenanthrene in the presence of Cd.

An Australian bentonite was modified in two steps; first by incorporating quaternary ammonium surfactant (Arquad® 2HT-75) at a loading rate equivalent to 100% cation exchange capacity (CEC) of the bentonite (CEC =85.80 cmol [p^+] kg^{-1}), and followed by a further anchoring of palmitic acid on surface of the organoclay at a similar loading concentration. The unmodified and modified bentonite products were characterised by X-ray Diffraction (XRD), Scanning Electron Microscope (SEM), Thermogravimetric Analysis (TGA) and Fourier Transformed Infrared Spectroscopy (FTIR). The Cd adsorption characteristics of the clay products were determined in aqueous solutions.

This study found that the two step modified bentonite (ABP = Arquad-Bentonite-Palmitic acid) provided the most favourable conditions for bacterial growth and proliferation by virtue of its surface properties which enhanced Cd adsorption. The XRD results revealed the intercalation of both the surfactant and palmitic acid into the interlayer of the smectitic clay. The d spacing was 30.3 Å in Arquad modified bentonite (AB) and 40.3 Å in ABP. The SEM images proved that the appearance of the clay products had changed due to the modification process. The sample ABP was less stable under the electron beam and yielded fewer electrons during the SEM analysis, which indicated a greater loading of organic molecules in this clay product. This was further confirmed by the TGA results where the sample ABP lost 44.7 % of its mass due to decomposition of organic matter at around 400 °C against a value of 34.7 % in case of AB. The FTIR analysis confirmed the presence of organic functional groups (e.g. carboxylic) on the

surface of the modified clay which resulted in greater adsorption of Cd through chelating effect. The surface characteristics of the modified clays are vital to reveal the mechanisms of contaminants adsorption by them and hence the bioavailability of the pollutants. Therefore, the current results motivate further investigation how phenanthrene and Cd compete for adsorption sites on the surface of modified clays and what implication it provides to the bioremediation of phenanthrene in mixed contaminated sites.

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Keywords：*Bioremediation, Phenanthrene , Cadmium adsorption, Modified bentonite*

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[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Effects of Natural Organic Matter on the Stability of Soil Nanoparticles

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Natural nanoparticles are ubiquitous in soils, and their quantity and stability play an important role in determining the fate, transport, and bioavailability of both nutrients and contaminants in soil and water. In the present study, the natural organic matter (NOM) extracted from a black soil, worm casts and Chinese milk vetch, respectively, was added to a soil nanoparticle (SNP) suspension to determine the effects of NOM on the stability of SNPs. The SNPs used in this study were extracted from four typical soils (HN, Oxisol; JX, Ultisol; LN, Inceptisol and JL, Inceptisol) from different regions of China. The critical coagulation concentration (CCC), one of the most important parameters to evaluate the stability of colloidal suspension in electrolyte solution, was determined. The CCC results showed that SNPs with NOM were more stable than SNPs without NOM with the same electrolytes (Na+, Ca2+ or La3+). The presence of NOM significantly increased the CCC of SNPs through steric stabilization and electrostatic effects. Since the NOM coating increases the negative charges on the surface of SNPs, the electrostatic force has a much larger effect on the stability of SNPs than the van der Waals force, leading to the decrease in aggregation rate of SNPs. In our work, the properties of NOM, such as molecular weight, degree of aromaticity and type of functional groups, made big differences to the stability of SNPs. Compared to monovalent cations (e.g. Na+), divalent and trivalent cations (e.g. Ca2+ and La3+) changed the surface charges of SNPs much more efficiently, causing the CCC of the SNPs to be smaller in the presence of NOM.

Keywords：*Soil nanoparticles; Stability; Natural organic matter; Critical coagulation concentration*

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[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Bioremediation of Hydrocarbon Contaminated Soil Via Plant-Microbe Interactions and Compost

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Petroleum contamination is an environmental threat to all life forms including human and crop plants. Plants grown in such type of soils are often subjected to physiological stress, subsequently growth and yield is negatively affected. Use of beneficial bacteria in the contaminated soil is supposed to be a strategy to cope with the harmful effects of hydrocarbon contamination on crop plants. Present study was focused to evaluate the potential of bacteria and compost in this regard. The pearl millet crop was grown on an artificially contaminated soil with kerosene and diesel using eight different levels, i.e. T1 (control), T2 (0.5% contamination), T3 (1% contamination), T4 (inoculation), T5 (0.5% contamination + inoculation), T6 (1% contamination+ inoculation), T7 (compost and inoculation), T8 (compost + 0.5% contamination + inoculation). Three parameters including agronomic, yield, and physiological along with chemical parameterswere studied. The contamination showed an overall negative impact on growth, yield and physiology of the pearl millet (T3). Interestingly, significant positive impact was shown when compost and bacterial inoculum was added to the contaminated soil either in combination or alone (T5, T6, and T7).The best growth and yield responses were observed when soil was amended with compost and bacterial inoculum in combination (T7). The present study will lead us to develop a cost effective technology for agricultural practices in hydrocarbon contaminated soils.

Keywords：*Hydrocarbons, bioremediation, soil inoculation, soil type*

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[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Properties of the Mineral Matrix as a Basis for Interphase Interactions in Soil and Soil Macroproperties

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The soil matrix is an arena on which all interactions in soil take place. Soil matrix organizes the adsorptive layer from ions complex, adsorptive water, the organic matter and the microorganisms and immobilizated enzymes around itself. Matrix size is evaluated as common surface of soil. Need of matrix allocation in the soil is caused by the following reasons. First, not all soil weight participates is active in interactions with a plant, water, air, microorganisms, only their surface. Secondly, matrix approach considers all mix of substances in the soil unlike traditional approach with division of soil components on organic, inorganic, aluminosilicates, clay minerals, readily soluble salts, microorganisms, nutritious elements and other. Soil matrix consists of three parts: mineral matrix, organic and organomineral. This surface is heterogeneous in chemical, electrical and power properties. The active centers are the most active elements on matrix which take up 1-25% of the whole matrix. The diversity of active centers and clasters on the soil surface forms the differences compartments. The active centers can be of the acid nature (hydroxyl groups, exchange cations, coordinately non-saturated cations) and basic nature (oxygen, hydroxyl groups, exchange cations), which reflect of the soil conditions and of rock composition. Method of the active centers definition is the programmed thermal desorption of ammonia (the test for the acid centers), carbon dioxide (the test for the main centers). Mineral matrix of Russian soils characterized by acidic properties: in chernozems the number of acid centers is in 3-4 greater than basic ones, in soddy-podzolic soils, the mineral matrix is represented practically only by acid centers. Energy of chemical bonds on these active centers can reach 70-150 kJ/mol. For comparison energy of bond in system “water-mineral matrix' is less 50 kJ/mol.

The feature of soil matrix is to organize matter around itself in defined order. Area of the directly matrix effect is near 100 nm. The main feature of organic matrix is in the capacity to replication itself. As a result of its process is the stability of the common humus content and group composition in soils with similar mineral matrix. The concept of matrix organization of soil allows us to observe the effect of properties of atoms, ions and molecules on formation of more organized elements of the soil structure. Mineral matrix determines the borders in which soil develops. The aggregate stability and stability of the soil profile are determined by the matrix organization. Matrix organization is the main mechanism in the stability of soils as biosphere systems. Matrix properties of the soil can be used in a rizosfer, criminalistics.

Keywords：*soil mineral matrix, acid and basic centers on matrix, mineral matrix as organiser of soil matter*

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[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Total and Extractable Trace Elements in Soil

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Although agriculture is the main economic activity in Sub Saharan Africa, this region still has the highest prevalence of malnutrition in the world. Its per capita food production has also been on the decline for the last two decades. The African soil resource is over utilized and there is little information linking soil quality to food production and nutritional quality. Soil supplies most of the essential elements required for the growth of crop plants. A reduction in the concentration of an essential trace element in soil may result to unhealthy low intake by plants, domestic animals and human beings. This could increase the risk of mineral deficiency related symptoms, diseases and malnutrition, worsening the region's current food and economic situation. In this study total and extractable essential trace element concentrations were investigated in soil samples from small scale farms in the neighborhoods of Nairobi, in Kenya. A set of 64 samples were analyzed for total elemental composition using total X- ray fluorescence spectroscopy (TXRF). Ammonium acetate ethylenediaminetetraacetic acid (AAAc-EDTA) extractable micronutrients were also investigated using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). A decrease with depth was observed in the total concentrations of Mn, Ni, Cu and Zn, while that of Fe increased. Concentrations of Mn, Cu and Ni were within the range of worldwide reported values whereas that of Zn was high compared to these values. The concentration of Fe was also high compared to the values with a mean of
5.61% in the top and 5.83% in the sub soils a characteristic of Nitisols found in eastern Africa. A complaint by farmers of P deficiency could be attributed to the soil acidity which varied from mild to strongly acidic in the studied soils. Total and (AAAc-EDTA) extractable Fe, Mn, Ni, Cu and Zn concentrations and variables affecting their extractability are presented. Variation of these elements in the top (0-20 cm) and sub soils (20-50 cm) are also discussed.

Acknowledgement
International Science Programme (ISP) at Uppsala University, Sweden for funding my stay and research work in Finland and also sample collection in Kenya. The World Agroforestry Centre (ICRAF) in Nairobi Kenya and MTT Agrifood Research in Jokioinen Finland for letting me use their laboratories and access scientific literature.

Keywords：*Micronutrients, Food production, Malnutrition, TXRF, ICP-OES, AAAc-EDTA*

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[C2.5-2] How do Interactions with Organo-Mineral Surfaces Alter the Dynamics and Properties of Microbes and Macromolecules in Soil?

Particles Interaction Forces and their Effects on Soil Aggregates Breakdown

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Soil aggregates profoundly influences soil fertility and environmental problems, and usually improving soil aggregates is the central issue in soil tilth and management. Compared with external forces, indeed, the internal forces of soil, i.e. surface hydration force, electrostatic force and van der Waals force, may play a crucial role in aggregates formation and stability. However, there are few quantitative investigations on those fundamental issues.

In the present study, we firstly calculated electrostatic force, van der Waals force and surface hydration force of soil/clay particles in aqueous solution, and then quantitatively evaluated the effects of the three forces on soil/clay aggregates breakdown by the combination of microscope observation and static sedimentation approaches and finally discussed particles interaction forces on soil aggregates breakdown. The results showed that: For these three forces: (1) with the decrease of electrolyte concentration, the electrostatic repulsive pressure between two adjacent particles in aggregate increased; (2) only Derjaguin-Landau-Verwey-Overbeek (DLVO) forces could not explain soil aggregates breakdown in aqueous solutions; (3) there were strong repulsive pressures-surface hydration force-as the distance between adjacent two particle surfaces was shorter than 1.4 nm approximately. Hydration force together with DLVO forces could properly clarify the process of soil aggregates breakdown. For soil/clay aggregates stability: (1) the aggregates breaking strength was slowly increased with the increase of surface potential (absolute value) when it was respectively lower than 146.4 and 94.1 mV for the soil and montmorillonite; (2) when surface potential was between 146.4 and 207.0 mV for the soil, or between 94.1 and 179.7 mV for the montmorillonite, the aggregates breaking strength was sharply increased with the increase of surface potential; (3) when surface potential was higher than 207.0 mV for the soil and 179.7 mV for montmorillonite, the aggregates breaking strength was again slowly increased with the increase of surface potential. Interestingly, there was critical surface potential in particles interaction pressure and aggregates breakdown. The critical surface potentials were 207.0 and 179.7 mV for the soil and montmorillonite, respectively. For particles interaction forces on soil and clay aggregates breakdown, we found that the surface hydration force played a crucial role in soil aggregates swelling, and without the surface hydration force, a dried aggregate could not be dispersed again even been re-wetted. Quantitative measurements showed that the electrostatic repulsive pressure (pE), however, determined the way of breakdown either in explosion, dispersion or swelling, which further determined the quantity of small soil particles (<2-10 μm) release after breakdown. Specifically, (1) the swelling process was observed even at the lowest surface potentials of 88.1 mV for the soil and 34.9 mV for montmorillonite, respectively; (2) at 0<pE<13 atm and 0<pE<8.4 atm for the soil and the montmorillonite, the released small particles after breakdown were slowly increased with the increase of the electrostatic repulsive pressure; (3) at 13<pE<17.1 atm and 8.4<pE<12.2 atm approximately for the respective soil and montmorillonite, the released small particles after breakdown were sharply increased with the increase of the electrostatic repulsive pressure; (4) at pE>17.1 atm and pE>12.2 atm for the soil and montmorillonite, with the increase of electrostatic repulsive pressure, the released small particles suddenly reached the maximum values.

In conclusion, our study suggested two steps in aggregates breakdown when dried aggregates were re-wetted: (1) separating soil particles in aggregates to a distance of 1.2-1.4 nm between two adjacent particle surfaces by the surface hydration forces (swelling process); (2) breaking soil aggregates in a way of explosion or dispersion under strong or weak electric field conditions. These results allow the macroscopic soil aggregates stability trends to be better understood at the molecule level. The knowledge of strong electric field resulting from soil particles surface may be of great importance to explain the aggregates breakdown and also provides a possible approach to improve soil structure and control the soil erosion by internal measure.

Keywords：*Soil particle interaction; Surface hydration force; Coulomb force; Van der Waals force; Soil aggrega*

P4-140

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil Erosion and Degradation on Agriculture Land in the Northeastern Region of India: Impact of Land Use Change

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The northeastern region of India, with an area of 255 090 km2, is predominantly hilly. Though the region is endowed with rich natural resources of soil, water and vegetation, it has remained economically backward due to gross misuse and mismanagement of these resources. Prevalence of shifting cultivation, the land ownership pattern, heavy precipitation, low accessibility due to hilly terrain, and a lack of proper infrastructure and marketing facilities, are the major socio-economic constraints hindering judicious management of soil resources. The people were small in number, primitive in technology and their needs were extremely limited. Slowly, their number increased and needs multiplied. The rural economy of the region is mainly dependent on shifting cultivation, a practice inducing soil erosion and land degradation. In the past, when the land was in abundance and population sparse, the rotational cycle of shifting cultivation used to be 25 to 30 years and the land used to get enough time for rejuvenation or revival of vegetation cover. The soil fertility was maintained with in-situ burning of vegetation of forests and the production was enough to feed the limited population. However, with increase in population, the rotational cycle has come down to 2 to 10 years and the land does not get enough time for rejuvenation. The soil fertility is on decline as there is limited material to burn and add to the soil. All efforts, including various government sponsored schemes, have almost failed to convince the shifting cultivators to do away with this uneconomical practice. The annual area under shifting cultivation in the region is 3869 km2, whereas total area affected is 14660 km2. Shifting cultivation is not only a set of agricultural practices but implies the whole nexus of people's religious belief, attitude, self image and tribal identity. This kind of inter-connections between different elements and domains of social life restricts the cultivators to leave shifting cultivation. This was mainly because of lack of alternate land use systems for food security and livelihood and to replace shifting cultivation. The farmers have usufructuary rights over land and so they have least interest in its development. The prevalence of free range grazing by animals during winter season is also a cause of soil erosion. Shifting cultivation alone results in deforestation and an annual loss of 88.3 million tonnes of soil and 10620, 370 and 6050 tonnes of available N, P2O5 and K2O, respectively. The heavy annual rainfall of 2500 Mm has caused unabated soil erosion in the hills, and silting of riverbeds and flooding in the plains. About 600 million tonnes of soil is eroded from the region every year, carrying away a nutrients load of 1.4 million tonnes.

A multi-disciplinary study was started in 1983 and is still in progress. It was based on watershed approach for different land use systems viz. livestock based, forestry, agro-forestry, agriculture, agri-horti-silvipastoral, horticulture and shifting cultivation. It is interesting to note that while in shifting cultivation 34.1% of rain water escaped as runoff, it varied from 0.6% to 17.7% in the new land use systems. Maximum of 99.4% of rain water was retained in livestock based land use system, followed by agriculture (99.1%). Mean annual soil loss due to erosion was 36.2 t ha-2 in the shifting cultivation whereas; it was only 0.2 to 2.0 t ha-1 in the new land use systems. These land use systems could be adopted to replace shifting cultivation in the region depending on topography, slope and nearness to the market. The benefit / cost ratio was found to be highest in livestock based land use system (2.1) and lowest in shifting cultivation (0.6). Reduced runoff due to land use change has soil erosion and land degradation in the region.

Keywords：*Soil erosion, degradation, agriculture land, northeastern region of India,land use change*

P4-141

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Modelling Impact of Storm and Catchment Characteristics on Soil Erosion by Water

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Soil erosion is the result of natural processes affected by human impact on soils and landscape. The use of soils by man - in particular for agriculture ? constrains to remove the natural vegetation cover and to replace it by crops. Thus, the protection of soils from the direct impact of wind and water is, at least, temporarily suspended. Accelerated erosion is the inevitable consequence.

Many difficulties are associated with the monitoring and surveying of soil erosion processes. In most cases direct measurements of soil loss are limited to small experimental plots on which the relevant hydraulic conditions of erosion cannot be completely reproduced. For the same reasons, plot measurements cannot be directly transferred to natural slopes or catchments without taking the differing hydraulic conditions into account. For an adequate representation and quantitative estimation of soil erosion and deposition the use of mathematical models is absolutely essential.

A major advantage of such models is to run comparative scenarios by varying selected parameters. This study uses the physically based model EROSION 3D in order to simulate the impact of storm and catchment characteristics independently of each other. For the simulation runs a small catchment (0,7 km2) was chosen located in the East of Germany within the Ore Mountain range. The modeled scenarios cover the variation of the following input parameters: rainfall intensity and duration, wind speed and direction, field crops and management practices. The morphology of the catchment as given by the digital elevation model and the distribution of soils and land use categories (arable land, rangeland, forest land, built-up land) are regarded as invariant.

Results reveal the sensitivity of soil erosion by water with respect to the varied parameters. In contrast to similar sensitivity studies the outcomes of this research are related to a catchment not to a single test plot. As the results show the polymorphic nature of a catchment is a highly decisive factor for water erosion processes. Most notable as well is the simulated impact of wind speed and direction. Up to now this interrelationship is widely unregarded so far. Simulations runs show that wind impact could double the total soil loss of the catchment compared to calm conditions. With respect to field crops and management the computed scenarios confirm existing experimental results. Increased soil losses are linked to intensive mechanical soil tillage in combination with late covering crops like corn, sugar beats etc.

Keywords：*Soil erosion, catchment scale modelling*

P4-142

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Impact of Land Use Change on Soil Erosion and Deposition of the Upper Yom Watershed in Northern Thailand

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The objective of this study was to evaluate the impact of rapidly changing land use on erosion and sedimentation in a mixed land use in the Upper Yom watershed of north Thailand. The research integrates remote sensing, geographic information system and soil erosion modeling approach with land use change detection to quantify the influence of changing land use on soil erosion and deposition risk in the Upper Yom watershed. Three land use maps were generated for a 15-year period (2002 through 2012) at approximately 5-year intervals to assess land use change. Land Change Modeler (LCM) was used to predict future land use in 2022 and the soil loss modeling with RUSLE and sedimentation model were applied to assess the impact on soil erosion and deposition risk. Total deposition from upland crop areas was predicted to increase by a factor of six between 2002 and 2022 based on the projected 2022 land use. Results indicate that this study highlights the interaction of changes in land use with soil erosion and deposition potential. Erosion and deposition risk on a landscape can be quantified by incorporating commonly available biophysical data with geographic information system and remote sensing, which could serve as watershed management tool for the rapid assessment of the effects of environmental change on erosion and deposition risk.

Keywords：*Eroision, Deposition, Land use change, Upper Yom Watershed*

P4-143

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Water Use Efficiency of Legume and Grain Cover Crops

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Groundwater from the Ogallala Aquifer used for irrigation in Kansas is rapidly being depleted. Increasing water use efficiency provides a way to save water in order to increase the length of the life of the aquifer. Winter cover crops are crops grown in Kansas to protect bare soil from blowing. Both legume and grain cover crops are grown, but their water use efficiencies have never been compared. One way to determine water use efficiency is to analyze the carbon isotope ratio of leaves. The number, called the δ13C, represents the difference between the ratio of 13C-12C found in a given sample and the ratio that exists in a standard. The ratio is expressed as a per mill (o/oo) deviation from the standard. In plants with the C3 photosynthetic system, an inverse relationship exists between the carbon isotope ratio and water use efficiency. That is, plants with the least negative value of δ13C (lesser discrimination against 13C) have the highest water use efficiency. This is because stomata of plants with low discrimination keep their stomata more closed, and take up less CO2 and lose less water via transpiration, than plants with high discrimination.

Because no one had determined the water use efficiency of cover crops in Kansas by measuring the carbon isotope ratio, we grew six cover crops and determined their ratios. The crops, all with C3 photosynthesis, were planted in the fall of 2009 and 2010 at three locations in Kansas: Manhattan in the northeastern part of the state; Hutchinson in the central part; and Tribune, in the west. The soil at Manhattan was a complex of a silt-loam and silty-clay loam soil. The soil at Hutchinson was a loam. The soil at Tribune was a silt loam. The six crops were: winter wheat (Triticum aestivum L.), triticale (X Triticosecale; Triticum x Secale), oat (Avena sativa L.), Austrian winter pea (Pisum sativum var. arvense Poir.), red clover (Trifolium pratense L.), and alfalfa (Medicago sativa L.). At Tribune, only pea and wheat were grown. The plants were grown dryland in Manhattan and Hutchinson and irrigated in Tribune. Between October, 2009, and May, 2010, Manhattan received 473 mm of rain; Hutchinson received 362 mm of rain; and Tribune received 304 mm of rain. Between October, 2010, and May, 2011, Manhattan received 362 mm of rain, Hutchinson received 217 mm of rain; and Tribune received 112 mm of rain. Because the crops at Tribune were irrigated, they were never water-stressed. In the spring of 2010 and 2011, a l m2 area of each crop was harvested. Leaves were dried and ground. A sample was taken and placed in 120 cm3 plastic container and submitted to the Stable Isotope Mass Spectrometry Laboratory in the Division of Biology at Kansas State University. The laboratory determined the δ13C of the different crops in 2010 and 2011 and determined the carbon concentration in the leaves in 2011.

In general, for both years and at all three locations, the legumes (pea, red clover, and alfalfa) had a more negative δ13C value than the grains (wheat, triticale, and oat). The differences were especially evident under the irrigated conditions at Tribune. In 2011, the δ13C values for the legumes and grains were -27.80+0.56 and -26.37+0.18 o/oo, respectively. The legumes had more carbon than the grains. In 2011, the average C concentrations in the leaves of the legumes and grains at the three locations were 40.9+0.16% and 31.2+7.5% C, respectively. Because the grains had the least negative δ13C values (least discrimination), the results indicated that grains should be planted to increase the water use efficiency of cover crops in Kansas.

Acknowledgement: We thank Dr. Scott A. Staggenborg, agronomist at Chromatin, Inc., for suggesting that research be done with cover crops.

Keywords：*Cover crops, water use efficiency, groundwater depletion*

P4-144

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Degradation on Agriculture Land Under Local Waterlogging in Steppe Zone

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During the last decades soils in a steppe zone of Russia are characterized by the development of some degradation processes. Special place among them occupies process of expansion of areas of soils periodically saturated with water. The increase of the areas of the locally hydromorphic soils has set the task of comprehensive investigation of change of regimes and properties of chernozems which are exposed intensive humidifying. This process has affected a lot of territories in South of Russia, Moldova and Ukraine. This phenomenon is paradoxial for a steppe zone which is in most cases characterized by insufficient humidifying. Expansion of areas of the locally hydromorphic soils is connected to replacement initial automorphic soils on hydromorphic soils which has a low level of fertility. Presence of water has adverse physical and chemical soil characteristics. The general tendency for all investigated soils was the development of salinization. The significant decrease in quantity of soil carbonates was also observed. Narrowing Ca2 + /Mg2 + ratio in composition of soil carbonates was marked. The secondary soil hydromorphism resulted in insignificant changes in the soil's texture related to some redistribution of the elementary soil particles by the particle size fractions. The physical clay content somewhat increased in the lower part of the soil profiles (in the B2 and BC horizons) at the expense of the clay particles. The bulk density of the waterlogged soils somewhat increased, particularly in the B2 horizon. The regular soil waterlogging worsened the soil's structural status with a decrease in the content of the silt size aggregates and an increase in the content of the coarse blocky aggregates. The mineralogical structure of the locally hydromorphic soils is presented by the same basic groups of minerals, as in the ordinary calcareous. There are differences in the content of the clay minerals. A distinguisher of Hydromorphic Chernozems was significant decrease of the chloride quantity. The humus state of rainfed chernozems affected by local waterlogging was studied. The total humus content in the hydromorphic chernozems increases, as well as the content of fulvic acids, whereas the content of nonhydrolyzable residue (humin) decreases. A significant increase in the portions of the third fractions of humic and fulvic acids is observed. The role of the fine silt and clay fractions in the binding of humic substances increases in the lower horizons of locally hydromorphic soils. The increase in the content of fulvic acids (fulvatization) is mainly due to their predominance in the clay fraction. The latter is specified by the significant narrowing of the Cha-to-Cfa ratio, the lower content of the nonhydrolyzable residue, and the increased content of the clay bound (3rd fraction) fulvic and humic acids. The composition of the humus in the fine silt fraction of the studied soils is characterized by an increased amount of humic acids of the second fraction with a decrease in the relative content of fulvic acids. The soils studied under different duration of waterlogging have shown that these tendencies will increase when waterlogging conditions are continues.

Keywords：*Chernozems, hydromorphic soils, waterlogging, degradation*

P4-145

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

A Land Resources and Management Diagnosis to Up-Scale And Mainstream Sustainable Land Management Interventions

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The article provides guidelines for a step-by-step approach to identify and map rapidly the status and trends of the quality of land resources in a country and to determine the actually applied land management practices, their impacts and effects. This diagnosis, carried out at national, sub-national and local level, serves to identify major human, physical, natural, financial and social bottlenecks and opportunities for enhancing Sustainable Land Management (SLM) adoption. The procedures proposed draw partly on previous work carried out by the World Overview of Conservation Approaches and Technologies (WOCAT) and the Land Degradation Assessment in Drylands project (LADA). The general methodology involves six main steps which are characterized by a number of milestones that require each monitoring and evaluation. The methodology focuses also on sampling along transects and on field surveys in selected rural communities situated in the major land use and land management systems identified at subnational level. A set of standard questionnaires that describe the land resource base, the land management situation and the socio-economic livelihood context is proposed. Feedbacks are assured between the different teams and the different levels of investigation. Finally a decision support approach is developed together with the team, the stakeholders, economists, policy- and legal national experts to resolve the identified bottlenecks for widespread mainstreaming and up-scaling sustainable land management systems in a country.

Keywords：*Sustainable Land Management, land resource assessment, land use and management assessment, land use*

P4-146

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Stepwise Multi-Parameter Optimization - A Multi-Objective Evluation of Apex for Environmental Benefits

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Studies have emphasized the need for optimization of watershed models for multiple objectives and multiple variables such as flow, sediment, and nutrients to evaluate environmental benefits of conservation practices. This can be achieved through automated calibration methods using high speed computers. The objective of the study was to develop and evaluate a cost effective parameter optimization technique for the Agricultural Environmental Policy and eXtender (APEX) model for three adjacent row-crop field-size watersheds in Northeast Missouri, U.S.A.

The data set consisted of runoff, sediment, total nitrogen (TN), and total phosphorus (TP) losses from three adjacent north-facing no-till corn-soybean (Zea mays L.- Glycine max (L.) watersheds (East-1.65 ha, Center-4.44 ha, and West-3.16 ha) at the University of Missouri Greenley Memorial Research Center, Missouri. The watersheds were established with grass waterways (fescue grass [Schedonorus phoenix (Scop.) Holub]) in early 1991 and were monitored for a 6-year calibration period. In 1997, contour upland agroforestry (tree+grass) and grass buffers were established on the Center and West watersheds, respectively.

A manually optimized APEX model was used as the baseline model for the current study. MATLAB (10.7.0) code was developed for the optimization module. The most sensitive model parameters from the parameter file were grouped according to the process they affect: sediment, biological soil properties, TP, and TN, and used consecutively for optimization. Hence the model was optimized step-wisely and progressively for runoff, sediment, TP, and TN outputs. At each parameter group optimization, the model was optimized for all the output variables: runoff, sediment, TP, and TN. Two multi-objective functions comprising of coefficient of determination (r2), slope of regression, and Nash Sutcliff coefficient (NSC), and a global objective function, the Generalized Likelihood Uncertainty Estimation (GLUE) were used for optimization. The stepwise optimization and calibration of the model was carried out based on the Center watershed. The optimized parameter file was used for the model validation using data from the West and East watersheds.

Model performance for runoff was not improved by optimization of runoff parameters; however, it was improved for sediment, TP, and TN simulations. The r2 values for sediment, TP, and TN increased by 0.18, 0.07, and 0.12, respectively. The respective increases in NSC values were 0.02, 0.13, and 0.06. The subsequent optimizations of parameters improved model performance for TP with NSC values increased by 0.11 and 0.20 after soil biological and TP parameter optimizations, respectively. The Pbias values for TP fluctuated and progressively reduced from 33% at baseline to -25% at runoff parameter optimization to -17% at biological activity parameter optimization and to finally 6% after TP parameter optimization.

The objective functions based on combinations and GLUE showed comparable performances. However, the values for optimal parameter combination varied among the different objective functions. The most sensitive parameters for runoff were soil evaporation-plant cover factor, Hargreaves PET equation coefficient, Hargreaves PET equation exponent and SCS curve number

index coefficient. The most sensitive parameter selected by most objective functions for sediment was the Sediment routing exponent. The most sensitive parameter for TP was the soluble phosphorus runoff coefficient and for TN was the nitrate leaching ratio.

The model validation showed significant increases in r2, NSC, and Pbias, except for the Pbias values for sediment of the East watershed. The percent increase in r2 ranged from 5 to 188% for validation with the highest increase for sediment by the West watershed. The r2 of the model validation for TN by West and East watersheds increased by 43% and 26%, respectively. The improvements in r2 values for TP were 12% and 14% for the model validation by West and East watersheds, respectively. The increase in NSC ranged from 2 to 257%. The range of improvement in Pbias values for validation by the optimized model were from 3% to 77% with the highest improvement found for validation by the West watershed for sediment output (from -52.12% to 12.16%, 77% increase). The results of the study demonstrated that proper selection of a limited number of parameters and a set of respective values coupled with stepwise optimization brought significant improvements in parameter optimization and calibration and validation of the model.

Keywords：*claypan, corn-soybean, runoff, sediment, total P*

P4-147

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Nutrient Dynamics In A Riparian Ecosystem in Central Alberta, Canada

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Introduction: Through the significant levels of biodiversity, riparian areas play a key role in maintaining the vitality of terrestrial environments. Riparian areas perform many important functions such as trapping sediments from upland agricultural operations and removal of nitrogen through denitrification. However, there is a considerable uncertainty about the relative importance of mechanisms that influence nutrient removal, storage and transport through riparian zones, particularly in Western Canada.The objective of this study was to develop an understanding of nutrient dynamics in riparian and upland agricultural areas in central Alberta, Canada.

Materials and Methods: The experimental site is located near the Edmonton International Airport (53°18'57" N, 113°36'43" W) on the Whitemud Creek tributary of the North Saskatchewan River. The 30-year (1971-2000) average annual precipitation at the site was 375 mm, with 344 mm occurring from May to September (growing season). The soil at the site is classified as a Black Chernozem in the upland position and a Humic Gleysol in the riparian position according to the Canadian System of Soil Classification. The study site supported different land uses and was parceled into upland (mainly in alfalfa-grass forage production), mid-slope (same as upland), riparian (native shrubs and grasses) and stream bank (mainly native grasses). Soils were sampled along transects that run from the stream bank, the riparian and mid-slope zones to the adjacent upland. Soil properties were determined on composite samples (collected from 3 to 5 spots) by the methods described by Azooz and Arshad (1996) and in Sparks et al. (1996).

Results and Discussion: The data on the particle-size distribution showed that clay and silt contents were higher in the stream bank and riparian zones than in mid-slope and upland soils. This is attributed to transport of finer soil particles from the upland to the riparian zones. Soil bulk density ranged from 0.61 (surface soil) to 1.49 g cm^{-3} (30-40 cm depths).The highest values for hydraulic conductivity were recorded in the riparian zone, reflecting greater macropores linked to luxuriant plant growth.Soil pH ranged from 5.5 (upland areas) to 7.4 (riparian areas). The mean concentration of Ca^{2+} in riparian soil was greater by 51 % and of Mg^{2+} by 72% as compared to upland soils. Such changes were attributed to acidification of upland soils resulting from greater nitrification rates and leaching of nitrates and their subsequent interaction with positively charged cations such as Ca^{2+} and Mg^{2+}. Depletion of these nutrients is known to cause nutrient imbalances and increased mortality of plants. Mean mineral N concentration of samples from stream bank, riparian, mid-slope and upland soils were 33, 25, 24 and 16 mg kg^{-1}, respectively, in May 2007. Compared to upland soils, the P concentration in riparian soil was more than twice as large in each of the 3 years of the study. This P enrichment in the riparian soil can be attributed to transport of P containing sediment from upland to the riparian zone. Total N ranged from 4.9 to 5.5 g kg^{-1} in the upland and from 5.9 to 8.4 g kg^{-1} in riparian soils. Total C showed a similar trend. Higher concentrations of total C and N in riparian and stream bank zones are attributed to greater plant litter input and slower decomposition of organic matter in relatively moist and reduced environmental conditions.Our results can help identify consequences of nutrient and sediment movement in a riparian-upland transect and help develop best management practices to improve soil and water quality in intensively managed agricultural watersheds in the Prairie.

References: Azooz, R.H, and Arshad, MA. 1996. Can. J. Soil Sci. 76:143-152.
Sparks, et. al.,1996. Methods of soil analysis, Part 3, SSSA, Madison, WI, USA

Keywords：*Hydraulic conductivity, Nitrate leaching, and Soil acidification.*

P4-148

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Influence of Earthworms on Soil Erosion and Degradation. a Functional Approach

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At present, there is a large consensus that soil biodiversity has a beneficial influence on ecosystem functioning and the provision of ecosystem services. Thus increasing biodiversity in ecosystems is seen as a promising approach for improving their sustainability, conserving or restoring soil quality, and mitigating climate change. However, caution should be employed regarding simplistic statements about the importance of diversity or conversely, its redundancy. Using examples from experiments carried out in Northern Vietnam, we show that earthworms might play a more important role through the biostructures they create than their own abundance or diversity. We also show that the beneficial influence of earthworms on soil erosion and ecosystem services in the tropics is not a uniform phenomenon, but depend on the species and environmental context being considered. Some species produce long lasting structures (i.e., stable globular casts and permanent galleries open on the surface) that resist to water and increase water infiltration. Other species produce unstable casts and temporary galleries that are rapidly fragmented. These biostructures increase soil compaction, water runoff and soil erosion. Finally, this presentation clearly stresses that a better understanding of the ecological requirements of earthworms, their distribution, interactions and influence on energy flow is an essential, but nontrivial task for the assessment and sustainable management of ecosystems.

Keywords：*earthworms; erosion; soil aggregation; functional classification*

P4-149

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Assessing Soil Erosion in a Southeastern Brazilian Agricultural and Pasture Field Using Fallout 210pbex

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The subcathment of Barro Branco in Sao Jose the Uba region on northwestern Rio de Janeiro state has experienced on the last three centuries severe land use changes, where the original rainforest has been continuously replaced by farming activities. Agriculture and pasture fields are common, in consequence, there is highly degraded hillslopes, where the combination of intense farming, steep slopes, erodible soils, sparse vegetation, fires and downhill soil ploughing favored the increase of surface runoff and soil erosion (sheet wash, rilling and gullying), causing a significant decrease in soil productivity, especially in the last few decades. In this study, we assessed the effects on soil erosion using a almost not use technique in Brazil, such as measurement of fallout 210Pbex (a convex-concave 160 m long transect along an abandoned agriculture field from the flat top to the bottom of the hillslope). One hundred ninety bulk core samples were taken to a depth of 50 cm, with 5 cm intervals, on pits with 24 m of separation vertically. The initial results suggest that at the upper and mid-portions of the hillslope, most of the 210Pbex is concentrated in the first 20 cm of the soil profile, while at the bottom of the hillslope it is concentrated in the first 30 cm of the profile. Besides, at the mid-portions, the inventories of 210Pbex are about 18% smaller than the ones measured at the flat top of the hillslope, suggesting intense soil erosion during the last 100 years. On the other way, sediment deposition is suggested by and increment of the 210Pbex inventories (about 30% greater than the flat top) at the bottom of the hillslope (concave portion).

Keywords：*210Pbex, soil erosion, Agricultural landscapes*

P4-150

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Evaluation of Mechanical Transplanter in Unpuddled Transplanting of Wet Season Rice in Sandy Loam Soil

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Alternate to puddling, unpuddled transplanting is a new concept of rice cultivation. This experiment was conducted to evaluate the performance of mechanical rice transplanter in unpuddled condition under minimum tillage practices in drought prone zone representing sandy loam soil in wet season 2012. Tillage treatments were (i) conventional puddling (CT) in puddled condition and (ii) no tillage (NT) (iii) bed planting (BP) (iv) and strip tillage (ST) in unpuddled condition. Results indicated that unpuddled transplanting saved fuel, time and labour remarkably in land preparation. Mechanical transplanting reduced drudgery of the farmers and ensured timely operation. Transplanting time was higher in unpuddled plot than puddled. Floating hill was also higher in unpuddled plot due to increase in soil hardness and unable to provide proper anchorage and gripping force to seedlings. Grain yield of unpuddled transplanting was similar to puddled transplanting. Water productivity was the lowest in unpuddled than puddled transplanting. Input cost was higher in conventional puddling than unpuddled transplanting. Mechanical transplanting overcome the constraints of manual transplanting in unpuddled condition. It might be an effective technology in rice production with limited seedling floating (10-15%) in sandy loam soil.

Keywords：*Wet season rice, bed planting, strip tillage, unpuddled transplnting, floating hill, yield*

P4-151

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Exploring Field-Scale Linkages between Accelerated Soil Erosion and Nematode Assemblages Using 137cs Soil Loss Quantification and Molecular Community Characterisation

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Elevated rates of soil erosion and sediment transport are common in arable agro-ecosystems. These detrimental processes affect on-farm productivity through physical and chemical degradation of the soil and off-farm impacts resulting from the delivery of sediment-associated nutrients and contaminants to the downstream channel network. However, fundamental knowledge-gaps remain in our understanding of the biophysical significance of erosion and sedimentation in terms of redistribution of soil organisms over different scales. We hypothesise that erosion is important in two ways, firstly by direct physical entrainment, transport and re-deposition, and secondly by the indirect effects of habitat changes exemplified by depletion of nutrients and carbon at eroding sites in contrast to their enrichment at depositional sites. This study, based in north eastern Scotland, explored the medium-term (~ 50 years) linkages between soil erosion on soil biota by combining radiometric (137Cs) erosion-tracing techniques with novel molecular identification techniques. The 137Cs technique permits modelling of soil loss/gain, which combined with detailed topographic and soil quality data, provides new insights into the physico-chemical controls underlying variations in nematode assemblages and functions at the field scale. This study, coupled with plot and catchment-scale investigations seeks to shed new light on the complex and multiple links between erosion and wider ecosystem services within agricultural landscapes.

Keywords：*Soil erosion; Biodiversity; Agriculture; Agroecosystems*

P4-152

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil Erosion Risk Assessment Using Remote Sensing and Gis Techniques : Indian Scenario

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Soil erosion by water occurs through out the world, especially more in the humid / sub-humid mountainous region. It is the process of detachment or entrainment, transportation of surface soil particles from original location and accumulation of it to new depositional area. Various human activities disturb the land surface of the earth, and thereby induce the significant alteration of natural erosion rates. Soil erosion by running water has been recognized as the most severe hazard threatening the protection of soil as it reduces soil

productivity by removing the most fertile topsoil. In the world map on the status of human-induced soil degradation (UNEP/ISRIC, 990), it is accounted that loss of topsoil and terrain deformation due to soil erosion are the consequence of deforestation, removal of natural vegetation and overgrazing in the mountainous regions, Soil erosion is a global environmental crisis in the world today that threatens natural environment and also the agriculture. Accelerated soil erosion has adverse economic and environmental impacts. It creates on-site and off-site effects on productivity due to decline in land/soil quality.The current rate of agricultural land degradation world-wide by soil erosion and other factors is leading to an irreparable loss in productivity on about 6 million hectare of fertile land a year .Asia has the highest soil erosion rate of 74 ton/acre/yr and Asian rivers contribute about 80 % per cent of the total sediments delivered to the world oceans and amongst these Himalayan rivers are the major contributors. It is articulated that the Himalayan and Tibetan regions although covers only about 5% of the earth's land surface, but supply around 25% of the dissolved load to the world oceans. In India about 5334 Mt 2 (16.4 ton/hectare) of soil is detached annually, about 29% is carried away by the rivers into the sea and 10% is deposited in reservoirs resulting in the considerable loss of the storage capacity. In India it is estimated that about 38 % out of a total reported geographical area, that is about 127 million hectare are subjected to serious soil erosion. Remote Sensing (RS) & Geographic Information System (GIS) have emerged as a powerful tools for handling spatial and non-spatial geo-referenced data for preparation and visualization of input and output, and for interaction with models. There is considerable potential for the use of RS & GIS technology as an aid to the soil erosion inventory with reference to soil erosion modeling and erosion risk assessment. A GIS can be used to scale up to regional levels and to quantify the differences in soil loss estimates produced by different scales of soil mapping used as a data layer in the model. The integrated use of remote sensing and GIS could help to assess quantitative soil loss at various scales and also to identify areas that are at potential risk of soil erosion. The present paper attempts to bring out the Indian scenario of the soil erosion status using RS & GIS tools. This study will form as a base line date for the future course of action for decision makers and other Bodies.

Keywords：*Soil Erosion , Productivity, Remote Sensing , Geographical Information System*

P4-153

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Antioxidant System and Chlorophyll Fluorescence in Argania Spinosa under Drought Stress

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Four ecotypes of Argania spinosa L. Skell (2 coastal ecotypes (Adm and Rab) and 2 paralittorale ecotypes (Alz and Lks) were subjected to moderate and severe water stress during 2 months to test the drought effects on photochemical and non-photochemical chlorophyll fluorescence quenching mechanisms and on antioxidant capacity of ascorbate-glutathione cycle. Under drought stress conditions, particularly under severe water stress, we recorded a decrease in the maximum efficiency of PSII, the intrinsic efficiency of open PSII, the coefficient of photochemical quenching and the quantum yield of PSII electron transport, compared to control ($P < 0.001$). However, water stress induced a significant increase in the coefficient of non-photochemical quenching. Thus, drought stress significantly increased the activity of the four enzymes involved in ascorbate-glutathione cycle (APX, MDHAR, DHAR and GR) ($P < 0.001$). These parameters studied in the leaves of plants stressed were increased significantly in a time-dependent manner ($P < 0.001$). The ecotype effect was significant for all these parameters ($P < 0.001$). The effects of the interactions between the factors fixed (Watering regime, ecotype and time) were tested by the two-way ANOVA. Moreover, significant correlations between these parameters were recorded. The four ecotypes studied were separated by two discriminant functions obtained by canonical discriminant analysis.

Keywords：*Argania spinosa, Drought stress, Chlorophyll fluorescence, Ascorbate-Glutathione cycle enzymes*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Erosion Characteristics of Steep-Slope Colluvial Deposits in Gully under Different Rainfall Intensity and Slope Gradient Conditions, South-East China

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Gully erosion in south-east China consists of colluvial deposits with high erosivity, they can lead to easy rainfall splash or runoff scouring. This study aimed to analyze the erosion characteristics of the colluvial deposits under different simulated rainfall and slope conditions. Rainfall intensity ranged from 1.00-2.33 mm min-1 and slope gradient from 36.40-83.91%. Infiltration, runoff and soil loss were monitored during rainfall. Infiltration rates were sharp decline in the initial stage, while an opposite trend was obtained for runoff rates, and then they reached to steady state. Unimodal peak and multiple peak models were the two types of changes in sediment yield process; and the unimodal yield was observed during the early stage of rainfall; whereas, the multimodal yield appeared during the middle and later stages of rainfall. Infiltration increased with increasing rainfall intensity and decreased with increasing slope gradient. Runoff and sediment yield increased with increasing rainfall intensity, but they had a critical slope gradient of erosion in the range of ~ 57.74% and > 46.63%, respectively. The sediment concentration increased with increasing rainfall intensity, while there were differences in the sediment content changing with increasing slope under different rainfall intensities. The average runoff rate exhibited an exponential function relationship with the average sediment yield rate and a power function with the sediment concentration. Average sediment concentration had a linear function relationship with the average sediment yield rate. The infiltration, runoff, sediment yield and sediment content of colluvial deposits could be well forecasted using rainfall intensity and slope parameters.

Keywords：*Colluvial deposits; Gully erosion; Rainfall intensity; Soil erosion; Steep-slope*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Determination Central Iran Soil Degradation Rate by Creating Multivariable Soil Degradation Index

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Soil degradation is a serious global environmental problem and may be exacerbated by climate change . it cause loss of organic matter, decline in soil fertility , decline in structural condition, erosion, adverse changes in salinity, acidity or alkalinity, and the effects of toxic chemicals, pollutants or excessive flooding, so finding different pattern to identify and monitoring soil degradation can be important pathway to combat this phenomena. In current study to identify central iran soil degradation rate we use multiple variable method to create soil degradation index. 120 soil sample were analyzed to determine their EC and pH , it considered that if EC is more than 4 ds/m the sample get 0 as bad index and if EC is less than 4 the sample get 1as a good index . also for pH if the amount of pH is more than 7.5 soil sample get zero index ,for less than 7.5 soil sample get 1 index. Finally we calculate the average of 120 index to determine the rate of soil degradation in study area . it's found that the average of soil degradation index in whole study area is 0.36 this its means that there is high rate of soil degradation in the region so there is need to identify different phenomena that caused to soil degradation and combat them to achieve sustainable management for the soil

Keywords：*soil degradation , multivariable soil index, degradation index*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Dynamic Development of Rill Erosion on Loess Slopes and its Simulation with Cellular

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Most soil erosion models are essentially steady-state models. Thus, they have limitations in real-time simulations of soil erosion. Cellular Automata (CA), with a 'from down to up' dynamic modeling framework, is capable of simulating the spatial-temporal evolutionary process of complex geographical systems. Here, the critical conditions for rill erosion were determined through laboratory experiments and through a one-dimensional numerical simulation (CA-rill model). Rill erosion on a loess slope of 15o under multiple rainfall events was investigated in indoor experiments with artificial precipitation. The development of rill erosion was presented graphically with a 3-D laser scanner. Slope rill erosion was also simulated with an existing model of CA-Rill under the same conditions.

The simulated and measured values of total runoff were not significantly different (paired t test, $p=0.753>0.05$), but there existed significant difference for total erosion (paired t test, $p=0.032<0.05$). In addition, the model was able to simulate the changes in runoff processes during each precipitation event well, but the simulation results of sediment yield were poor. The 3-D scanner indicated that rill erosion is a process of steady growth and continuous strengthening. The entire development can be represented as the following steps: splash erosion, sheet erosion, drop pit, erosion caves, intermittent rills, and rill network. These were accompanied by the phenomena of gully head deep-cutting, head erosion, and gully-wall collapsing. The simulated morphological rill developments were compared to the 3-D laser scans. The model simulated the whole process but was not ideal for erosion parameters. Compared with the measured parameter values, the simulated ones were relatively good for planar rill density (paired t test, $p=0.967>0.05$) and maximum rill length (paired t test, $p=0.079>0.05$). For average rill depth, maximum rill depth, and average width of the longest rills, there were significant differences (paired t test, $p<0.05$), indicating poor simulation.

Keywords：*Rill erosion process; CA-Rill model; Runoff and sediment yield; Dynamic*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil Hydrological Properties as a Response to Tillage Erosion in a Regosol of Hilly Landscapes

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Two or more processes of soil erosion simultaneously exist in a hillslope landscape, and those processes may interact with each other. Yet, how one process impacts another one remains unresolved. Five slopes were selected from hilly areas of the Sichuan Basin, China to explore the mechanism of tillage erosion impacts on water erosion. On those slopes, soil hydrological properties with reference to water erosion were examined in different landscape positions with discrepant intensities of tillage erosion. The Cs-137 data showed that the most severe erosion occurred in upper slope positions, and there was a decreasing pattern of soil erosion from upper, middle, to lower slope positions. Tillage erosion ranging from 80 to 125 t ha^{-1} yr^{-1} mostly contributed to total soil loss in upper slope positions. Contrarily, substantial soil deposition by tillage with deposition rates of -67 to -120 t ha^{-1} yr^{-1} was present in lower slope positions, whereas only slight erosion or deposition occurred, with rates of -12 to 4 t ha^{-1} yr^{-1} in middle slope positions. The drastic differences in total soil depth were observed among different landscape positions, averagely being 17, 28, and 39 cm deep for upper, middle, and lower slope positions, largely due to tillage erosion. Soil water storage capacity (SWSC) at saturation exhibited remarkable differences among different landscape positions as a result of substantial variations in total soil depth. The lowest steady-state infiltration rates were found in tillage-eroded areas (upper slopes) with a mean of 1.01 mm min^{-1}, followed by deposited areas (lower slope) with a mean of 1.67 mm min^{-1}, while the largest steady-state infiltration rates were observed in the balanced areas between soil loss and gain (middle slope) with a mean of 2.00 mm min^{-1}. Thickness of soil profiles and local slope gradients were found to be two important determinants of soil infiltrability. It is suggested that soil degradation by tillage erosion alters soil hydrological properties, thereby resulting in poor soil infiltrability which may enhance overland water flow in relation to water erosion.

Keywords：*Soil hydrological property; soil infiltrability; soil water storage capacity; tillage erosion;, landscape position; steep slope*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Evaluating Agricultural Sustainability in Tropical Watersheds: An Integrated Geographical Approach

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A framework for evaluating agricultural sustainability in tropical watersheds was established using spatial multi-criteria analysis. This GIS-based decision support system was able to integrate localised sustainability indicators and reflect the vulnerability of the watershed's resources to land degradation processes. The derived spatial sustainability indices may now be able to support design of alternatives towards interventions for long-term productivity that could ensure food security to the community while at the same time preserving the environment.

The high poverty incidence among staple crop farmers and persistent low productivity that could barely support the needs of the growing population within the province motivated a watershed-scale approach in investigating for enhanced sustainable farming practices that could help address the pressing concerns in the locality. The overall contribution of this study has been to evaluate the degree of agricultural sustainability and map out alternatives or options for long-term sustainability, best utilising the watershed's limited resources. An integral component was the selection and identification of applicable sustainability indicators that could locate vulnerable areas when aggregated in a flexible and intuitive decision support framework. The integration of derived indicators was carried out to allow calculation of sustainability indices in a geographical manner.

An operationalisation for a case and site specific meaning of agricultural sustainability and its breakdown into functional units was key to the establishment of localised sustainability indicators. A systems approach was employed for a holistic description of what would constitute agricultural sustainability for the particular watershed as perceived by the local stakeholders. Achievable sustainable management options that could be implemented for the existing farming systems were then generalised to reflect the long-term sustainability goals which essentially became the operational components of agricultural sustainability. The localised definition, as a result of the systems analysis, describes agricultural sustainability as determined by an appropriate combination of cropping systems employing suitable erosion and runoff interventions to help preserve soil and water resources while sustaining agricultural productivity and consequently ensuring at least subsistence food security and financial income for farmers.

Soil erosion and runoff were identified as the main factors of land degradation affecting the study area of the upper Inabanga watershed in Bohol, Philippines. High runoff and soil loss were pronounced over the watershed, especially in extensively cultivated areas of corn and cassava. Mapping the spatial extent of probable risks to high erosion and runoff as well as incorporating other vital contributing factors constituted the most important collective indicator for agricultural sustainability evaluation. Available agro-socioeconomic parameters associated with the likelihood of communities to overexploitation of resources and inappropriate farming practices were also considered a critical indicator group that contributed to the deterioration of the environment. For water

resources, the rapid decline in hydrologic conditions of a gauged sub-watershed, which were found comparable with other ungauged sub-watersheds, exhibited trends towards unsustainability if not mitigated immediately. And importantly, information extracted from a multi-temporal analysis of remotely sensed imageries indicating changes in land use conditions over time revealed a range of human activities that could have significant impacts on susceptibility to environmental degradation.

The integration of all identified sustainability indicators enabled development of a comprehensive and powerful decision support tool for sustainable management of an agriculture dependent tropical watershed. The logical structure for the aggregation and hierarchies of the input indicators was organised in a user-defined criteria tree addressing a goal of locating vulnerable areas to land degradation processes. The entire procedure involved standardisation and assigning of weights to each input parameter prior to a weighted summation technique in the calculation of the resulting composite index map. The process was facilitated through utilisation of a GIS application termed 'Spatial Multi-Criteria Evaluation'. The data driven approach in setting up the sustainability criteria and the exercise of value judgement rendered this framework more flexible for problem-solving and decision-making. The derived spatial sustainability indices illustrated varying degrees of vulnerability which could then be applied in prioritisation for the application of sustainability interventions. Strategies for employing site specific conservation measures particularly for dealing with high runoff and soil loss in cultivated areas were also developed and identified through scenario simulations of suitable input parameters for the spatial multi-criteria analysis.

Keywords：*soil erosion, runoff, land degradation, sustainability indicators, GIS-based decision support system, spatial multi-criteria analysis*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

How the Ridge and Furrow System Mulched with Plastic Film Affects the Transport of Soil Water, Heat and Nitrate in Drylands?

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Nitrate leaching in drylands has led to nitrate accumulation in deep soil layer in loess area, which not only reduces Nitrogen use efficiency, but also shows the negative effects on environment. Plastic film mulching as a cultivation method, has played an important role in improving food production in this drylands area due to the changes of soil water and heat. However, the transport process of nitrate under plastic film mulch is poorly understood. To investigate the effects of plastic film mulching on the transport processes of soil water, heat and nitrate, we measured the soil water content, soil temperature, and soil nitrate concentrations in 10, 30, 60, 100, and 160 cm soil layers in two treatments (the ridge mulched with plastic film and the furrow grew with maize system, RFS, and the flat without plastic film mulching, Control) during the maize growing season (1 May to 1 October, 2013). The water content and soil temperature were measured at 10 min interval, using the soil profile moisture and temperature monitoring instruments (EM50). The nitrate concentrations in soil were measured at 10 days interval by analyzing soil collected using soil auger; and the nitrate concentration in soil water were measured during rainfall by analyzing the soil water collected using ceramic tubiform soil solution collectors (SMS100).

The results showed that the RFS treatment significantly improved the soil water content in 0-160cm soil profile during maize growing season, 33% higher than control treatment on average. The daily evapotranspiration during maize growing season are 2.14 and 2.92mm for RFS and Control, respectively. The coefficients of variation for mean soil water content in 60 and 100 cm layers were lower in RFS treatment (9.7%-10.5%) than that in Control (19.7%-28.2%), suggesting that the RFS treatment had large potential to keep water in 60-100 cm soil layers. The horizontal transport of water occurred from furrow to ridge in 0-60cm soil layer during rainfall. The mean temperature and the coefficients of variation all decreased with soil depth in both treatments. The temperature in top soil layer (10 cm) had larger coefficients of variation and showed significant difference among ridge-RFS (22.6℃), furrow-RFS (21℃) and Control (21.4℃). The ridge-RFS had higher temperature in each layer than furrow-RFS and Control. The nitrate concentrations both in soil and soil water were larger in ridge-RFS than furrow-RFS, probably because the higher temperature caused the higher nitrification rate or the horizontal transport of nitrate from furrow to ridge with water. The peaks of nitrate concentrations in soil profile moved from top to deep soil layer after several rainfalls in RFS and Control. When maize harvest, the peaks of nitrate concentration occurred at 160 cm and 100 cm depth soil layers for RFS and Control. Those results indicated that the RFS treatment could increase the water storage, reduce the evapotranspiration, and increase the soil temperature; however it could enhance the nitrate leaching and accumulation in deep soil layer. Although the RFS treatment as a cultivation method is largely applied on Loess Plateau, the evaluation should not only consider the food production, but also the environment influence.

Keywords：*soil water content, temperature, nitrate, coupling transport of soil water, heat and nitrate*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Degraded Soils of the Savannah Ecology of South Western Nigeria: Extent, Characterization and Evaluation

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Soil degradation is a very serious land resources management issue in sustainable agriculture. It may be slow and gradual, but may be very difficult to control once it occurs. Degradation may occur naturally or may be as a result of land use by man. One of the natural processes of degradation aided by man activities is plinthization. Soils with hardened plinthite are some of the major problematic soils of the world. There are no good estimates of the area occupied by such soils under cultivation in Nigeria. Regretfully, these soils have not received much research attention despite the FAO estimates of over 20 million ha of such soil. A semi-detailed soil survey was carried out in the Savannah ecology of south western Nigeria to determine the extent, characterize and assess the potentials of these soils. 913,000 ha (35%) of the area surveyed were occupied by soils with hardened plinthite, of these, 410,000 ha (16%) were occupied by petroferric contact soils and 503,000 ha (29%) were occupied by petroplinthitic soils. The thickness of the pan varies from 30 to 130 cm, where pan can be dug out. The soils over pan are sandy to sandy clay loam, while the soils under pan are sandy clay to clay. Pedologically the formation of petroferric contact and petroplinthite can be attributed to continental geological uplift and peneplanation. Also, alternate wetting and drying encouraged by climate and degradative activities such as annual bush burning, cultivation and over grazing are other factors. Due to population and socio-economic pressures, these soils are increasingly coming under cultivation. The challenge of the future use by farmers in this region is to develop appropriate sustainable land management options. The available options are discussed in this paper.

Keywords：*Soil degradation; Savannah ecology; Plinthite; Sustainable land management*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Impact of Soil Degradation and Climate Change on the Dry Zone Agriculture Land: Challenge to Food Security in India

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Protection of soil and sustainable management of land are challenging issues in developing countries like India with a fast rising population, large-scale environmental degradation, and inadequate environmental protection measures. Controlling soil degradation is important in achieving food security and poverty alleviation. Indian economy has been traditionally dependent on agriculture and life of more than half of the population, especially the rural poor is some way related to agriculture. Most of the land area in the country shows evidence of degradation, and the falling soil fertility affects the productive resource base of the economy. Out of the total geographical area of 329 million hectares, 175 million hectares are considered degraded. Arid and semiarid agricultural area comprises a large share of this. Rainfall is becoming highly seasonal and intense. Long gap in rainfall reduces soil moisture and makes the soil drier. Drylands are potentially threatened by desertification. Extreme hydrological conditions together with anthropogenic activities erode soil in the hilly regions. In such regions, landslides and floods reduce the area of cultivable land. Intensive agriculture and unscientific irrigation leads to water logging, soil salinization and alkanization in farms. Waste outflow from urban centres and domestic areas, salinity intrusion due to groundwater overdraft in the coastal zones, overgrazing, deforestation, industrial development etc. result in widespread degradation of rich soil. In the arid western zone of India, wind erosion increases desertification, whereas in the plains, erosion due to floods and eutrophication due to agricultural runoff are evident. The agricultural revolution made India self-sufficient in food, but resulted in losing fertility of rich farming lands and contaminated the soil and water. Sand quarrying and landfilling of wetlands and paddy fields for industrial and residential purposes add to the already shrinking agricultural area. Feeding the increasing population is a real challenge and soil protection and efficient land management has a key role to do in it. Unfortunately, the administrative and legal measures for resources protection fail because of because of various social, political and economic reasons. Present study is a comprehensive analysis of the issues associated with soil degradation and sustainable land management in the drier zones of India under a changing climate and environment. A critical review of current policies and management practices has been made. Suggestions for better management and adaptation have been provided.

Keywords：*soil degradation, India, agriculture, climate change, management, policy*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil Erosion Estimation Using Morgan-Morgan-Finney Model in Gis Environment in Northern Ethiopia Catchment

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Tools for understanding the spatial distribution of erosion influencing parameters using Geographical Information System (GIS) is necessary for erosion modelling and designing sustainable technologies against its impact as soil degradation. Despite this fact, little is documented in the application of GIS technique in developing spatial data for Morgan-Morgan-Finney (MMF) erosion model in many developing countries such as Ethiopia. The aim of this study was to derive and assess spatial distribution of hydro-physical parameters and apply in the MMF model for estimating soil erosion in the Mai-Negus catchment, northern Ethiopia. Major data input for MMF model include climate, topography, land use, and soil related data which collected from field and laboratory, empirical relations and literature review. Geo-statistical technique was also used in developing model inputs. The model was applied in GIS environment for estimating erosion. This study demonstrated the usefulness of GIS in developing and managing spatially distributed erosion influencing factors and the resultant variability in erosion for decision-making process. The rate of total soil detachment (F+H) varied from less than 20 t ha-1 y-1 to higher than 170 t ha-1 y-1 in the catchment, whereas the soil transport capacity of overland flow (TC) ranged from less than 5 t ha-1 y-1 to higher than 42 t ha-1 y-1. The average soil loss estimated by MMF model at catchment level was 26 t ha-1 y-1. In the catchment (> 80%), the model predicted soil loss rates higher than the maximum tolerable rate (18 t ha-1 y-1) estimated for Ethiopia. Hence, introducing appropriate interventions based on the erosion severity in the catchment landscape predicted by MMF model is crucial for sustainable resources management.

Keywords：*Hydro-physical parameters; Spatial variability; MMF model; Soil erosion; Soil transport capacity; So*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Changes in Selected Soil Properties and Top Soil Depth Under Contrasting Watershed Management Practices in Southeastern Nigeria

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Over 50% of the land mass of Anambra State in Southeastern Nigeria is threatened by various forms of water erosion and other soil degradational forces. Most of these hazards can be attributed to the nature and management of watersheds in the area. Studies were therefore conducted to assess the impact of management practices on the soil physical properties and top soil depth of a typical watershed in the agro-ecological zone. Part of the watershed (MW) is under some kind of management initiated by the state government in 1995 while the adjacent side (UMW) is unmanaged. The managed watershed was characterized by terraces separated by earth bunds and stabilized by permanent trees forming hedge rows. The unmanaged section had none of these installations. Results showed a significant reduction in top soil depth from 8.35cm in the managed watershed to 3.76cm in the unmanaged section. The significant loss in top soil was as a result of accelerated erosion which was evident in the unmanaged section of the watershed. Such loss amounting to 4.95cm of top soil over 26 years is a monumental loss in plant nutrient. Bulk density of the surface soil (0-15cm) increased as a result of lack of management from 1.30 to 1.59 Mg m-3. Similarly, significant reductions were recorded in soil pH, organic C, N, P, and K content of the soil in the unmanaged compared with the managed watershed. The magnitude of changes associated with these watershed management practices constitutes significant limitations to soil productivity and sustainable land use in the region.

Keywords：*watershed, management, soil productivity, bulk density, and soil depth.*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Diemdiem Dam: A Local Way to Fight Againt Land Salinization

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Southern part of Senegalese territory is the one where lands are the most productive. Therefore, with saline water from Atlantic Ocean introduction to the river, a urge part of these lands become saline and no more used for agriculture.

An experiment has been conducted in on of the most productive valley in Seydiou region. The experiment done on 2008 allowed use of the valley for rice production since the Dam built till nowadays. With two Polytechnic school student's thesis the authors demonstrates that clay is more resistant for such operation than lateritic materials, despite its stronger mechanical resistant demonstrated by student .

Keywords：*land, salinization, clay, Lateritie, dam*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Alternative Pasture Species to Reduce Nitrate Leaching Losses from Grazed Pasture Systems

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Nitrate-N (NO3--N) leaching losses from grazed pasture systems can be detrimental to water quality. The main source of NO3--N leaching is animal urine, deposited in high concentrations of nitrogen (N) over small areas during grazing events. Most leaching losses occur from these urine patches during the winter period when soil moisture content is above field capacity, resulting in drainage. Further, typical grassland pastures (e.g. perennial ryegrass/white clover) have slow growth rates during this cool period and therefore take up a relatively small proportion of the deposited N. Very little is known about the use of alternative pasture species in intensively grazed pasture systems to reduce NO3--N leaching losses by capturing greater amounts of soil N during this high risk drainage period. The objective of this research project was to determine the effect of four different pasture species on NO3--N leaching losses from dairy cow urine patches.

Sixteen large undisturbed soil monolith lysimeters (50 cm diameter x 70 cm depth) were collected from a pasture site at Lincoln University Research Dairy Farm (LURDF), Canterbury. The soil was Templeton fine sandy loam (Immature Pallic soil, Udic Ustochrept). The lysimeters were installed into an outdoor facility, and thus, were exposed to natural climatic conditions. The trial was setup as a completely randomised design, with four pasture species treatments consisting of: (i) perennial ryegrass, white clover (P. ryegrass WC); (ii) tall fescue, white clover (T. fescue WC); (iii) Italian ryegrass, white clover (It. ryegrass WC); and (iv) Italian ryegrass, perennial ryegrass, white clover, red clover, chicory, plantain (Diverse). Two litres of fresh dairy cow urine was applied to the lysimeters in late autumn at an N loading rate equivalent to 1000 kg N/ha. Leachate and pasture measurements were made for up to 12 months following urine application. The research trial was repeated for a second season. In season one pastures were recently established (first year pasture). In season two the lysimeters were collected from areas where identical pasture mixes had been established for approximately 12 months (second year pasture).

In season one, NO3--N leaching losses were lowest under It. ryegrass WC at 230 kg NO3--N/ha (25% less than P. ryegrass WC) and highest under T. fescue WC (63% greater than P. ryegrass WC). In season two, NO3--N leaching losses were 24% less from It. ryegrass WC compared to P. ryegrass WC; while differences between the other three pasture species were not significant. Winter dry matter production was highest in It. ryegrass WC (6564 kg DM/ha) and lowest in T. fescue WC (2996 kg DM/ha) in season one. During the season two winter period, It. ryegrass WC produced up to 21% more dry matter than the other pasture species and took up 36 kg N/ha more N than P. ryegrass WC. In conclusion, the higher winter activity of It. ryegrass WC has the ability to reduce NO3--N leaching losses through greater use of soil N during the leaching period. Therefore, strategic use of It. ryegrass WC pasture is a viable mitigation option for intensively grazed pasture systems to reduce NO3--N leaching losses.

Keywords：*Pasture species, nitrate-N leaching, winter activity, N uptake.*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Predicting Rainfall Erosivity and Hillslope Erosion across South-East Australia

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There is considerable spatial and temporal variability in rainfall amount and intensity across South-east Australia (SEA), and the relationship between rainfall and rainfall erosivity may change significantly in a CO2-warmed world due to future climate change. Climate impact assessment and adaptation require quantitative analysis of rainfall impacts on erosivity and soil loss under a changing climate.

Recently, high-resolution (down to 2km) rainfall data from regional climate models (RCMs) has become available for Sydney Region (SR) at sub-daily time steps for two 20-year periods (1990-2009, 2040-2059). The 10km rainfall data from New South Wales (NSW) / Australian Capital Territory (ACT) Regional Climate Modeling (NARClim) will be available soon for the entire SEA area for three 20-year simulations for present (1990-2009) and two future periods (2020-2040, 2060-2080). These climate projections can be used for detailed climate impact assessment and prediction of rainfall erosivity and hillslope erosion for the future periods. Historical and current rainfall data can be used to develop a baseline rainfall erosivity map based on a standardised reference period so that rainfall erosivity at any time can be consistently and quantitatively assessed and compared.

The aims of this study was to provide 1) a baseline rainfall erovisity map in SEA for the standard 30-year climatology (1961-1990), 2) time-series rainfall erosivity maps at monthly and annual interval at a high spatial resolution for all the NARClim simulation periods, and 3) the impact analysis of rainfall on rainfall erosivity and hillslope erosion in current and future periods.

In this study, we developed a suitable rainfall erosivity model to estimate rainfall erosivity values for the baseline, current and future periods using daily rainfall data. We further produced time series hillslope erosion risk maps using the revised universal soil loss equation (RUSLE) for the same periods. Both rainfall erosivity and hillslope erosion products are at monthly and annual intervals, and spatial interpolated into high spatial resolution (100m). We implement these processes in a geographic information system (GIS) using automated scripts so that they are fast and repeatable.

The results show significant spatial and temporal variations of rainfall erosivity and hillslope erosion rate across SEA. Among 38 natural resource management (NRM) regions within SEA, the mean annual rainfall erosivity in coastal NRMs is about 10 times higher than that in the inland NRMs. Rainfall erosivity in summer is about 5 times higher than winter on average. With projected future rainfall increase (about 20-50%), rainfall erosivity and hillslope erosion are expected to increase by about 23-140% if there is no good ground cover protection by 2060. The time series high resolution rainfall erosivity and hillslope erosion maps can provide detailed information for climate impact assessment and adaptation, and cost-effective means for hillslope erosion hazard identification and rehabilitation, such as setting minimum ground cover targets for high erosion hazard areas.

Model performance is measured by the coefficient of efficiency (Ec) and regression analysis. Our prediction of rainfall erosivity shows relatively good correlation with point-based pluviograph calculation and previous studies, both Ec and R2 are greater than 0.90 with an overall bias of 0.99. There is also good agreement among the modelled rainfall erosivity values from the three different data sources (Bureau of Meteorology, NARCLim 2km and 10km data).

This study has demonstrated an appropriate approach for modelling and predicting time-series rainfall erosivity and erosion risk over SEA. With the automated GIS process developed in this study, the erosivity and erosion modelling can be readily upgraded when better rainfall data and models become available.

This paper outlines the methods and procedures used to produce the time series rainfall erosivity and erosion maps for SEA. The GIS implementation and the impact assessment of rainfall on erosivity and hillslope erosion are discussed. The paper also recommends immediate further research directions.

Keywords：*Rainfall erosivity, hillslope erosion, RUSLE, climate impact, South-east Australia, GIS.*

P4-167

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Intrasoil Ice Sheet as a Factor of Forming Snowmelt Runoff on the Western Siberia, Russia

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Soil erosion is a major worldwide environmental problem. In Russia, the soil erosion losses from arable slopes are 560 million tons yearly. Most of the erosion-prone lands in Russia are concentrated in Asian part, mainly in southeastern Western Siberia, where the main types of soil are Chernozems and Phaeozems. The water erosion intensity depends on a variety of factors, the most important are: slope gradient, utilization type, autumn and winter precipitation, snow cover thickness, and freezing depth. The geomorphological and climatic conditions of Western Siberia are characterized by strong dissection of the relief, large amounts of winter snow, rapid snowmelt processes and the presence of sheet ice that prevents meltwater infiltration. All these factors make the soils in this region extremely vulnerable to erosion. As a result, during the snowmelt period abundant runoff occurs on the slopes that equal approximately 60% of the region arable land.

At the beginning of the cold period, the intrasoil ice sheet, which rests during the spring period, is formed and promotes a development of a surface snowmelt runoff and soil erosion. The autumn and winter precipitation, snow cover thickness, frost penetration depth and the volume of surface runoff were estimated in Predsalairye (the south-east of Western Siberia, Russia). The study was carried out on chernozem-type soils during different hydrological years. The hydrothermal regime for arable and virgin soils was determined. The water content of the snow varied from 65 mm under very low-snow conditions to 255 mm in extremely high-snow winters from 1969 to 2012. The greatest frost depth of Chernozems in Predsalairye was observed in high-snow years. Capacity of the frozen soil depth in these years was almost 50 cm more than in very low-snow years when there is a minimum of snow cover. The reason for the formation of a thick frozen soil depth in high-snow years was the scanty quantity of an precipitation in the beginning of the cold period (November – December) and if the soil profile was dry since autumn, then that allowed negative temperatures to penetrate into the soil. The snowfall covering Chernozems at the end of December and in January did not provide protection, and negative temperatures could penetrate the entire soil profile down to the parent material.

Snow melt, as a rule, begins in the first part of April. When the daily air temperatures becomes positive, there is a fast thawing of snow with the big water return and intensive snowmelt runoff, especially on southern exposed slopes. Simultaneously with the thawing of the surface soil, the surface soil became humid, and water moved into the soil profile. Because the air temperatures weren't yet high enough, only the top soil layer warmed. The layer of frozen soil (with temperature from 0 to -2°C), the so-called intrasoil ice sheet, interfered with the advancement of positive temperatures and water penetrated further into the soil profile. On the hillside surfaces, snowmelt waters saturated the thawed layer of soil, and then the surplus water moved downhill, forming intrasoil and superficial runoff. Our study established that during 1999–2012, the intrasoil ice sheet was located in chernozems at a depth of 20 – 60 cm, regardless of the type of spring weather. The presence of the intrasoil ice sheet was also confirmed by the soil humidity data during the snowmelt period. Under the influence of warm snowmelt waters and solar radiation on the sites where soil was released from snow on day 3 or 4 of the snowmelt period, the frozen screen starts to collapse. At this time, the average daily air temperature became positive. As soon as the temperature of the surface layer reached +10…15°C, the soil started to thaw to a 30-50 cm depth and the frozen screen disappeared.

On a virgin site (non-eroded Haplic Chernozem) the snowmelt runoff always minimal due to the absence of an intrasoil ice sheet because the maximum depth of freezing this soil is 10–15 cm, and sometimes 25–30 cm. In the first days of the snowmelt period there is a fast and uniform warming up of a profile, without formation of an ice layer. Therefore snowmelt water migrated into the soil profile, warming and humidifying it.

Keywords：*Soil erosion, spring snowmelt, hydro-thermal regime, snow cover, intrasoil ice sheet*

P4-168

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Impact of Organic Agriculture on Runoff and Soil Erosion in a Silty Soil

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Conventional management in agriculture has led to different environmental problems. Some of them are identified by the European Commission as threats to soil (EC, 2006). Among them, soil erosion has been identified as a major threat (Van Camp, 2004). Indeed, it causes damages to arable land like exposure of the roots of some perennial crops, affects the water quality (Lecomte et al., 2001) and leads to such a soil loss that soil may not be sustainable in the long-term (Jones et al., 2004). Therefore, soil erosion has to be reduced, especially in the areas where soils are prone to surface crusting (Augeard et al., 2005). Environmental improvements due to the conversion of conventional to organic farming have already been observed (Stolze et al., 2000), notably Zeiger and Fohrer (2009) and Kuhn et al. (2012) who observed a decrease in runoff and earlier soil crusting signs in the conventional farming soil. In this context, the aim of this study was to assess the influence of a young conversion to organic farming system compare to a conventional farming system on runoff genesis, soil erosion and soil crusting dynamics in a soil which is very sensitive to soil surface crusting. For that, rainfall simulations with different intensities have been performed in two fields of the Brie area, 80 km east of Paris, France. Runoff, soil loss have been measured and the formation of soil surface crusting was observed.

The 2 fields under investigation are similar: they belong to the same farmer, they are close to each other (600 m), the slope is similar, between 1 and 2°, and the soil of the 2 plots is a silty typic haplustalf (USDA, 1999) developed from loess material. The difference was the soil management: when the study was conducted, one field was in the third year of conversion to organic management (OM), the other one was cultivated in conventional management (CM).

In the CM field, no runoff was observed when the rainfall intensity was 10 mm.h-1. Runoff coefficients were 4.8% and 6.9% when intensities were 25 and 40 mm.h-1 respectively. In the OM field, a slight runoff occurs when rainfall intensity was 50 mm.h-1, whereas, contrary to CM plots, no runoff was observed when intensities were 25 and 40 mm.h-1. Soil losses follow the same trend: the maximum soil losses were 0.6 g.m-2 in the CM experiment when rainfall intensity was 40 mm.h-1. The crust coverage was observed in the plots where runoff occurred. The more the crusts cover the experimental plot, the more the amount of runoff water was important.

This study shows the impact of organic agriculture in soils prone to surface crusting. Even after only three years of conversion to organic farming, the conventional agricultural soil generate more runoff and are therefore more likely to be eroded than organic farming soil.

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Keywords：*Organic agriculture, soil erosion, surface runoff, aggregate stability*

P4-169

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Characterization of Microstructural Stability of Northern German Marshland Soils by Rheological Measurements

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Rheological measurements were performed on Marshland soils of the riparian zone of the Tidal Elbe River (North Germany) to analyze and evaluate microstructural stability against hydro-mechanical stresses, such as wave action. Amplitude sweep tests (AST) with controlled shear deformation (CSD) were conducted with a modular compact rheometer MCR 300 (Anton Paar, Ostfildern, Germany) with a profiled parallel-plate measuring system at a plate distance of 4 mm (Markgraf et al. 2006). Sieved (< 2 mm) and repacked soil samples (ρt = 1.4 Mg m-3) were equilibrated to a quasi-saturated state and a matric potential ΨM of -15 kPa and five replicated samples were measured. During AST soil samples experience a gradual depletion of microstructural stiffness. This degradation of internal structure can be characterized by the dimensionless parameter integral z, which is derived from AST and quantifies the stability of microstructure.

Saturated soil samples exhibit a faster depletion of microstructural stiffness compared to predried (ΨM -15 kPa) soil samples. Additionally this degradation of internal structure is more pronounced in fine textured soil samples, distinguished by smaller values of integral z (around 10 for clayey soils). As matric potential decreases to -15 kPa an increase in microstructural stability is obtained, because the mobility of water molecules is reduced due to thinner water layers and more intense bonding to the mineral surface, thus their viscosity is considerably high. Moreover the distance between particles becomes smaller and electrostatic interactions are intensified, resulting in higher shear strength. Therefore greater integral z-values up to 68 are attained. Texture and organic substance provoke this effect because the stabilizing response through desiccation is greater in fine textured substrates.

In the first instance, the destabilization by water in fine textured soils can be explained by sliding shear behavior, which results in smaller shear strength. Furthermore, the chemical properties of the fraction < 2 µm must be considered as well. Finally, adsorption of water molecule layers increases the distance between particles, consequently reducing the electrostatic interactions. Furthermore microstructural soil strength depends on organic matter content, pH, present exchangeable cations and ionic strength in the pore fluid.

In conclusion, rheological measurements reveal that the stability of microstructure depends on predrying, texture and chemical properties associated with the fraction < 2 µm. The stability of microstructure in predried soil samples (ΨM -15 kPa) is higher than in saturated soil samples due to menisci forces and stronger bonding of water molecules to the particle surface. Moreover rheological analyses detect that the microstructural stability in saturated clayey soils is lower than in saturated sandy soils, because of occurring sliding shear behavior with increase in clay content, the chemical properties associated with the fraction < 2 µm and adsorption of water molecules. Hence, the vulnerability against hydro-mechanic stresses increases with increasing water and clay content. Furthermore microstructure of soil is not only influenced by water content and soil texture but also by organic matter content, pH, present exchangeable cations and ionic strength in pore fluid. Finally we can state that rheometry is an appropriate method to evaluate and characterize shear behavior of riparian soils and their colloidal stability.

Keywords：*Rheometry, Micromechanics, Structural stability, Riparian soils*

P4-170

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil and Water Conservation Practices for Upland Farming

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A qualitative-quantitative study of soil-water and its corresponding environmental pollution from agricultural farmlands has been given much attention. Managing sediment runoff during storm events can be quiet challenging because they are very episodic and largely unpredictable. At the same time, water becomes scare not only in arid and drought prone area but also in regions where rainfall pattern is spatial-temporally varied. Therefore, many water-related techniques have been devised over the centuries to increase the effectiveness of water application and control the agricultural pollution discharge. This study implemented one of the eco-friendly and effective synthetic polymers for agricultural purpose. For quantitative and qualitative assessment of synthetic polymer, this study applied it to two different studies. The findings of this study showed that the versatility of synthetic polymer makes it attractive. It could control surface sealing and crusting, increase seedling emergence, reduce runoff and erosion, as well as reduce fertilizer and pesticide losses. All these benefits help alleviate on-site and off-site pollution as well as costs. Laboratory and field tests were carried out to assess its performance of synthetic polymer and the study findings clearly showed that it could be supplementary to reduce turbidity in agricultural runoffs. At the same time, its application to topsoil enhanced the soil-water movement through soils, which eventually helps crops to absorb water and relevant nutrients.

Keywords：*Synthetic polymer, Best Management Practice (BMP), Nonpoint source (NPS) pollution, Agricultural Water Use, Soil-Water movement*

P4-171

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Evaluation of Swat for Sediment, Discharge and Crop Yield: Impact Assessment of Different Land Use Scenarios to Identify Efficient Land Use for Sediment Retention in Haean Catchment, South Korea

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The study focuses on small catchment of 60 km2 in Haean, in S-korea. Intensive agriculture including various land management practice and changes in land use due to urbanization and deforestation continue to affect the nature and magnitude of groundwater-surface water interactions and water availability influencing ecosystems and their services. In Soyang Watershed, typical Land use system and farm management practice, especially the Haean and Jawoon Catchment expert large amounts of sediment and associated nutrients (non point pollution source) due to high erosion rate during monsoon rains. The high erosion rate and consequence of muddy flow with high sediment from upstream watershed like Haean catchment is of big concern for silt deposition and deterioration of water quality in Soyang reservoir. The study analyze different land use scenario of expanding dry land crops (potato, cabbage, soybean and radish) to study the capability of each scenarios in retaining sediment vs. associated yield. The model SWAT (soil and Water Assessment Tool) was used to quantify daily stream flow, sediment and crop yield from the study catchment. The SWAT model based on CN (curve number), MUSLE (modified universal soil loss equation) and basic heat unity theory for daily simulation of stream discharge, sediment and crop yield respectively. The intensive research in Haean catchment by TERRECO project (2009) has generated perquisite data set for SWAT model simulation and implemented for different land use scenarios. The purpose of the study was to evaluate environmental efficiency of the catchment in relation to agricultural yields vs. sediment retention capacity of each land use scenario to recommend environmentally potential best farm management methods based on studied land use scenarios. Prior to the implementation of land use scenarios, the study calibrated and validated the model hydrologically and for sediment by using daily flow and sediment data at several outlet within the haean catchment. The model performance indicated by coefficient of determination (R2) and Nash and Sutcliffe Efficiency (ENS) values were greater than 0.75 during calibration and validation period and finalizing the specific related parameter for sediment, stream discharge and crop yield for further scenario analysis. After model calibration and validation the simulation for sediment, stream discharge and crop yield were evaluated at the catchment level for baseline and associated scenarios. The model was implemented for baseline scenarios and other crop expansion scenarios namely Potato Expansion, Cabbage Expansion, Radish Expansion and Soybean Expansion. The study observed insignificant difference in discharge simulation which were in the rage of 1030-1040 mm for all scenarios at the catchment level. The least sediment yield (12.83 ton/ha) was simulated in radish expansion scenario and highest sediment yield (16.56 ton/ha). However the base line scenario was simulated for 10.03 ton/ha mainly due to higher coverage of tree crops than other scenarios. The highest yield (4.8 ton/ha, dry basis) was simulated for potato expansion and least (1.6 ton/ha) for Soybean and base line scenarios. The study found, the land use system with radish expansion scenario has highest capacity to retain the sediment. In contrast, the radish expansion scenarios was not simulated for higher yield (2 ton/ha). In considering, sediment vs. crop yield supports explicitly for the potato expansion due to highest yield in the expense of higher sediment by 0.62 ton/ha from the lowest sediment yield scenario. The study could be concluded for adoption of land use system in combination of potato and radish expansion scenarios for maximizing crop yield and sediment retention. Implementation of scenario with care is recommended due to limitation of the study in considering yield stress from pesticides, which could be inevitable in monoculture expansion scenarios.

Keywords：*Soil and Water Assessment Tool (SWAT), Erosion, Sediment, Crop yield, Land Use, Non point pollutant*

P4-172

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Spatial Analysis of Penetration Resistance on Irrigated Area in South of Tocantins - Brazil

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Brazil, despite being one of the largest producers of agricultural commodities, has regional climate limitations, like seasonal drought. To bypass this situation, the irrigation with center pivot is considerably used, allowing 2 or 3 annual harvests. As the cost of equipment is high and the bought of rural electricity for irrigation is expensive, is extremely important that the productivity will be urged maximally. The intense mechanization, like seed, management, lime application, tillage, harvest and lading of the production on center pivot soil, could benefit the compaction, intervening in productivity of the harvest, caused by hamper of the root growth. The objective of this work was to evaluate soil penetration resistance (PR) with an impact penetrometer at layer 00-0,06; 0,06-0,12; 0,12-0,18; 0,18-0,24 e 0,24-0,30 meters on irrigated area with center pivot and analyze spatially by means of geostatistics. The center pivot locates in south of the state of Tocantins, Brazil. The native vegetation is arboreal savanna (cerrado). The regional climate is tropical wet and dry AW and has 1500 mm of annual average precipitation. The center pivot has 126 ha and the soil is heterogeneous, composed by OXYSOLS, PLINTHOSOLS and INCEPTISOLS. In the last 6 years, the center pivot was basically used for the cultivation of soy-bean (Glycine max) and bean (Phaseolus vulgaris). In 2008 and 2013 the soil were limed and tilled, in 2010 the area were chiseled and later tilled. 25 marks were georeferenced at the field and afterward data taken on a grid of 230x220 meters, resulting 1 mark every 5 ha with 10 repetitions each. Soil samples in the layer 0,0-0,20 meters were taken every mark and the soil moisture measured at laboratory. The study revealed high values of PR with maximum values variation between 5,35 and 23,4 MPa. Has been realized that compaction increased by the upper layer to under layer. The soil moisture has varied between 4,52% and 12,01%. One explanation for so high values of PR beyond the low soil moisture is that the soil has 3 soil orders on the irrigated area, including PLINTHOSOLS, and this could have done interference by the data extraction with the impact penetrometer, because plinthite were sighted as in their irreversible form, ironstone, on the field. Excluded the first layer, the spatial distance between the marks increased, revealing that the utilized grid disfavors the spatial distribution. The variation coefficient (VC) oscillate between 43% and 62%, considered average and high, however, on soil science, high values of VC are acceptable when compared with other authors. The conclusion of the work is that a heterogeneous soil with plinthic characteristics, low soil moisture and intensive mechanization favors soil compaction on irrigated areas by central pivot.

Keywords：*geostatistics, central pivot, soil compaction*

P4-173

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Estimation of Carbon Carrying Capacity in the Yanhe River Catchment of China's Loess Plateau

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Estimation of carbon carrying capacity (CCC) can provide a reliable reference for the prediction of carbon sequestration potential by comparing it with the existent carbon stock, which is critical to the development of mitigation strategies and effective policies. The objectives of the present study were to approximate the CCC in a loess hilly region in China's Loess Plateau, analyze its change with bioclimatic gradients, and its validity as a reference for the prediction of carbon sequestration potential. With remnant secondary ecosystems as the basis, an environmental stratification sampling method was used to identify sample sites that covered most of the typical secondary communities in the Yanhe River catchment. Then a classification method was used to predict the above-ground CCC, and a generalised additive modelling approach was used to estimate the below-ground CCC in the Yanhe River catchment. The result showed that the above-ground CCC varied from 0.25 to 39.51 t ha-1 across the catchment with an average of 4.12 ± 9.26 t ha-1, and the below-ground CCC (0-60cm) varied from 14.73-182.99 t ha-1 across the catchment with an average of 35.62 ± 12.82 t ha-1. If covered with natural secondary communities, the predicted total CCC of the catchment was 32.77×106 t, of which the above-ground stock accounted for 10% and below-ground stock accounted for 90%. This result may be valuable for accounting carbon stocks and fluxes and provide support for the development of improved management directions and landscape planning.

Keywords：*Carbon carrying capacity, Carbon sequestration potential, Loess Plateau, Natural ecosystem, Yanhe Ri*

P4-174

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Contribution Rate of Influent Factors Affecting Soil Moisture and its Scale Effect in Loess Plateau, China

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Despite the great importance of environmental factors in influencing spatial distribution and variability of soil moisture, how it changes along the scale remains poorly understood. Here, we examined contribution rate of environmental factors affecting soil moisture and its scale effect by using four scales (patch scale, slope scale, small watershed scale and regional scale, respectively) in Loess Plateau, China. All of which had similar soil conditions (Calcaric Cambisols, FAO). Along the scale, the influence of meteorological factors generally increased, whereas that of the topographic factors generally decreased. Consequently, the information controlled by slope position slowly turned to slope, Rainaver, Temaver and other meteorological factors. Shifting of the information in our study could also be associated to role of the conversion of the determinant and main limiting factors between different scales. These results suggested the key scale of temporal and spatial variability of soil moisture and its dominant factor are different with time and space in response to scale effect of environmental factors influencing soil moisture.

Keywords：*Loess Plateau, soil moisture, environmental factors, scale effect*

P4-175

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Investigation of Erosion Degree at Agricultural Terrain in Southern Moravia by Using of Soil Magnetic Parameters

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The pedogenic magnetic enhancement of topsoils is responsible for typical variations of magnetic parameters along the depth of natural soil profiles. Due to the removal of the uppermost soil layer, this pattern is disturbed in areas heavily affected by erosion. Tillage operations substantially enhance soil degradation, because the soil particles are easily removed by rainwater and wind. In agricultural land, the morphology is one of the main controlling factors for soil redistribution along a slope. A detailed field study on a small test site of agricultural land situated in loess region in Southern Moravia (Czech Republic), and subsequent laboratory analyses have been carried out in order to test the applicability of magnetic methods for the estimation of soil erosion. The site is characterized by a flat upper part (slope 0-0.5°) while the middle part, formed by a substantive side valley, is steeper (up to 15°). We carried out field measurements of magnetic susceptibility on a regular grid, resulting in 101 data points. The bulk soil material for laboratory investigation was gathered from all the grid points. We used mass-specific magnetic susceptibility χ and its frequency dependence kFD to estimate the significance of ultrafine superparamagnetic particles (predominantly magnetite) of pedogenic origin in the top soil horizons. Thermomagnetic analyses, hysteresis measurement and scanning electron microscopy were used in order to determine the dominant ferrimagnetic carriers in top-soil and sub-soil layers. We found a strong correlation between the volume magnetic susceptibility (field measurement) and mass-specific magnetic susceptibility measured in the laboratory ($R2 = 0.80$). Values of the magnetic susceptibility and also organic carbon content are spatially distributed depending on the position. Higher values were measured in the flat upper part, where the original top horizon remained. The lowest values of organic carbon content and magnetic susceptibility were obtained on the steep valley sides. Here the original topsoil was eroded and mixed by tillage with the soil substrate (loess). High values of both properties were measured also in colluvial fan (where the soil eroded from the top horizon in the upper parts has accumulated). The regression analysis showed a positive correlation between the organic carbon content and the volume magnetic susceptibility ($R2= 0.89$).

The soil profile that was unaffected by erosion was investigated in detail. The vertical distribution of magnetic susceptibility along its virgin profile was measured using the stratigraphic sensor Bartington MS2F and mass specific susceptibility in laboratory on the samples from 2-cm layers along the whole profile. The undisturbed profile shows several soil horizons. Horizons Ac and A show a slight increase in magnetic susceptibility down to a depth of about 70 cm. Horizon A/Ck is characterized by a decrease in susceptibility, and the underlying C horizon ($h > 103$ cm) has a very low value of magnetic susceptibility. The differences between the values of susceptibility in the undisturbed soil profiles and the magnetic signal after uniform mixing of the soil material as a result of tillage and erosion are fundamental for the estimation of soil loss in the studied test field. Using uneroded profile from this locality as a basis for examining the changes in cultivated soils, tillage homogenization model can be used to predict changes in the surface soil magnetism with progressive soil erosion. This model was derived using a mathematical procedure described by Royall (Catena 46, 2001); the model is very well applicable at our investigated locality. The degree of erosion, ranging from 3 cm to more than 100 cm, is directly proportional to the slope of the terrain.

Acknowledgement: This study was supported by NAZV Agency of the Ministry of Agriculture of the Czech Republic through grant No QJ1230319.

Keywords：*soil magnetic parameters, soil erosion*

P4-176

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

A Bayesian Belief Network for Assessing and Mapping the Risk of Soil Erosion by Water

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Soil erosion is a major environmental problem and a serious threat to agricultural soils across the world. Soil erosion causes adverse on-site effects including loss of fertile soil and soil organic matter resulting in reduced crop yield and soil productivity and off-site effects such as siltation of watercourses and reservoirs and increasing flood risk. There is a need for methods to assess and identify areas at risk of soil erosion to ensure that resources are targeted to areas at greatest risk and help decide where conservation measures should be implemented in order to reduce the threat and protect the soil quality. However, assessing the risk of soil erosion is not straightforward as soil erosion, like most soil degradation threats, results from the complex interaction of anthropogenic, climatic, topographic and soil specific factors. Risk assessment of soil threats is furthermore often hampered by the lack of key data and process understanding, and in many cases it is necessary to resort to more qualitative assessments based on expert opinion.

Recently, Troldborg et al. [Soil & Tillage Research, 132 (2013) pp. 56–68] developed a generic risk framework based on Bayesian Belief Networks (BBNs) to assess the risk from soil threats and applied this to the specific issue of soil compaction. BBNs are graphical probabilistic models that are effective for integrating quantitative and qualitative information, and thus can strengthen decisions when empirical data are lacking. Here, we have used the generic framework to develop a BBN for assessing the risk of soil erosion. The developed BBN combines analytical and morphological data from standard soil surveys with qualitative expert knowledge to estimate the risk of soil erosion. The BBN structure follows a standard risk assessment approach, with the risk evaluated by combining assessments of vulnerability and exposure. The soil's vulnerability to erosion is assessed from inherent soil and site characteristics (e.g. soil texture, organic matter concentration and slope), land use (e.g. vegetation cover) and from climatic factors influencing the soil water content, while the exposure is assessed from an evaluation of the climatic factors (e.g. rainfall intensity). A major advantage of using such a BBN approach, compared to the existing rule-based and deterministic models for soil erosion risk assessment, is that the BBN explicitly accounts for the uncertainties involved the assessment of the risk. An assessment of the risk and the associated uncertainty provides better informed and more robust decision-support. The BBN is applied to quantify and map the risk of erosion for Scotland using available soil maps and associated data from the Scottish Soils Knowledge and Information Base (SSKIB) and the National Soils Inventory of Scotland (NSIS). The impact of different climate scenarios and management strategies on the erosion risk is explored.

This work is still in progress.

Keywords：*soil erosion, risk assessment, Bayesian belief network, uncertainty, modelling*

P4-177

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil Erosion Processes and the Application of Harisine-Rose Model for Rill Erosion (Laboratoary and Field Experiments)

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The understanding soil erosion processes and the development of accurate erosion prediction models require understanding of detachment, deposition, and sediment transport in rills. This paper describes the results of controlled laboratory and field experiments carried out to study the flow-driven processes of soil erosion in small rills. It is also aimed to evaluate the Hairsine-Rose model for prediction of total sediment concentration at steady state condition. At the laboratory phase, five soil samples of contrasting physicochemical properties were packed into a 2.5 m long by 0.05 m width tilting flume and were subjected to six runon flow rates of 0.03, 0.05, 0.075, 0.1, 0.15 and 0.2 liter per second at 2 percent slope. The field experiments were carried out at a dry-farming land in a semiarid region, in which four flow rates of 0.028, 0.083, 0.167 and 0.2 liter per second were tested at three slopes (1, 3 and 5 percent) in trapezoidal preformed rills of 3 m long and 0.05 m base width. All experiments were continued for 40 minutes and out flow were sampled periodically to determined changes in sediment concentration and size distribution. The concentration and size distribution of outflow sediment showed a dynamic changes with time which was affected by flow rate, slope and soil types. The sediment concentration was generally highest in the commencement of the experiment, decreases with time and reaches to an almost steady state level. Though as expected sediment concentration was higher for higher flow rates at the early unsteady conditions, in some cases the final steady concentration was somewhat lower for higher flow rates in compare to lower flow rates. The effects of flow rate and slope were more detectable on sediment concentration at the early unsteady conditions than at the final steady conditions. The performance of Hairsine-rose model to predict steady sediment concentration was evaluated by different efficiency criteria. The model showed a better performance at lower flow streampowers, but generally over predicted sediment concentration. This was observed for both laboratory and field experiments showing a systematic error probably due to model formulation. Weighted coefficient of determination (wR2) and Nash-Sutcliffe efficiency with logarithmic values (Elog) were better criteria for the model evaluation than the coefficient of determination (R2) and Nash-Sutcliffe efficiency (E). The results of both laboratory and field experiments supported (i) a selective bimodal pattern of sediment transport of different sizes, and (ii) transportation of different sizes of particles by different mechanisms including suspension-saltation and rolling. There was a spatial threshold streampower for each mechanism to be active. The results also showed that the particle size with minimum transportation, which may be considered as boundary between the suspension-saltation and rolling processes, is unique for each soil depends on its particle size distribution. This boundary was not changed by increasing flow rate/streampower at the laboratory experiments. Based on this boundary, the relative importance of rolling was increased by increasing flow stream power (combination of flow rate and slope).

Keywords：*Sediment transport, Suspension-saltation, Rolling, soil erosion*

P4-178

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil Erosion Processes and Soil Organic Carbon Re-Distribution: An Experimental Rainfall Simulation Approach

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Water erosion influences the redistribution of soil organic carbon (SOC) in landscapes and there is a strong need to better understand these processes with respect to the carbon (C) budget, from local to global scales.

We present a study in which the total carbon budget of a loess soil under erosion was determined in an experimental set-up. We measured fluxes of SOC, dissolved organic C (DOC) and CO2 in a climate controlled pseudo-replicated rainfall-simulation laboratory experiment. This approach has been rarely followed to integrate all components of the C budget in one experiment. We characterized different C fractions in soils and redistributed sediments using density fractionation and determined C enrichment ratios (CER) in the transported sediments. Erosion, transport and subsequent deposition resulted in a significantly higher CER of the sediments exported ranging between 1.3 and 4.0. In the exported sediments, C contents (mg per g soil) of particulate organic C (POC, C not bound to soil minerals) and mineral-associated organic C (MOC) were both significantly higher than those of non-eroded soils indicating that water erosion resulted in losses of C-enriched material both in forms of POC and MOC. The averaged SOC fluxes as particles (4.7 g C m-2 yr-1) were 18 times larger than DOC fluxes. Cumulative emission of soil CO2 slightly decreased at the erosion zone while increased by 27% at the deposition zone in comparison to non-eroded soils. Overall, CO2 emission was the predominant form of C loss contributing to about 90.5% of total erosion-induced C losses in our 4-month experiment. However, only 1.5 % of redistributed C was mineralized highlighting that the C sink induced by deposition is much larger than previously assumed. Our study also underlines the importance of C losses by particles and as DOC for understanding effects of water erosion on the C balance at the interface of terrestrial and aquatic systems. Furthermore our study revealed that the C fluxes for the different phases (solid, dissolved and gas) showed good correspondence with values obtained in real landscapes as reported in literature. This confirms that a lab-approach, despite its shortcomings with respect to scale, is valuable and gives additional information on processes affecting the soil carbon budget. This is urgently needed and improves our knowledge on the fate of SOC in erosion-depositional systems.

Keywords：*carbon budget, mineralization, DOC, POC, SOC, sink-source*

P4-179

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Using Magnetic Susceptibility and Soil Spectra Measurements for Mapping of Soil Degradation Due to Erosion

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Soil erosion is a frequent problem of agricultural arable soils. Evaluation of soil degradation due to erosion processes using common direct methods is costly and time-consuming. Therefore there is a need to develop suitable indirect methods for this purpose. One of the alternative approaches, which can be used, is measurement of soil magnetic properties. Another method is visible and near infrared reflectance (VNIR) spectroscopy. The aim of this study was to evaluate the suitability of these two approaches to assess soil degradation due to erosion processes at four locations with different soil types. The first studied area was in Brumovice. The original soil type was Haplic Chernozem on loess, which was due to erosion changed into Regosol (steep parts) and Colluvial soil (base slope and the tributary valley). A similar process has been described at other three locations Vidim, Sedlcany and Zelezna, where the original soil types were Haplic Luvisol and two Haplic Cambisols, respectively. The regular and semi-regular soil sampling grids were set at all four sites. Following soil properties were measured: oxidable organic carbon content, CaCO3 content, pH_H2O, pH_KCl, soil particle density, bulk density, porosity, field soil-water content, content of iron and manganese (in ammonium oxalate extract, Fe_o and Mn_o, and dithionite–citrate extract, Fe_d and Mn_d) and mass specific magnetic susceptibility. The soil aggregate stability (WSA index), which is essential when assessing soil vulnerability to its degradation, was also evaluated. Terrain attributes were obtained from the digital elevation models.
Statistical analysis at different locations showed different degrees of correlations between soil properties, and soil properties and terrain attributes measured at each location, which mainly depended on soil substrate and contrast between variables measured on soil samples impacted and not-impacted by erosion. Results showed limitations of both methods. For instance in the case of the Brumovice location, the statistical analysis showed that the almost all soil properties were closely related, which was mostly given by the spatial distribution of the soil organic matter (redistributed due to erosion and deposition processes) and partly also by the spatial distribution of CaCO3 (exposition of the loess substrate). The simple correlations revealed that WSA index were positively impacted by the oxidable organic carbon content (Cox), porosity, Mn and Fe contents and magnetic susceptibility (expressing content of ferrimagnetic particles). The soil aggregate stability was also negatively influence by the plan and mean terrain curvatures, i.e. larger aggregate stabilities were measured at concave parts in comparison to that at convex parts. The multiple linear regressions further showed that the WSA index may be predicted combining the Cox content, mean terrain curvature and actual field soil-water content. In this model the Cox content positively, and the mean terrain curvature and the actual field soil-water content value negatively influenced value of the WSA index. Since the oxidable organic carbon content, Cox, was closely related to Fe_o , Mn_o, Fe_d and Mn_d contents and thus also to the mass specific magnetic susceptibility, magnetic susceptibility measured in the laboratory or field could be applied for mapping of soil organic carbon redistribution and even for predicting the WSA index using the multiple linear regression model (by replacing Cox). In addition the organic carbon content and Mn and Fe contents were at this location well predicted using VNIR spectroscopy, which again documented its suitability for soil degradation mapping. Less conclusive results were obtained at other three locations.

Acknowledgement: Authors acknowledge the financial support of the Ministry of Agriculture of the Czech Republic (QJ1230319).

Keywords：*soil degradation, WSA index , organic matter content, Iron content , magnetic susceptibility, VNIR spectroscopy*

P4-180

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil Water Variability and Transpirable Soil Water in a Small Basin of the Mediterranean North East Spain: Influence of Soil Properties and Climate Characteristics

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The levelling and deep tillage operations before vineyard establishment give rise to high variability of hydrological soil properties, which affects crop's soil water availability. This paper presents an analysis of soil water content at different locations within a small ungaged basin located in a Mediterranean climate area, whose main crop is vines. The basin has 0.46 ha, with Chardonnay and Cabernet Sauvignon as the main vine-grape varieties. The plantation pattern was uniform in both cultivars, 1.3*3m. The main soil types are Typic Xerorthent and Fluventic Haploxerept and soil is bare most of the time to avoid the competition of weeds for water. A soil survey was carried out at in each of them (15 points in each area in a regular pattern of 10 x 10 m), and analysed for texture, organic matter, water retention capacity at different potentials, soil depth and bulk density. Soil moisture was analysed at each area from 10 to 90 cm every 20 cm, using TDF probes during two crop growing cycles. Soil water balance for years with different rainfall amount and distribution throughout the year was simulated using the Soil and Water Assessment Tool (SWAT).

The results show that land levelling created heterogeneity of soil properties in different parts of the plot. Soil water content was lower in the upper part of the slope, where shallow soils existed. At that locations greater variability within the soil profile were observed. However, in the middle and in the lower part of the slope, soil moisture was greater as well as the water retention capacity, with higher uniformity within the profile. Precisely, the lower part of the slope was the most affected by land levelling, with outcrop of unconsolidated non-saline marls. Nevertheless, despite the fact that the steady infiltration rate is lower, these soils provide the best conditions for available water retention capacity for crop development, as it is demonstrated by the yield. In addition, rainfall distribution had a significant influence on water available in critical periods in which water deficits had a significant reduction on yield. Yield reductions up to 38% in relation to the average yield were found in some years.

Keywords：*soil water variability, transpirable soil water, Mediterranean climate, rainfall distribution*

P4-181

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Influence of Drainage Terraces on Runoff and Soil Losses under Different Rainfall Patterns in a Small Vineyard Catchment

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This work presents the analysis of the influence of drainage terraces on soil and water losses in a small catchment, whose main land use is vines. The watershed was located in the municipality of Piera (Barcelona, Spain). Other crops like olive trees, winter barley and alfalfa were also found, as well as some residential areas. Soil and water losses were simulated using the Soil and Water Assessment Tool (SWAT). The model was calibrated and validated using soil water and runoff data collected in the field during the period May 2010- May 2012. Then, the model was run for the period 2000-2011, which included years with different rainfall amount and characteristics. Soil losses with and without that soil conservation measure was compared. The annual rainfall recorded during the analysed years ranged from 329.8 to 785 mm with different rainfall distributions within the year. Runoff rates ranged from 17 to 141 mm, which represented respectively 4.7 and 21% of total precipitation. Both extreme situations were recorded in the driest years of the series, with precipitation below the average. Soil losses ranged between 0.31 Mg/ha in the driest year and 13.9 Mg/ha, in the wettest. The construction of drainage terraces produced a reduction of soil losses up to 20%, although total runoff rates did not change.

Keywords：*soil loss, runoff rates, drainage terraces, SWAT simulation*

P4-182

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Land Use, Topography and Hydrological Process Effect on Suspended Sediment Dynamics in an Agriculture-Forest Dominated Watershed

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Suspended sediment (SS) and associated nutrients transport from land to watercourse is an immense problem that has threatened soil and water conservation in the world. Understanding SS transport mechanism is important for soil erosion estimation and making the best management practices.

This study was conducted in an agriculture-forest dominated Shibetsu River watershed (SRW) and its two sub-watersheds with different land uses and topography located in Hokkaido, Japan, to understand effects of land use, topography and hydrological process on SS dynamics. The agriculture-dominated sub-watershed (AW) had flat topography, the forest-dominated sub-watershed (FW) was characterized by steep slopes. During the snowmelt seasons and rainfall events, stream water level (H) was measured and stream discharge (Q) was calculated from H-Q equations. Water samples were collected by auto-sampler and filtered through 0.7 μm glass microfiber filters for analyzing suspended sediment concentration (SSC). Measured hydrograph of six rainfall events and wavelet analysis for daily streamflow from 2003 to 2008 were analyzed to understand the time-lag between streamflow and rainfall. Relationships between Q and SSC were analyzed by hysteresis loops for two snowmelt events and six flood events.

Measured hydrograph and wavelet analysis results showed that response of streamflow to rainfall was faster in AW than FW during the flood events. During snowmelt events and flood events, results showed that mean and maximum SSC were much higher in AW than FW. However, stream water yield was much higher in FW than AW and this resulted in higher SS yield in FW than AW in two flood events and a snowmelt event in May 2006, even though the mean SSC was lower in FW than AW. For most of the flood events, SS yield was much higher in AW than in FW, indicating that soil erosion was more serious in AW due to the plant cover (most area was covered by pasture) and management practices, such as grazing, even though slopes of AW was more flatter than FW. Results of hysteresis loops showed that most of the flood events were characterized with anti-clockwise hysteresis (peak of SSC happened after peak of Q) in AW, indicating that the SS source maybe mainly from distant areas with relatively steeper slopes from the streams. However, most of the flood events were characterized with clockwise hysteresis (peak of SSC happened before peak of Q) in FW, indicating that the SS sources maybe mainly from the near stream areas with steep slopes. At the whole watershed outlet SRW, most flood events were characterized with clockwise hysteresis, it is concluded that existence of earlier SS supply or increased portion of streamflow during the recession limb of discharge. The earlier SS sources might be mainly from agriculture land, such as AW, due to its higher soil erosion, faster response of streamflow to rainfall, and located nearer to the main outlet SRW compared with FW. The increased portion of streamflow during the recession limb of discharge at SRW might be from the forest land, which had more stream water yield and slower response of streamflow to rainfall during flood events, and also located further to the main outlet compared with agriculture land.

In conclusion, streamflow response to rainfall was faster, mean and maximum SSC were higher in AW than FW. Stream water yield was higher in FW than AW during snowmelt and flood events. Regarding the SS transport dynamics during all flood events, AW was mostly characterized with anticlockwise hysteretic loop, indicating SS source from distant areas, while FW and SRW were mostly characterized with clockwise hysteretic loops, indicating SS source from near stream areas. Agriculture land was identified with critical soil erosion, thus, management practices should be carefully conducted in these areas, especially in distant areas with steep slopes, such as avoiding tillage, harvest and dairy cattle grazing practices during snowmelt and rainfall events and reducing grazing frequency.

Keywords：*Land use; Slope; Hydrological process; Suspended sediment dynamics; Hysteresis*

P4-183

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

An Investigation of Aeolian Particles Vertical Distribution in Degraded Lands of Central Iran (bam-Kerman)

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Wind erosion is a highly land destructive process in arid and semi-arid lands of the world. Vast lands of Iran, mostly located in the central, southern and eastern regions, are covered with sand dune. The study area is part of Narmashir plain in Bam, Kerman province, located at latitude range 28° 32′ 30″ to 28° 38′ 00″ and longitude range 59° 5′ 30″ to 59° 11′ 00″. The land is mostly a flat area in the altitudinal range of 541 to 618 m above sea level. There are no permanent rivers in this region. Some part of the region consists of agricultural lands and gardens particularly palm trees which are irrigated by kariz (subterranean) or well water. Date is the main tree crop in this area. Since wind erosion in this area has the major role in land degradation, and sand storms cause the burial of villages, and also many other problems for farmers, quantifying wind erosion in the land is essential, although its measurement process is difficult. Characterization of the mass–height profile of wind eroded aeolian sediment is an important step to compute soil loss/mass transport. Optimization of calculating method of Aeolian mass flow and transport capacity in wind erosion hotspots of Iran is of high significance. In his study, first, wind erosion measurement station is established in 1.5 ha plot during two wind erosion events which occurred between October 27, 2012 and January 5, 2013. BSNE samplers were placed in 12 points at 0, 30, 60, 90,120 m distance from plot edge with a height of 5, wind speed was recorded by means of a meterological satation placed in middle of the sampling plot.

After each storm, the trapped sediments were collected and weighed with precision and then the data was corrected with collection and storage coefficients. Each of power, exponential, and natural logarithm equations has been used to estimate the amount of passed sediments through 1kg/m width unit and transmit capacity for each cluster was calculated with different equations. The collected sediment in clusters varies with height, intensity and direction of storms, but main material movement is up to 1m from surface and with height increase the transported material decreases. the result shown, relationship between the collected sediment and the type of equation for estimating sediment among logarithmic, power and exponential models, the exponential model had the best correlation coefficient of y=aeb/x. , 75 % Correlation coefficient gained from clusters with exponential equation of R2=0.95 indicates that implementing exponential equation can justify more dependent variability than independent variable.

Keywords：*Wind Erosion, Sampler, BSNE, Equation, sediment.*

P4-184

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Pedogenic Processes and Chemical Properties of Acid Sulfate Soils in the Northwestern Area of Mekong Delta, Vietnam

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The Mekong Delta (MD) is a flat wide plain (average slope < 0.0085°) that lies primarily on the southern edge of Vietnam. Its area (~4 million ha occupies around 12% of Vietnam's total land area. Despite its small area, this delta plays a significant role in the agricultural productivity of Vietnam. Acid sulfate soils (ASS), which typical induce low agricultural productivity due to their strong acidity, cover approximately 1.6 million ha of the delta. The ASS in the MD developed in response to inundation by brackish water in tandem with coastal evolution, with huge amounts of organic matter and sulfuric ions supplied by mangrove forests and seawater, respectively. Many kinds of sulfur compounds exist under various redox conditions in ASS, such as the weathering processes of AAS can be recognized from the composition of sulfur in soil profiles. On this basis, the present study aim to elucidate factors affecting ASS distribution and soil properties in the region of the Bassac River stream in northwestern MD.
Deep soil core samples (maximum depth: 4.5 m) were collected from 9 sites at various distances (10, 20 33, 45, 59, 62, 70, 75, 83 km) from the Bassac River in Kien Giang and An Giang province in MD.
Rice harvest yields at the site 10 km and 75 km from the Bassac River were approximately 9 and 2~3 t ha-1, respectively. The suggested that rice yields decrease with increasing distance from the river; this may be a result of the surface cover of alluvium and low pH derived from oxidizing sulfuric materials in deeper soil layers. The pH (H2O) of the topsoil at the 10 km site was weakly acidic, whereas strongly acidic conditions (pH < 4.0) were indicated at the surface for the 62, 72 and 83 km sites. It appears that the deeper soil layers were derived from different parent materials to the upper layers, which are highly acidic. Between one and three pyrite peaks were observed in the vertical soil profile at all sites except the 10 km site, with maximum pyrite content reached 47.7 g kg-1. Moreover, the layers with the highest pyrite contents occurred at greater depth with increasing distance from the Bassac River. These differences in the location and concentration of pyrite may reflect variations in the supply of sulfur derived from seawater and alluvium deposition processes after land evolution.
The isotopic ratio of δ34S derived from pyrite in the area of the Bassac River was higher than that in the area of the Gulf of Thailand area. Pyrite formation typically occurs in closed basins, such as the area adjacent to the Bassac River. The Gulf of Thailand can be considered an open basin, yet pyrite contents there were found to be higher than those in closed basins are. The value of δ13C was found to be approximately 29 ‰ in a layer that contained abundant reduced sulfur. Mangrove, which are a C3 plants, were previously dominant in the region and seems to play an important role in the pyrite formation, acting as a carbon provider. Value of δ15N at the 10, 33, 59, and 83 km sites were higher than those at the other sites, likely owing to the presence of well-decomposed organic matter under oxidative conditions at these sites. Moreover, these high-δ15N sites appear to have experienced a much more rapid sea level regression than the other sites.
Based on the results described here, agricultural productivity in the studied region is dependent on geological soil formation factors such as landform and the depth of the surface alluvium cover derived from the Bassac River. In particular, these factors were important in the control of rice yields, which varied with time for the formatted pyrite layer in northwestern area of MD.

Keywords：*Acid Sulfate Soils, Pyrite, Sulfur speciation isotopic ratio*

P4-185

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Effects of Cropping Systems on Soil Erosion in the Moldavian Plateau, Romania

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The experiments carried out at the Podu-Iloaiei Agricultural Research Station, during 1987-2012, had the objectives to study of water runoff and soil losses, by erosion, in different crops, the annual rate of erosion processes under the influence of anti-erosion protection of different crops, the influence of water runoff and soil erosion on losses of organic matter and mineral elements from soil. The qunatification in different crops, of water runoff, soil, humus and nutritive element losses by erosion was made using plots for loss control, which are isolated from the rest of the area by metallic walls and have basins and devices for division; we collected water and soil samples from plots for determining the partial turbidity and for chemical elements analyses.

The climatic conditions in the Moldavian Plateau were characterized by a multiannual average temperature of 9.6oC and a mean rainfall amount, on 80 years, of 544 mm, of which 161.2 mm during September-December and 382.8 mm during January-August. In the last 26 years, the annual average rainfall quantity recorded was of 562.5 mm, of which 359.7 mm determined water runoff and soil losses by erosion.

Assessment of soil erosion risk is necessary for establishing land use and crop structure planning in critical season of soil erosion. Critical season for soil erosion in the Moldavian Plateau, when recording the most aggressive rain events is in June and July. On crops as sunflower and maize, the total soil loss recorded in the Moldavian Plateau, 19.4 -20.5 % occurred in the spring, 71.6-69.8% in summer and 6.2-6.7% in the autumn months. Differences of 2.8 to 3% of total annual soil losses by erosion were recorded in winter with snow melting.

The determination of water runoff, soil, humus and nutritive element losses on fields arranged by anti-erosion was done on the whole area of the retention basin (159 ha), where experiments were conducted since 1982; bands with grasses and field strips were also set up. The erosion control was done by using hydrological station with triangular waste weir, rain gauge, recording rain gauge, limnigraph and devices for water and soil samples uptake during rainfalls. The average of annual losses of soil by erosion, registered during 1987-2012 were 0.186 t•ha-1 in perennial grasses on the second growth year, 4.528 t•ha-1 in beans, 9.234 t•ha-1 in maize and 9.657 t•ha-1 in sunflower.

Erosion has affected soil fertility by removing once with eroded soil, high amounts of humus and mineral elements, which reached 16.7-17.8 kg•ha-1 nitrogen, 1.16 kg•ha-1 phosphorus and 2.26 kg•ha-1 potassium, in maize and sunflower crops. Based on direct determinations, we found out that the effective erosion in the Moldavian Plateau, in peas-wheat-maize rotation, had a mean value of 4.523 t•ha-1•year1. Results recorded on erosion in different crop rotations, showed out that in 14 % slope fields from the Moldavian Plateau, soil losses by erosion were diminished below the allowable limit of 3-5 t•ha-1•year-1 only in case of 4 year-crop rotations with one or two reserve fields, cultivated with Leguminosae crops and perennial grasses, which protect soil. These elements were necessary for establishing the crop structure and dimensioning the anti-erosion measures, which determine the decrease of soil erosion and water runoff, soil and nutrients losses below the limit corresponding to the natural capacity of annual soil recovering, of 3-5 t•ha-1•year-1 of eroded soil.

Keywords：*soil erosion, water runoff, nutrient losses, cropping systems, yield, environment quality*

P4-186

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Water Erosion in Planted Forest under Different Management Systems in Brazil

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Soil erosion is considered one of the greatest environmental problems worldwide, affecting both agricultural and forest soils. In Europe, approximately one third of the countries have more than 20% of the agricultural area is moderately or severely affected by water erosion. Globally, the same percentage of soil degradation by water erosion is found. Studies show that water erosion rates are higher in Asia, Africa and South America, and soil losses are much higher of the average soil formation rates. The same situation is found in Brazilian agricultural areas. In tropical soils, the rainfall action, in other words, water erosion has been the primary form of soil wear. Thereby, the soil coverage and management are important factors that affect the intensity of surface runoff and consequently water erosion. In regarding to forest plantations, there is an aggravating factor, the fact of being inserted in sensitive ecosystems to human disturbance due to reasons such as: occurrence of plantations on steep reliefs; soils with low natural fertility; and plantations established on old agricultural fields and degraded pastures. In this context, the assessment of water erosion in forest ecosystems is an important instrument in the planning of soil conservation management. This way, the aim of this paper is to estimate the soil and water losses from different soil classes under eucalyptus planted forest, in different management systems, and native areas (Brazilian Savannas – "Cerrado" and Atlantic Forest). The study was performed in five experimental areas located at east region of Brazil: in states of Bahia, Espirito Santo, Minas Gerais, Mato Grosso do Sul and Rio Grande do Sul. The experiments were conducted on major soil classes existing in these regions (Oxisols, Ultisols, Inceptisols, Spodosols and Aquox) in watersheds of reference in the study area. The assessment of soil and water losses were conducted in erosion-plots established in the field with dimensions of 12.0 x 24.0 m and 12.0 X 12.0 m to the soils under eucalyptus plantation (E), 4.0 x 12.0 m under native vegetation (NV) and bare soil (BS). The greater length of the plots followed the direction of the slope. The rainfall erosivity ranged from 3,628 to 11,284 MJ mm ha-1 h-1 yr-1. The erodibility of the soils showed the following behavior Inceptisol > Spodosol > Aquox > Ultisol > Oxisol. The soil and water loss in all assessed areas have the following order NV < E < BS. Demonstrating the effectiveness of both the native vegetation and eucalyptus plantations, especially in managements conducted with no-tillage and level tillage, to protect the soil against raindrop impact and preventing water erosion. Regarding to eucalyptus management systems the highest soil losses were observed for areas without mulching, showing the negative effect of the removal of cultural residues, especially when they are eliminated by burning. Thus, the soil coverage can be considered as one of the most important factors controlling runoff and soil loss. This way, its maintain constitutes an effective tool to reduce water erosion in forest systems. Among biomes studied, the native vegetation called as Atlantic Forest presented a more conservationist behavior in relation to water erosion than the Cerrado. The highest values of soil loss in the Cerrado are mainly associated with low natural fertility, hence the predominant vegetation of this biome, with sparse gramineae and trees with low height and low plant density, providing little protection to the soil, allowing the direct raindrop impact on the soil surface, creating splash and surface sealing, reducing the water infiltration into the soil and increasing soil and water loss by water erosion. However, it's noteworthy that in all areas studied showed soil losses values lesser than tolerable rates, indicating adequacy of management systems relating to water erosion.

Keywords：*Eucalyptus , Savannas, Atlantic Forest, Erodibility, USLE/RUSLE*

P4-187

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Effect of Soil Management on Soil Erosion and Phosphorus Losses

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In cereal cropping systems, soil management is a major factor contributing to increased risk of soil erosion, transport of soil particles and losses of particulate phosphorus by water. We present results based on several studies undertaken in various European countries on the effect of soil management on soil particle and phosphorus losses. The examined soil tillage methods include direct drilling (no-till), shallow cultivation and ploughing. Landscape features, such as e.g. slope length and angle, drain spacing, prior soil leveling, soil properties, soil tillage methods and their timing and a number of measured or derived climate-related variables were accounted for as potential explanatory variables. Preliminary results show that, in general, deeper and more intense soil tillage results in greater soil erosion at the plot scale. The effect of soil tillage on losses of total phosphorus generally follows the pattern of soil losses by erosion, but the relationship between soil tillage and losses of phosphorus are much more complex. Besides using descriptive statistical measures, we used a data mining tool - classification and regression tree analysis (CART) - to explore what geological, landscape, climatic and management factors – or their combinations - were most influential in determining the success of tillage experiments in terms of reducing soil erosion and associated particulate phosphorus losses.

Keywords：*soil management, soil particle loss, phosphorus loss, regression tree*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Phosphorus Forms in Suspended Sediments as Indicators of Anthropic Pressures and Sediment Origin in a Agricultural Catchment in Southern Brazil

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Agricultural activities are among the activities that most disturb the environment in southern Brazil. Inadequate management of cultivated areas exposes the soil to erosion processes, accelerating the transfer of sediment and phosphorus (P) to water bodies, especially when the P fertilization is frequent and employs high doses, as in the tobacco fields. In this study, we evaluated the P forms present in suspended sediments collected at two rainfall events in the stream of the small watershed of Agudo in the state of Rio Grande do Sul in southern Brazil, which is characterized by sloping relief and subtropical climate, and with tobacco as the predominant crop. The objective was to demonstrate that the forms of P present in the suspended sediments in the watershed vary according to the degree of human disturbance, as well as with different seasonal soil managements for tobacco crop (i.e. fallow, transplantation). Suspended sediment samples were collected upstream and downstream in three sub-watersheds with different degree of anthropogenic pressures and in three phases of hydrograph in the watershed outlet during rainfall events occurred during two periods, corresponding to fallow and transplantation of tobacco crop. The sediment P forms were evaluated by successive extraction with anion exchange resin, 0.5 M NaHCO3 at pH 8.5, 0.1 M NaOH, 1.0 M HCl, 0.5 M NaOH, and finally by digestion of the residue with H2SO4 and H2O2 in the presence of MgCl2. Furthermore, we evaluated the content of total organic and inorganic P. Our results demonstrated that the increase in anthropogenic pressure causes an increase in total inorganic P, decreasing the levels of organic carbon and total organic P in sediment. In the control area, maintained under natural conditions without human interference, the quantity and quality of the eroded material remained the same in both rainfall events, even though they presented total precipitation and intensity quite different. The levels of total P in sediment were not sufficient to determine the influence of soil management prevalent in each sampling period. However, the results of P fractionation clearly show that P in the sediment eroded during the transplantation period of tobacco, when the soil is plowed and it is apply large amounts of phosphate fertilizers, was presented mostly in labile fractions, and therefore has higher potential for pollution than the sediments eroded during the fallow period. It was also demonstrated that the sediment P forms may be used as indicators of sediment origin in time and space, and that the method of chemical fractionation of P provides some tracers properties with great potential for use in studies of identification of sediment sources.

Keywords：*Eutrophication, Diffuse pollution, Soil erosion, Human activity, Water quality, Tobacco crop*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Detection and Mapping of Rainfall Erosivity for Conservation Planning in Dry Valleys, the Eastern Desert, Egypt

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In this study, some of the GIS facilities were employed to model the vulnerability of the dry valleys in the eastern desert of Egypt, in terms of erosion. The problem in these valleys has endangered agriculture, and consequently leading to other problems, such as migration of the farmers to other surrounding large cities. Other problems are water scarcity and flooding during very short time in the winter. The flood usually causes damages to the urban areas. The study is mainly based on understanding the geopedologic setting in each of the selected valleys. This is done using GIS (ArcGIS) facilities, not only for geomapping but also for analyzing the obtained data and presents them in maps and tables. In this research, the Universal Soil Loss Equation (USLE) was used in order to generate and produce the erostivity rate after each stormy rainfall. The established model includes soil parameters, slope, climate and human activities. The obtained values were rated and served as inputs into the Revised Universal Soil Loss Equation (RUSLE) to calculate the present state and potential risk of soil degradation processes (i.e. water erosion). The produced maps and tabular data show the risk and present status of soil degradation process.

In order to fulfill this objective, twelve soil profiles and other observation points were chosen to represent the different dry valleys in two selected regions at the eastern desert; “Luxor-Suhag” and “Suhag-El-Minia”. These regions are exampled by two dry valleys (Asyuit and Qena). These valleys are planned for agricultural development. The output results demonstrate high risk of water erosion and sediment load discharge into the cultivated land in “Luxor-Suhag” region. The other region of “Suhag-El-Minia” is moderately affected by water and sediment load discharge. It is recommended to carry out a detailed integrated survey, including physical-social aspects, within GIS environment, allowing use of satellite and other required data for actual situations modeling.

Keywords：*Management planning, Rainfall erosivity, Revised Universal Soil Loss Equation (RUSLE), ArcGIS, Egypt*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil Erosion Vis-A-Vis Soil Physical Quality in Shiwaliks of Lower Himalayas of India

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The Shiwaliks, one of the most fragile region in lower Himalayas is severely degraded due to soil erosion by water largely because of deforestation, developmental activities, very steep slopes and high intensity rainstorms. The ecological degradation contributes immensely towards excessive sediment discharge as high as 200 t ha-1 year-1 surface runoff to the tune of 35-50% resulting in flash floods especially in plains, reduced discharge of groundwater and impoverishment of the arable lands and overall reduction in land production, which consequently affect the socio-economic status of the inhabitants.

Soil physical quality and soil erosion are interrelated phenomenon with soil quality affecting the rate of soil erosion and vice-versa. Soil erosion affects soil physical quality through its effects on inherent soil properties and efficiency of use of external inputs. The magnitude of erosion and, therefore, its effect on soil physical quality vary with land use.

Physical indicators of soil quality in terms of soil erodibility were evaluated in Shiwaliks region of lower Himalayas of India. A field experiment was conducted with both natural and simulated rainfall conditions under four land uses - barren, cultivated, grassland and forest. Sustainability index approach (Gomez et al. 1996) and cumulative rating approach (Shukla et al. 2004) were used to measure the soil physical quality in terms of soil erodibility. The mean sustainability indices were observed to be highly correlated with the respective soil erodibility values under natural ($r = -0.83$) and simulated ($r = -0.87$) rainfall conditions. The cumulative rating approach had a significant positive correlation with soil erodibility both under natural ($r = 0.75$) and simulated ($r = 0.81$) rainfall conditions. The sustainability index approach was found to be more suitable for assessing the sustainability of the system in terms of soil erodibility as it required less soil inputs and had a higher correlation with soil erodibility. , It was observed that water stable aggregates < 2 mm size were having significant correlation with soil loss under both natural ($r = 0.88$) and simulated ($r = 0.76$) rainfall conditions. Principal component analysis (PCA) technique used to identify dominant soil physical characteristics in relation to soil erodibility. PCA was performed on 22 physical and chemical soil characteristics, which grouped these soil characteristics into five distinct principal components (PCs). These five PCs namely soil hydraulic factor, density factor, structural factor, sand factor and cation factor, explained 86 per cent variability in data. These PCs also explained 51, 88 and 93 % variability under natural rainfall conditions and 86, 73 and 77 % variability under simulated rainfall conditions in relation to runoff, soil loss and soil erodibility, respectively. It showed that the soil structural characteristics viz. mean weight diameter can be considered as dynamic soil physical quality indicator and can be used to monitor temporal and spatial changes in soil physical quality.

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Keywords：*Erosion, Himalayas, Shiwaliks, soil physical quality, soil structure*

P4-191

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Effectiveness of Filter Strips in Reducing Soil And Nutrient Losses in a Small Basin with Rainfed Vines as the Main Land Use

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Most of vines in the Mediterranean area are cultivated under rainfed conditions and with bare soil due to the scarcity of water. A clear example is the Penedès area located NE Spain. That area, that has a Mediterranean climate, suffers significant erosion processes. The rainfall characteristics (highly erosive), the land use and the soil characteristics and management favour high erosion rates with high soil and nutrient losses. Thus, it is necessary to introduce some soil conservation measures in order to reduce these losses.

In the work, the influence of the application of filter strips in the vineyards of a small basin is evaluated. Soil and nutrient losses were simulated using the Soil and Water Assessment Tool model (SWAT). Filter strips, 3m-wide, were simulated. The results with and without that measured were compared. The model was calibrated for runoff, soil and N and P losses with data collected within the basin during the period May 2010- May 2012. The results were than extended to the period 2000-2010, which included years with different rainfall amounts and distributions.

Soil losses in the basin ranged from less than 1 Mgha-1year-1 to 14 Mg ha-1year-1 depending on the climatic conditions, with an average rate for the analysed period of 5.9 Mgha−1. Average nutrient losses of about 17 kg N ha-1 (ranging from 1 to 40 kg N ha-1) and 6 kg P ha-1 (ranging from <1 to 14 kg P ha-1) were simulated for the analysed period. The introduction of filter strips reduced soil losses between 9.7% and 42%, with an average value of about 33% for the 12-year period analysed. The nutrient loss reduction was also significant: from 30 to 70% for N and from 30 to 75% for P. Despite of the fact that this measure has not been accepted by farmers in the area until now the results highlight the effectiveness of the measurement, which in addition did no imply the need of modifications in the plantation.

Keywords : *filter strips, nitrogen and phosphorus losses, SWAT simulation, soil loss, vineyards, Mediterranean*

P4-192

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

How Runoff and Particulate Transport Processes Influence the Fate of Glyphosate and Ampa in Soils

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Glyphosate (N-(phosjonomethyl) glycine) is a non-selective herbicide, widely used in agriculture and horticulture. Its application worldwide has increased significantly in the last decades because of the continuous application on genetic modified crops. More and more scientists are worried about its potential negative effects on human health and the environment. Studies on the fate of glyphosate and its first metabolite AMPA (Aminomethylphosphonic acid) in soils as a sink show very contrasting results. The half-life time varies from a couple of days to months or even years; adsorption coefficients indicate nearly 100 % adsorption onto soil particles, however, glyphosate and AMPA are found in German groundwater bodies. To estimate the spatial distribution and the related risk of this herbicide and its first metabolite for the environment in hilly regions, research into its transport with runoff water and as particulate transport related to soil erosion is essential. Therefore, we focus in this study on the transport of glyphosate and its main metabolite AMPA as solute with runoff and as particulate transport with the suspended load related to soil erosion.

We conducted the experiment under controlled conditions in a rainfall simulation hall using a movable hydraulic flume. We simulated conditions from the hilly regions of the Wei River catchment in China. We studied the fate of Glyphosate and AMPA on loamy soils from farmland in Yangling, Shaanxi Province at two slope gradients (10 ° (S10) and 20° (S20)) and with two dose of glyphosate (3.6 kg ha-1 (G1) and 7.2 kg ha-1 (G2)) (3 replicates). One hour after application of Glyphosate we started the rainfall simulator and ran it for 1 hour at an intensity of 1.0mm min-1. Runoff and suspended load were sampled at 3 minute intervals. Soil samples were taken at depths of 0-2, 2-5and 5-10 cm at the end of the experiment. Glyphosate and AMPA concentrations were analysed in all samples.

The results showed that runoff increased during the first 15 min of rainfall and then remained constant, being significantly higher at S20 (0.59~0.87 L m-2 min-1) than at S10 (0.42~0.64 L m-2 min-1). The soil erosion rate increased during the first 15 min and then decreased for S10 (0.0095~0.0155 kg m-2 min-1). However, at S20 the maximum erosion rate was reached after 5 min of rainfall (0.0204~0.0218 kg m-2 min-1).

The concentration of glyphosate and AMPA in the runoff reached a maximum directly after the start of the rainfall in all treatments and then decreased. Slope gradient did not influence the concentrations. However, application rate did make a difference with G1 showing significantly lower concentration than of both AMPA and glyphosate than G2 during the whole experimental time. The high AMPA concentration directly after the start of the experiment suggests that glyphosate decay starts directly after application.

With respect to the environmental fate of glyphosate, after 1 hour more than 80% of the initial glyphosate was recovered. 13% of the initially applied glyphosate was metabolized to AMPA during the simulation time. 3.6% of the initially applied glyphosate was transported with runoff and 9.3% with suspended load. At the end of the experiment 65% in G1 and 79% in G2 of the initially applied glyphosate remained in the upper 2cm of the soil as glyphosate (8.2mg kg-1 under G1 and 20.1 mg kg-1 under G2) and AMPA (0.8mg kg-1 under G1 and 1.5 mg kg-1 under G2). Almost no leaching was observed.

We conclude that the high rate of particulate transport of glyphosate and AMPA leads to a strong environmental off site risk and should strongly be taken into consideration in hilly regions.

Keywords：*Glyphosate; AMPA; environmental fate, erosion, runoff*

P4-193

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Phosphorus Fractions in Agricultural Constructed Wetland Sediment: Depletion of Plant Available Phosphorus as a Response to Erosion and Redox Reactions

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Constructed wetlands and ponds (CWs) have been introduced as a tool to decrease the suspended material from agricultural runoff. Over time plenty of soil material originating from the surrounding fields accumulates in the pond and has to be removed. The soil material is, however, subject to several processes during the erosion process, in the bottom of the pond and further after returning the sediment to the field. These processes include 1) selective erosion 2) depletion of easily soluble phosphorus (P), 3) reducing reactions in the sediment, resulting in mobilization of iron (Fe) and 4) oxidation and formation of new Fe (hydr)oxide surface upon oxidation of the sediment. This study investigates how these processes change the chemical characteristics and P sorption of the soil material.

The samples were collected from four agricultural CW sites in south-west Finland representing three fine-textured and one coarse mineral soil. The sediment samples from each CW and the soil samples from the surrounding catchments were analyzed for describing sediment P, soil P and P sorption of the material in relation to P bioavailability to the crops. Certain analyses were carried out with both fresh and air-dried sediment samples to illustrate the situation before and after dredging. Phosphorus was characterized by the Chang & Jackson sequential extraction (NH4Cl-P, NH4F-P, NaOH-P, H2SO4-P) and anion exchange resin extraction (AER), which is an estimate of potentially desorbable P. Aluminium (Al) and Fe (hydr)oxides (Alox, Feox) were extracted with acid ammonium oxalate. The P availability of the sediment for Italian ryegrass was assessed in a pot experiment using mixtures of soil and sediment.

The sediments had 38 – 80% more clay and 21 – 160% more Alox than the corresponding fine-textured soils. At the site with coarser soil texture, the surrounding soil had 19% more clay than sediment, which still had 9% more Alox. Drying of the sediments increased Alox and Feox contents by 9 – 47%. Concentration of NH4F-extractable P, associated with Alox, was higher in the soils (26 – 132 mg P kg-1) than in the sediments (10 – 76 mg P kg-1). In each fine-textured mineral soil site, AER-P was significantly higher in the fresh sediments (41 – 240 mg P kg-1) compared to air-dried sediments (30 – 133 mg P kg-1) or catchment soils (14 – 67 mg P kg-1), indicating P mobilization in the reduced sediment and immobilization upon re-oxidation.

During erosion easily soluble P fractions (NH4Cl-P and NH4F-P) were depleted. Drying of the sediments increased amounts of Alox and Feox, indicating more sorption sites of P on clay particles and resulting in the decrease of P saturation of these sorption components. Oxidized CW sediments had a very high capacity to adsorb P attributable to the processes to which the material was subjected. This impact was clearly demonstrated in the pot experiment. When the growing medium contained 12.5% of sediment, plant P uptake decreased by 6 – 50% in the non-P-fertilized pots and by 6 – 17% in the P-fertilized pots, compared with the ryegrass grown in the field soil alone. The higher the sediment content in the pot was, the smaller was the plant P uptake, despite abundant P application.

The sediments are thus poor substrates to crops and their application to agricultural land can be recommended only in small doses. An alternative option may be the use of CW sediments as amendments in sites with excessive soluble P concentrations, such as cattle feeding areas.

Keywords：*constructed wetland sediment, erosion, phosphorus fractions, plant available phosphorus*

P4-194

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Protective Role of Humic Acids on DNA Methylation Caused Cadmium Stress in Vicia Faba Seedlings

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Heavy metal pollution is one of the most important environmental problems. Heavy metals pose serious problems for the environment and human health. So the present study was aim to observe epigenetically changes of Cd2+ (10-3 M-10-5 M) on Vicia faba seedlings. The results showed that all doses of Cd2+ (10-3 M-10-5 M) caused DNA methylation changes. In addition, when different five concentrations of HA (%2, %4, %6, %8, %10) were added together with 10-3 M, 10-4M, 10-5 M of Cd2+, DNA methylation changes decreased .Results suggested that HA have an antagonistic effect against Cd stress induced DNA methylation. Especially, the degree of antagonistic effect of HA against Cd2+ is probably related to its concentration ratio.

Keywords：*Cadmium, DNA methylation, Humic acid, CRED-RA.*

P4-195

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Role of Soils in Conservation of an Endangered Shrub in the Oil and Gas-Rich Uinta Basin, USA

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Schoenocrambie suffrutescens (shrubby reed mustard; also Glucocarpum suffrutescens or Hesperidanthus suffrutescens), an endangered perennial shrub endemic to the Uinta Basin, Utah, faces habitat loss and fragmentation due to energy development particularly road construction and gas and oil drilling. Although shrubby reed mustard (SRM) has been long been observed in a particular shale strata of the Green River formation (Eocene), little is known about the ideal range of soil chemical and physical properties required for successful establishment, growth, and survival of SRM populations. Soils with (SRM) and without (Non-SRM) shrubby reed-mustard vegetation were sampled at three populations within the Uinta Basin: Johnson Draw, Big Pack Mountain, and Badland Cliffs. Vegetation in Non-SRM plots was typically Artemisia nova (black sagebrush). A total of 49 soil profiles were described and sampled by morphologic horizon in small, hand dug excavations. Soil samples were sieved to obtain the <2mm fraction and analyzed for particle size distribution, available phosphorus, inorganic and organic carbon, nitrogen, cation exchange capacity (CEC) and total elemental analysis. Electrical conductivity (EC), sodium adsorption ratio (SAR), pH, and elemental analysis were determined on water extracts (1:1 soil:water). Using field and remote-sensed spectral data, a predictive model of potential SRM habitat was created to assist land managers in conservation and revegetation efforts. We found that SRM grows exclusively on shale and in shallow soils. Average depth to bedrock for SRM soils was 23 cm, with only one soil deeper than 50 cm. On a weighted-average pedon basis, SRM soils had siltier textures (silt or silt loam) whereas Non-SRM soils had sandier textures (loam, sandy loam, clay loam). Inorganic carbon as carbonates was higher in SRM plots (6.0% versus 4.2% for Non?SRM plots), but organic carbon and nitrogen were similar in both plots (1% C, 0.1% N). Organic carbon to nitrogen ratios (C:N) were higher for SRM soils (14) than for Non?SRM soils (10), indicating that the organic matter present in SRM soils is less highly decomposed than in Non?SRM soils. Available phosphorus in the SRM plots (17.4 mg P/kg soil) was about half the levels found in Non?SRM plots (41.8 mg P/kg soil). SRM soils had slightly higher CEC, pH and SAR than Non-SRM soils, but lower concentrations of the potentially toxic heavy metals Ag, As, Co, Cr, Cu, Ni, Sn, and Zn. The soil of this endemic plant is spectrally distinct, so we were able to predict the general area of potential habitat successfully with Landsat remotely sensed spectral data. Once in the area, a limited set of soil observations further indicated high probability of potential habitat. These predictions can be used in planning new energy development strategies, locating additional plant individuals, identifying areas to focus possible revegetation efforts.

Keywords：*conservation ecology, remote sensing, soil-plant relationships, digital soil mapping, , endangered species*

P4-196

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Improving Rainwater-Use in Cape Verde Drylands: Effect of Land Management Techniques on Runoff and Erosion

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Land degradation is a major environmental issue in Cape Verde and has been associated to prolonged droughts and inadequate dryland agricultural practices such as cultivation of steep slopes and bare soils. Food production is severely hindered by inconsistent rainfall patterns, high intensity storm events, water losses through rapid runoff, and low soil fertility, resulting in poor rainwater-use efficiency. This study proposed to evaluate the effects of selected soil and water conservation techniques combined with organic amendments in Cape Verde drylands, aiming to improve the efficiency of rainfall through reduction of runoff and sediment yield. The study approach combined traditional and scientific knowledge in a field-based participatory approach. We conducted a local farmers´ workshop in which farmers identified the major constraints on dryland, proposed solutions, and selected the treatments to be tested according to specific site characteristics.

We compared the effects of crop residue mulching (4 ton ha-1), Cajanus cajan (pigeon pea) barriers, soil surfactant (1mL m-2), compost (4 ton ha-1), animal manure (4 ton ha-1), and green manure (Leucaena leucocephala pruning at 1 ton ha-1) on runoff, soil erosion and soil moisture during 2011 and 2012 rainy seasons.

Three experiments were conducted: one on-research station, representing a sub-humid agro ecological zone with 8% slope, and two on-farms, representing semi-arid agro ecological zones with slopes of 23 and 37%. The four treatments (including the untreated control) were applied, in three replicates, to experimental units, hydrologically isolated, consisting of 44 and 24-m2 field plots in the two on-farm and the on-station trials, respectively.

A local variety of maize and two types of beans were planted after the first significant rain in each plot.

Field instruments (rain gauges, TDR, data logger with moisture sensor) were installed for continuous monitoring of rainfall and soil moisture. After each rainfall event, runoff and suspended sediment were collected and quantified. We estimated the total runoff and erosion for the rainy seasons.

Of the total rain events that occurred during the experimental seasons, 16 in 2011 and 18 in 2012, only 7 produced runoff in the first year and 6 in the 2012. The highest amount of runoff occurred for large rainfall events (>35 mm in 2011 and >25mm in 2012) and depended on slope gradient, degree of soil cover, soil texture and distance between rain events.

Results showed a highly significant effect ($p<0.01$) of treatments on both total seasonal runoff and sediment yield reduction across sites. The application of residue mulch combined with an organic amendment and/or pigeon pea barriers generated 89, 84, and 56% less runoff than the control for the three sites in year one, and 99, 99 and 95% of the same sites in year two.

Even though the number of rain events was lower in 2012, total runoff was generally higher than in 2011 for all treatments, except for the mulched plots.

The total amount of runoff varied from 0.2 l m-2 in a loam soil with 8% slope to 20.1 l m-2 on a silty clay loam soil with 23% slope. Slope gradient alone cannot explain the high amount of runoff since the site with the highest slope gradient did not generate the highest amount of runoff.

For the sites with higher slope gradient, even though total runoff was higher for the 2012 rainy season, total sediment yield was higher for 2011 rainy season. However, for the site with low slope gradient (8%), both total runoff and total sediment yield were lowest for 2011 and highest for 2012.

Total annual sediment yield was almost negligible (0.02 g m-2) for treatment with mulching combined with an organic amendment, and as high as 16,6 Mg ha-1 for the control. The application of organic amendments, either combined with soil surfactant or pigeon pea barriers, did not significantly affect total runoff or sediment yield ($p>0.05$).

We conclude that a combination of surface cover with an organic nutrient source, with or without vegetation barriers can contribute to a significant reduction of runoff and soil loss from dryland agricultural fields in Cape Verde, thus improving rainwater-use efficiency at the plot level.

Keywords：*Dryland, land management techniques, erosion, runoff, rainwater-use efficiency, Land degradation, Cape Verde*

P4-197

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Comparison of Legumes Types for Soil and Water Conservation and Cassava Production Increase

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The study about the legumes types comparison for soil and water conservation and cassava production increase was conducted by Land Development Research and Technology Transfer Division at Pakchong District, Nakhonratchasima Province. The objectives of this study were to compare physical and chemical soil properties and intercrop cassava and legumes types' incomes. The experiment was randomized complete block design with 4 replications of 6 treatments consisting of plot controlling, and five intercropping legumes as cavalcade (Centrosema pascuorum cv. Cavalcade), jack bean (Canavalia ensiformis), stylo (Stylosanthes guianensis), hamata (Stylosanthes hamata cv. verano) and pigeon pea (Cajanus cajan). Four types of legumes; i.e., cavalcade, stylo, hamata and pigeon pea were cut off twice after growing them for 90, 150 days, respectively. Their bodies were used to cover the soil surface in the study areas, whereas jack bean was cut down once after its growth for 90 days. In crop 2, the results showed that pigeon pea intercropping with cassava had the highest increasing physical and chemical soil properties with the soil moisture of 22.79 percent, the organic matter in the soil of 1.73 percent. The biomass was 7,566.69 kilogram per hectare. The carbon-nitrogen ratio is 14: 1. The cassava yielded 27,343.75 kilogram per hectare. The highest net income was given by intercropping with pigeon pea which was 37,662.50 bath per hectare. Cassava intercropping with pigeon pea was the most suitable for both of soil and water conservation and cassava production increase as well management.

Keywords：*Legumes tyes , Soil and Water Conservation , Cassava , Intercropping*

P4-198

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil Compaction in Sugarcane Fields Due to Cultivation and Mechanical Harvesting (South West of Iran, Khuzestan Province)

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In sugarcane cultivation devices and heavy machinery are widespread use. The farm machinery traffic can have detrimental effects on the soil surface stability and leads to compact the soil. This is undesirable from the standpoint of agricultural soil compaction reduces porosity, aeration and increases the soil mechanical resistance to root penetration. Since sugarcane is a crop that is sensitive to soil compaction, this can be considered an agent of the yield reduction in recent years. In this study the bulk density of soil layers at three farms (Plant, Ratoon1 and Ratoon2) was determined at different times and the results were analyzed. The results show that even after ratooning operations, the average bulk density of soil layers in the field, there are significant differences. Bulk density after crossing the Harvester machine increases that is predictable according to the weight of the heavy, clay percentage and low organic carbon content of the upper layers of soil. Evaluation of changes in bulk density of soil in both pre-harvest and post ratooning also demonstrated the impact of these practices on farms ratooon1 and ratoon2 in comparison with farm plant is probably due to the presence of plant debris left over from the previous year in these two fields causes the soil structure has been relatively more stable. Comparison of this parameter (bulk density) in the different layers of soil shows significant different for the second layer of soil (after 40 cm).

In agriculture, soil compaction lead to decreased soil aeration and increased the soil mechanical resistance to root penetration. For sugarcane critical penetrometer resistance is 200 KPa. In compacted soil, root growth is limited and decreases the efficiency of nutrient uptake that in this respect phosphorous and potassium is more important.

So in sugarcane fields to prevent soil compaction, addition of ratooning operations, good management should be applied to all process of cultivation and the traffic of heavy farm machinery.

Keywords：*Keywords: sugarcane, cultivation, soil compaction, bulk density, soil porosity, mechanical resistanc*

P4-199

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

The Practice of Coivara in Agriculture and the Effects on the Physical, Chemical And Hydraulic Properties of Soil In Intensived Waved Relief in Hilly Environmental in the Atlantic Biome - Brazil

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Issues related to the theme of the environment are very discussed nowadays, among which we can put in evidence agricultural practices involving soil management using fire during the process. The resident people of Atlantic Rainforest, during the process of agriculture, set fire in the forest after cutting the weald in order to facilitate the cultivation procedure of species by making it possible to select and to spread some specific plants. Thus, the landscape that we are in - classified as natural - can be, in fact, a system than has been managed by people who lived in there for centuries. The coivara (slash and burn agriculture) in its broadest definition, is any uninterrupted agricultural system in which the gaps are opened to be grown for shorter periods of tine than those intented for fallow. The process is done before the rainy season in the region. The bare plots are cultivated in one, two or at most three years - rarely more than that - and then are abondoned to the fallow forest to regenarate the soil's nutrients so it can be used later again - with an alternation - for planting. The purpose for which the work is proposed consists in analyzing the physicochemical properties of erosion and water dynamics in the soil in an area under the practice of coivara. This study has been developed in Sao Pedro da Serra, 7th district of the city of Nova Friburgo, in the mountainous region of the State of Rio de Janeiro, southeastern Brazil. The climate is Tropical Altitude, with averages ranging from 18 ºC in winter and 24 ºC in summer because of the altitude related to sea level. It shows rainfall indexes around 2,225 mm to 1,500 mm. Two distinct periods can be observed: a wet season (November to April), with continuous rain occurrences, and a dry season (May to October), with lower rainfall. On geomorphological aspects, to be inserted in the mountainous region of Rio de Janeiro, Sao Pedro has a very rugged topography with steep topography, typical of the region characterized as Serra do Mar, alternating with small valleys and floodplains, cut by streams and small rivers. This geomorphological character implies in the field of Cambisols, Oxisols Red-Yellow and rocky outcrops. On the geology, there is a predominance of Precambrian igneous and metamorphic rocks. In these grounds highlights two tectonic compartments called Atlantic Mobile Belt (consisting of the Serra do Mar, the Paraiba do Sul Complex, Serra da Mantiqueira), in a track oriented NE / SW and range of Juiz de Fora (composed of granulitic rocks). The mountain of Serra do Mar is presented with the remnant of the Atlantic Rainforest. To develop the study was selected an area with a 2-3 years fallow in which 3 plots bounded by steel plates with dimensions of 22m x 4m totaling 88m² were installed. These are connected with water storage tanks (1000L) by a PVC tube. The first plot installment (PO) limits the fallow area in which the study will be done. The second installment (PC) was performed the practice of coivara, consisting of cutting the existing forest and after a period committing the burning of this material. After the burning, it was done the planting of sweet potatoes, a cultivation that has high prevalence in the region, also acting as a forage kind. The third installment (SC) has been left without vegetation cover, exposing the soil to simulate a degraded area. In each parcel are being monitored the matrix soil water potential with the use of the Granular Matrix Block (GMS) in order to obtain the soil humidity and understanding the dynamics of the water in the soil at depths of 20cm and 40cm. The results have shown that the fallow (PO Plot) assists in the issue of protecting the soil, minimizing water losses and soil, providing good drainage. Regarding the PC Plot, the results will be more efficient with the increase of cultivation, since the action of the practice of coivara with the implemented specie (sweet potato), the water loss and soil tend to be minimminimized, unlike SC parcel, which initially shows a behavior with high water losses and soil with slow drainage of the lower layers.

Keywords：*slash and burn agriculture; erosion plot; PROPERTIES OF SOIL*

P4-200

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Digital Soil Mapping Available Water Content Using Proximal and Remotely Sensed Data

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Two thirds of all irrigated agriculture in Australia is undertaken within the Murray-Darling Basin. However climate change predictions for this region suggest rainfall will decrease. To maintain profitability, more will need to be done by irrigators with less water. In this regard, irrigators need to be aware of the spatial distribution of the available water content (AWC) in the root-zone (i.e. 0.0-0.90 m). To reduce cost of mapping, digital soil mapping (DSM) techniques are being used to map soil properties related to AWC (e.g. soil texture). The purpose of this study was to create a DSM of the AWC at the district scale. This is achieved by determining AWC by difference between laboratory measured permanent wilting point (PWP) and field capacity (FC) and using pressure plate apparatus. The PWP and FC data is coupled to remote (i.e. gamma-ray spectrometry) and proximal (i.e. EM38 and EM34) sensed data and two trend surface parameters. Using a hierarchical spatial regression (HSR) we predict PWP and FC across the areas of Warren and Trangie, (lower Macquarie valley, Australia). The reliability of the DSM of PWP and FC were compared using prediction precision (RMSE – root mean square error) and bias (ME–mean error). The best results were achieved using EM38-v, EM34-20, eU, and eTh. The DSM map of AWC is consistent with known Pedoderms and provides a basis for agricultural water management.

Keywords：*Available water content, EM, gamma-ray spectrometry*

P4-201

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Impacts of Land Use/land Cover Change on Rainfall in Nam Pong Watershed, Thailand

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Nam Pong watershed in the northeast region of Thailand, the upper part of Chi River basin a tributary of the international Mekong River basin, covers an area approximately 15,190 km^2. The upstream watershed is comprised four main rivers; Choen river, Prom river, Pa Niang river and the upstream Pong river, which flowing into Ubolratana reservoir. The downstream watershed area comprised the Pong river and its tributaries flowing into Chi river basin. Due to the rapid population growth, urbanization and agricultural in Nam Pong watershed has been subjected to considerable land use changes over the last decade. The change of land use/land cover due to strong influences of energy, moisture and turbulent fluxed which lead to affect precipitation generation, patterns and associated water resources. In this connection, the purpose of this study was to determine the impact of land use/land cover change on rainfall in the Nam Pong watershed in northeast, Thailand over a 10-year period using an integration of remote sensing, Geographic Information System and statistical methods. The daily rainfall from thirteen meteorological stations during 1999-2008 was used in this study. The land use/ land cover change showed an expansion of agricultural areas, urban areas and water bodies by 1.0% (from 4,142.7 km^2 in 1999 to 4,181.8 km^2 in 2008), 0.4% (from 181.5 km^2 in 1999 to 182.3 km^2 in 2008) and 0.2% (from 331.4 km^2 in 1999 to 332.0 km^2 in 2008) respectively, whereas the forest areas were declining by 2.4% (from 1,722.9 km^2 in 1999 to 1,682.4 km^2 in 2008). The Nam Pong watershed was no significant long-term trends in rainfall characteristics. However, the highest rainfall amount was found in the rainy season approximately 85%, while only 15% of rainfall amount was found in dry season. The distribution of rainfall amount in the upstream watershed is higher than the downstream watershed. This result indicated the relatively small decrease in the land coverage of forest areas may have had a disproportionally large impact on amount, pattern and distribution of rainfall. Nevertheless the most important cause on change of rainfall amount was influenced by south west moon soon, tropical storm and also the effect of climate change.

Keywords：*Land use/ Land cover change, Rainfall, Climate change, Nam Pong watershed*

P4-202

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Predictive Performance of the Wepp Model on Runoff and Sediment Yields under Soil Conservation Measures on Hillslope Area: A Case Study Under Tropical Savanna Climate, Thailand

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Soil erosion is a hazard traditionally associated with agriculture in tropical areas and is important for its long-term effects on soil productivity and sustainable agriculture. Soil conservation measures based on contour grass strips or hedgerows are extremely effective in reducing water runoff and controlling erosion on steep slopes but field experimenting of their potential application is costly, long-term monitoring and laborious. The Water Erosion Prediction Project (WEPP) model allows simulating many types of non-uniformities on a hillslope through the use of strips or Overland Flow Elements (OFE's) which each is a region of homogeneous soils, cropping, and management. The objective of this study was to evaluate the performance of the WEPP model on predicting of runoff and soil loss under applying various soil conservation practices. Simulation of the WEPP was conducted on loamy-skeletal, siliceous, isohyperthermic, Kanhaplic Haplustults. Meteorological, runoff and sediment data on the experimental runoff plots of bare fallow, maize mono-cropping, inter-cropping of maize with chilli and hedgerow strips between maize inter-cropping with chilli was collected for assessing predictive performance under different conservation cropping systems on soil loss and runoff controls on hillside area with the representative rainfall events of tropical savanna climate. The model evaluation indicated that the WEPP models perform well in prediction of runoff (RMSE; bare plot = 28.20 kg/m2, mono-cropping = 42.60 kg/m2, inter-cropping = 24.16 kg/m2, and hedgerow = 47.23 kg/m2). The result showed that the WEPP model performed well for predicting runoff in the complicated inter-cropping but very poor prediction of sediment yields.

Keywords：*WEPP model, Soil loss, Runoff, conservation cropping systems, hillslope, Tropical savanna*

P4-203

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Effect of Pasture Improvement Strategies on Indicators of Soil Physical Quality and Pasture Yield in Southern Chile

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INTRODUCTION

Pasture improvement strategies normally applied in southern Chile involve tillage or only soil fertilization (Siebald et al., 1983), being the most commonly used tillage and sowing seeds of genetically improved pasture species. This choice mainly considers pasture production parameters, without taking into account changes that may occur in the soil from a physical perspective and temporal quality, which are related to the sustainability of the pastoral system. Thus, it was evaluated the physical quality of a Duric hapludand (Valdivia Series) in two seasons (Dec. 2010 and Oct. 2011) as a consequence of pasture improvement strategies.

MATERIAL & METHODS

Four pasture improvement strategies were applied to a degraded pasture grazed by sheep (T1: Lolium perenne L. + Trifolium repens; T2: Bromus valdivianus Phil., L. perenne, Dactylis glomerata and T. repens; T3: Naturalized without fertilization; T4: Naturalized with fertilization). Physical parameters determined considered the capacity–intensity concept proposed by Horn and Kutilek (2009). Plant available water (PAW), S index and air capacity (AC) are consider capacity indicators; and defining intensity are air conductivity (kl) and pore continuity indices.

The soil bearing capacity (BC) and aggregate strength (AS), as indicators of soil mechanical stability were determined. Additionally, the soil volumetric water content in situ with moisture sensors (SM200) with which the water consumption of different grassland soil was estimated.

RESULTS & DISCUSSION

The strategies related to soil tillage (T1 and T2) increased PAW levels (40%), S index (0.080) and AC (15%). The no-tillage soil had higher values for intensity (kl) ($p<0.05$) and pore continuity index ($p<0.05$). Consequence of this the parameters of the relationship between air permeability (ka) and air-filled pores (εa) improved their adjustment in the logarithmic scale. On the other hand, the volume of blocked pores (εb) was larger in the tilled soils, reaching a maximum of 4% in T2. It was a tendency of T3 and T4 pastures to show greater soil stability when grazing events occurred.

The in situ behavior of soil water showed that tilled pastures had significantly larger water consumption (40 m3 ha-1) than the no-tilled pastures, explaining this higher water consumption the high pasture growth rate of the tilled soils. However, the pastures that

maintained their original soil structure showed in the long term higher forage growth rates and higher herbage mass accumulated. The total herbage mass accumulated for the whole evaluated period showed that the total herbage mass produced by the tilled soils and sown pastures was similar to that produced by the non-tilled soils.

It is possible to argue that while soil tillage favors the parameters describing the soil's ability to storage water (PAW, S index and AC), allowing high pasture growth rates and biomass accumulation during the beginning of the lifespan of the improved pasture, this strategy also involved a higher energy consumption and mineralization of soil carbon. In the long term, the no-tilled and fertilized pasture achieved higher levels of herbage production, but also it was able to better grow through the summer water restriction and tolerate in a better manner the mechanical disturbance due to grazing sheep. Thus the no-tilled pasture improvement strategy conferred a larger sustainability to the grazing system.

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Keywords：*Soil physical quality, pasture improvement strategies, soil capacity-intensity*

P4-204

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Erosion in Hillside Para Rubber Plantation of Northern Thailand as Affected by Soil Conservation Measures: A Case Study

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As widely known, Para rubber plantation in Thailand has become very popular recently. Substantial increases of planting areas and number of farmers can be especially observed in the North and Northeast of Thailand. Nowadays, many farmers in the uplands of northern Thailand replace short-term cash crops by monoculture of rubber tree plantations. Moreover, some of the original forest cover in upland areas has been cleared for agriculture including Para rubber cultivation. Therefore, in recent times, the expansion of rubber growing into primary forest has been most common in the uplands of northern Thailand, as a result of population growth, and insecurity of land rights. In the case of Para rubber, homogeneous monocultures can indirectly result in deforestation and manifold negative biodiversity and environmental consequences. Intensive rubber plantation in upland areas is susceptible to erosion as a result of land clearing and preparation. Therefore, the objective of this study were to assess (i) erosion in hillside rubber plantation and (ii) effects of soil conservation measures on soil loss and runoff. Data were collected from an erosion trial on a clayey, isohyperthermic Petroferric Haplustults and investigated 2 years old rubber trees during 2013 -2014 at Wang Thong district, Phitsanulok, Thailand, with slope gradients ranging from 18%. The experiment was randomized complete block design with 3 replications and 5 treatments. The treatments consisted of 1) sole rubber 2) rubber intercropping with maize 3) rubber and vetiver grass strip 4) rubber intercropping with maize and rotated crop with soy bean 5) rubber intercropping with maize and vetiver grass strip. The result shown that treatment 3 gave the most soil losses and treatments 1 gave the second soil losses whereas treatments 5 gave the least amount of soil losses .We recommend that rubber intercropping with maize and vetiver grass strip gave positive trend and appropriate to use as soil conservation patterns to farmers in northern Thailand.

Keywords：*Para Rubber, soil losses, runoff, intercropping*

P4-205

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Effects of Conservation Agriculture Practices on Resource Use Efficiency and Crop Yield in Rainfed Semi Arid Regions of India

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Rainfed agriculture in india is characterized by recurring drought, ill distributed intense rainfall, degraded soil with poor nutrient status and water holding capacity. Soil degradation in rainfed agriculture is caused by the complete removal or burning of crop residues at harvest and intensive tillage practices leading to soil erosion. This has resulted in reduced organic carbon content in soil and crop productivity. Hence, development of feasible conservation agriculture practices involving minimal soil disturbance, crop residue retention and crop rotation is considered as more sustainable cultivation system. However, sparing of crop residues to the soil is a major challenge as it has other diverse needs.

In this context, an experiment was initiated to evaluate the performance of different tillage practices and residue levels on surface runoff, soil loss, soil carbon content and crop yield in pigeon pea-castor cropping systems in semi arid alfisols of India. The experiment was laid out in split plot design with tillage as main plot and residue levels as subplot. Different tillage practices studied was conventional tillage, reduced tillage and zero tillage. The three tillage systems represent three different tillage intensities. The conventional tillage is the usual farmers practice under existing rainfed conditions. This consists of one pass with disc plough in off season between April to May depending on the rainfall, and was followed by one pass of cultivator and one pass of disc harrow after the onset of monsoon before sowing of the crop. Weed control is achieved by three inter cultivation operations with bullock pair drawn harrow and hand weeding. Reduced tillage is attained by reducing one pass of disc plough in off season, and involves one pass with cultivator followed by disc harrowing before sowing. Weeds are controlled with one inter cultivation operation by bullock drawn harrow and application of pre emergence herbicide. The third tillage treatment is zero tillage in which direct sowing is done without any tillage and weed control is achieved by using pre and post emergence herbicides. In all the three tillage systems the crop was sown with herbicide cum seed and fertilizer planter. The sub plot treatments involve three harvesting heights (0 cm, 10 cm and 30 cm) which resulted in different heights of anchored residues. Recommended package of practices were adapted for cultivation of both pigeon pea and castor crops. Runoff gauging devices (tipping buckets) was installed in various treatments to monitor soil and water runoff loss. Soil and water were analyzed using standard procedures for quantification of nutrient losses.

Results of the four year study reveal that, less intensive tillage practices have reduced the surface runoff and soil loss from pigeonpea-castor cropping systems. Surface water runoff loss was 28% higher in conventional tillage and 17% higher in reduced tillage over zero tillage. 67% and 66% higher soil loss in conventional and reduced tillage was observed as compared to zero tillage. Similarly nutrient losses were lower in zero tillage as compared to conventional and reduced tillage. Surface runoff and soil loss decreased with increase in residue levels. Soil organic carbon on equivalent mass at 0 to 7.5 cm and 7.5 to 15 cm soil depth decreased in conventional tillage where as in reduced tillage decrease was observed only in surface layers (0-7.5 cm). Zero tillage has recorded increase in soil organic carbon on equivalent mass basis up to 15 cm soil depth. In initial years of the experiment conventional tillage and reduced tillage has recorded higher seed yield as compared to zero tillage. However, difference in the yield levels between tillage systems has narrowed down with years of experiment. In castor difference in yield is narrower as compared to pigeon pea. Zero tillage with 10 cm anchored residue have recorded higher yield as compared to no residue (0 cm) plot. It is concluded that conservation agriculture increases resource use efficiency by reducing soil, water and nutrient losses and increasing the soil carbon content and crop yields.

Keywords：*Conservation Agriculture, tillage practices, residue levels, soil loss, crop yield*

P4-206

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Phosphorus Fractions in Waterway Sediments under Different Land Uses

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P forms into waterways are affected by type of land uses. P mainly transports as particulate form, as bound to the most erodible soil components (clays, organic matter, and oxides of Fe and Al). To determine of land use effect on the phosphorus fraction, 24 samples collected from waterway sediments adjacent to various land uses of Ivak river, in a semi arid region, Hamadan, western Iran. Iron-P of sediments adjacent to agricultural lands (301.8 mg kg-1) was greater than adjacent to rang lands (157.5 mg kg -1) due to more fine-textured sediments and the higher Al and Fe concentration probably reflected sorption Al and Fe by fine sediments. In spite of agricultural lands (17.7 mg kg -1) the higher Ca-P concentration was observed in rang lands (31.5). More Ca-P content in rang lands based on correlation analysis could be related to increase of sand particles in texture of rang lands. Generally loading phosphorus from agricultural lands was more than rang lands. Based on statistical analysis observed that there are positive correlations between Fe extracted by oxalate and Fe-P and between sediment oxalate-extractable Fe/Al and clay and silt particles. It could be associated with the contribution of fine particles in Fe and Al maintenance. Thus higher Fe and Al in sediments adjacent of agricultural land is as a results of selective erosion. The results of isotherm experiment showed that maximum phosphate sorption was 1428.7 in sediment with 30.5 % clay. Qmax of the sediment from agricultural lands were the highest. The content of Qmax and bL for drainages of adjacent of agricultural lands were 434 to 1482 and for rang lands varied 277 to 769. This finding is consistent with the fine texture in agricultural lands.

Keywords：*Phosphorous, waterways, sediment, land use*

P4-207

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Application of Inverse Geochemical Modeling for Predicting Surface Water Chemistry in Ekbatan Watershed, Hamedan, Western Iran

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Description of surface water chemistry evolution was conducted by multivariate statistical analysis and inverse geochemical modeling using PHREEQC computer program. Using Hierarchical cluster analysis the 14 sampling sites were classified into three groups (recharge, transit and discharge areas). Water chemistry changes in flow path so that waters with Ca-HCO3 and Mg-Cl composition changed to Mg-Cl-HCO3 waters. The order of abundance of the major cations was Mg > Ca > Na > K. Their concentrations averaged 21, 19, 3.6 and 2.5 mg l-1 respectively. Inverse geochemical modelling along flowpaths indicated that the dissolution of sylvite and kaolinite and precipitation of feldspars and andalusite happened with Na into the solution and Ca, Mg, and K out of the solution.

Keywords：*Surface water; Inverse modeling, PHREEQC, Calcite, Hamedan*

P4-208

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Reservoir Sediment Prediction in Duhok Dam Using Artificial Neural Network and Conventional Methods

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Estimating soil erosion and sediment yield in watershed can play an important role for study on dams and reservoirs. Because of complicated and nonlinear process of sediment load and the lack of data in hydrological stations, it's difficult to measure exact sediment yield. However, the classic methods usually cannot handle the problem as well. In this study, Artificial Neural Network (ANN) as a non-linear black box model is used for modeling sediment yield in the dam of Duhok, located in Duhok, Kurdistan region, Iraq. The ANN is becoming a strong tool for providing environmental engineers and hydrological process with sufficient details for design purposes and management practices. For this aim, Observed time series of water discharge at current and previous time steps are used as input to a three-layered back-propagation feed-forward neural network model and the output will be the estimated sediment yield. The best architecture of the ANN method is obtained by try and error. The obtained results are compared with the results of two conventional methods (i. e., linear regression model and rating curve method) by using coefficient of determination (R2) and model efficiency factor (E) in order to approve the efficiency and ability of the proposed method. Results indicated ANN model performed better than conventional methods.

Keywords：*Artificial Neural Network, Linear regression, Curve number, Sediment load*

P4-209

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil Erosion Conservation Measures in Nepal: A Review

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Soil erosion is one of the most serious environmental problems facing by human society. It has also resulting the loss of agricultural crops and top soil every year. Soil conservation techniques are being promoted by Department of Soil Conservation and Watershed Management (DSCWM) in Nepal. Although the soil erosion conservation measures are being implemented, there has been no considerable progress in modeling erosion and validation of these models for principal soils and ecological regions in Nepal. Further, erosion-induced losses on crops yield are increasing every year which has created the land degradation and losses in its potential to yield the crops. Erosion can cause change in soil carbon dynamics and non-point emission of minute particles into the environment causing air and water pollution.

Keywords：*Soil erosion, conservation measures, DSCWM, Nepal*

P4-210

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Specific Ion Effects in Polyacrylamide-Containing Aggregates

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Aggregates stability plays an important role in blocking soil erosion and soil loss. Studies demonstrated that the stability of aggregates can be improved through the addition of polyacrylamide. The specific ions effects, known by some micro mechanisms in the area of physic, chemistry, and biology, are significantly important in the study of soil science, specifically for aggregates stability. Therefore, it is worth to understand the mechanism of specific ions effects on the aggregates stability, and to clear the effect of coupling between the specific ions effects and the PAM on the aggregates stability. In this paper, we measured the percentages of micro-aggregates <10, <5, and <2 μm which released from aggregates break down, and scanned the conformation of K+/Na+-aggregates with different content of PAM with the scanning electron microscopy. The specific ions effects are presented by K ion and Na ion, so the accompanying K+/Na+ electrolyte solution with different concentrations is adjusted to the electric field strength of the surface of soil particles. The main results are as followed: 1) micro-aggregates which released from aggregates break down were very high in the high electric field strengths, and vice versa, and that the percentages of micro-aggregates were very high when the electric field strengths were above the critical potential of the aggregate bursting down, and were low when that below. 2) Using the same electric field strength of -382.3 mV, the soil aggregates break down percentages of micro-aggregates <10 μm of K+ and Na+ at various concentrations of PAM (0%, 0.005%, 0.01%, and 0.03%) showed a decline pattern. At 0%, 0.005%, 0.01%, and 0.03% PAM concentrations soil aggregates break down percentages of micro-aggregates <10 μm for Na included 57.3%, 46.0%, 21.6%, and 6.1%; whereas K included 22.6%, 12.5%, 16.4%, and 6.4% respectively. Additionally, the result indicated that at 0.03% concentration of PAM showed significant difference from 0% PAM concentration which reflected the strongest ability to keep the aggregates from breaking down. However, the significant differences were noted on the percentages of micro-aggregates which released from the K+-aggregates and Na+-aggregates break down. The biggest difference (Na-K) of the percentages of microaggregates between K+-aggregates and Na+-aggregates exceed 20% ~ 35%. 3) The conformation of Na+-aggregates had larger and mostly big particle space than that of K+-aggregates which is scanned in the same concentration of PAM. The conformation of K+-aggregates showed a little dispersion but was compact for a single. Additionally, from the angle of size distribution, the main largely particles which supplemented by small particles were included in Na+-aggregates; and both large particles and small particles were almost uniformly distributed in K+-aggregates. As the concentration of PAM was increased in the K+/Na+-aggregates, the conformation of the soil aggregates were more compact. But the larger and smaller dispersing particles were distributed in Na+-aggregates, and K+-aggregates made the directly opposite. The meaningful conclusion of specific ions (K+/Na+) effects is the coupling effect of electric field strength and the quantum fluctuation which played a leading role in the difference stability of the K+/Na+-aggregates. Because the outer of atomic nucleus of K+ ion have more electrons than Na+ ion, the conformation of K+ ion can be more easily changed than that of Na+ ion, thereby making K+ ions on the surface of particles effective aggregate between the soil particles. As a result of that, K+-soil aggregates are more stable than Na+-soil aggregates. The stability of aggregates was evidently improved with the addition of PAM, and specifically for Na+-soil aggregates in a low steady-state.

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Coupling of Soil Electric Field and Specific Ion Effects in Soil Particle Transport During Rainfall

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Specific ion effects are presently thought to be important in physics, chemistry, and biology while they have been given little attention by soil scientists. In this paper, we used three electrolyte solution (Na+, K+, and Cs+ nitrate) with different concentrations (0.0001, 0.001, 0.01, 0.1, and 1 mol L-1) instead of rainwater to adjust electric field around soil particle surface and studied the specific ion effects of monovalent cations on the intensity of soil transport during 110 min rainfall simulation with intensity of 150 mm/h-1. The specific ion effects were characterized by the intensity of soil particle transport. The results showed that there was remarkable discrepancy of the intensity of soil transport among Na+, K+, and Cs+ systems, showing strong specific ion effects on soil transport. This result opposed the classic double layer and DLVO theories. The classic double layer and DLVO theories just focus on counter-ionic valence and concentration but totally neglect the difference among ions, especially among the homovalent ions, which indicates that the electric field strength and particle interaction are the same value in two different homovalent ion systems, and further induce the same intensity of soil particle transport during rainfall. Obviously, it was not the case, referring to the results in this study. For example, at the concentration of 0.0001 mol L-1, the particle transport intensity in Na+ system was 6.0 and 26.3 times stronger than that in K+ and Cs+ systems respectively. On the other hand, the differences of soil transport intensity between two cation species significantly increased with the decrease of electrolyte concentration. This result completely changed the current theories for describing specific ion effects. The origin of specific ion effects is generally accepted as the result of ionic size, hydration effect, and dispersion force, which often present in high concentration electrolyte solution, and decrease with the decrease of electrolyte concentration. Therefore, the specific ion effects always appear in concentrated solution. However, in this study, the specific ion effects presented at low concentration, and gradually disappeared with increase of electrolyte concentration, showing that the current opinions of specific ion effects were defective. Further analysis showed that soil electric field and specific ion effects were coupled to influence soil transport during rainfall. The soil electric field, which originates from soil particle charges, could be up to 4.5×108 V m-1 that was at the same order of magnitude of the electric field strength at ionic outer shell electrons. Therefore, the quantum fluctuation of cationic electrons might be strongly enhanced. Thereafter, with different strength of quantum fluctuation in soil electric field, three cations had different abilities to oppose soil electric field, and finally resulted in different particle transport intensity. The suggested coupling of soil electric field and quantum fluctuation of electrons of cation might result in the specific ion effects in soil transport during rainfall and successfully explained all the observed phenomena qualitatively.

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Specific Ion Effects from Divalent Cations on Clay-clay and Clay-humus Interactions

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The origins and quantitative descriptions of specific ion effects on clay-clay and clay-humus interactions are not clear at present. We conducted a dynamic light scattering (DLS) study of montmorillonite montmorillonite and montmorillonite humus aggregations in Ca(NO3)2, Mg(NO3)2, and Cu(NO3)2 solutions (at pH 7). The total average aggregation rate(TAA) and critical coagulation concentration (CCC) were used to characterize the specific ion effects. Strong specific ion effects from divalent cations were found on the clay-clay and clay-humus aggregations. In 0.5 mmol/L Cu(NO3)2, Ca(NO3)2 and Mg(NO3)2 solutions, the difference between the average aggregation rates in the Cu(NO3)2 and Ca(NO3)2 solution was 196 nm/min and the difference between the average aggregation rates in the Cu(NO3)2 and Mg(NO3)2 solution was 219 nm/min for montmorillonite only suspensions. However, no aggregation occurred in either the Ca(NO3)2 or Mg(NO3)2 solutions when the humus content was increased to 1%. Apparently, Cu2+, Ca2+ and Mg2+ had significant specific ion effects on the CCCs, and the specific ion effect series followed the order CCC(Cu2+)<<CCC(Ca2+)<CCC(Mg2+). The Cu2+, Ca2+, and Mg2+ CCCs for the 100% montmorillonite suspension were 0.650, 2.38, and 7.99 mmol/L, respectively. The Cu2+, Ca2+, and Mg2+ CCCs for the 99% montmorillonite and 1% humus suspension were 2.00, 5.76, and 10.4 mmol/L, respectively. The observed specific ion effects could not be explained by ionic hydration effects, induction force (polarization), or coordinative adsorption, but the dispersion force dominated the Cu2+, Ca2+, and Mg2+ effects on the clay-clay and clay-humus interactions. The dispersion force intensities decreased in the order Cu2+>Ca2+>Mg2+, which could be explained by their electron shell structures. Cu2+ having the most electron shells and Mg2+ having the least. Quantum fluctuations in Cu2+ are, therefore, the strongest, resulting in it having the strongest dispersion force of the cations studied. We present a new approach, which could evaluate the amount of cations adsorpted on particle surfaces by dispersion force. Using this approach, we found that the dispersion force between a cation and particle surface was very strong for the divalent cation species studied, and dispersion force adsorption neutralized the negative montmorillonite surface charge to a significant degree (by 62.5%, 50.2%, and 26.1% for Cu2+, Ca2+, and Mg2+, respectively) at the critical coagulation concentrations (CCC). Approximately 69.3%, 37.7%, and 8.30% of the surface charge could be neutralized by the dispersion force adsorbed Cu2+, Ca2+, or Mg2+ onto the 99% montmorillonite plus 1% humus particles surface, respectively. We concluded that the dispersion force play a critical role in specific divalent cation effects on clay-clay and clay-humus aggregations. Compared with monovalent cations, the divalent cation species could strongly screen the electric field around the particles, meaning that the dispersion force would become relatively important in the cation surface interactions, resulting in the specific ion effects that were found, especially at relatively high electrolyte concentrations. However, the dispersion force adsorption of cations could greatly enhance screening effects from the cations, which could reverse the specific ion effects. While other forces may be important in specific ion effects in systems containing monovalent cations because the electric field cannot be sufficiently screened in such systems.

Keywords：*Hofmeister effects (specific ion effects), montmorillonite-humus complex, dynamic light scattering, dispersion force, divalent metal ions*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

The Effects of Water-Table Depth on Carbon Dioxide Emissions for Oil Palm Cultivation on Peatlands

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Globally, around 16.4 million hectares of land is under cultivation by oil palm plantations, which produce a third of the world's vegetable oil. Most oil palm expansion is in Southeast Asia, an area with vast peatlands. Plantations are increasingly being established on these carbon-rich organic soils. Tropical peatland draining for oil palm cultivation leads to a net release of greenhouse gas emissions to the atmosphere. Recent research identifies a relationship between increasing drainage depth and increasing carbon loss from peatlands. We apply regression analysis to assess carbon loss as a function of water table depth as measured by subsidence or closed chamber methods from oil palm and other perennial tree plantations in Southeast Asia. We limit these studies to those that include drainage depth, report at least nine months of emissions, are measured more than five years after initial drainage, and in the case of closed chamber studies, exclude autotrophic respiration. Our chosen model, developed from subsidence studies, suggests an emission rate of 68 tons CO2 ha-1 yr-1 at 70 cm water table depth for peatlands that have been drained for >5 years. This rate falls within the range of values suggested by other authors that conducted mass balance studies or compiled subsidence measurement reports. Based on our selected model, reducing water table depth from 70 cm to 50 cm would reduce emissions by 19% per year. Because peat soil emissions are disproportionately high in the first years after peatland drainage, we offer an optional and highly uncertain modification of our base emissions rate by a factor of 2.6 for the first five years after drainage, derived from a study by Hooijer et al. (2012). While our recommended emissions factor is derived from the best currently available data, long-term, large-scale, oil palm-focused studies are needed to more accurately estimate greenhouse gas emissions from oil palm plantations on peatland, as is necessary for policy decisions about sourcing oil palm for everything from cooking oil to biofuels. Moreover, water management techniques serve only to reduce emissions rates; only active protection will reduce total future emissions from tropical peatland ecosystems.

P4-214

[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Soil Water Erosion and Conservation in Xinjiang, the Most Arid Region of China

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Located in the inland arid area of central Asia and northwest of China, Xinjing is getting more attentions on water erosion issue, which is, highly related with the sustainability of soil and water resources. The Chinese national soil erosion survey Data (1985-2011) and Xinjiang statistical yearbook (2000-2010) data were used to analyze the trend, extent and influencing factors of soil water erosion in Xinjiang, as well as their environmental impacts, and integrated counter measurements. Results showed that the soil water erosion area in Xinjiang was 8.76×104 km2 in 2011, which mainly distributed in the Ili river valley and the northern and southern Maint Tian. Soil erosion degree was mainly weak, and the average erosion modulus was 2186 t km-2?a-1. During the past 26 years, soil water erosion area in Xinjiang reduced by 23.2%, whereas the extent is increasing. The influencing factors included (an order from high to low impact): population growth and human activities> vegetation degradation> rainfall and climate change> topography> soil erodibility> tectonics movement. Water erosion resulted in eco-environmental and social and economic losses, such as destroying farmlands and grassland, triggering flooding, deposition sedimentation in reservoirs, damaging transportation and irrigation facilities, and aggravation poverty, etc. Ecological restoration and integrated treatment of soil erosion in small watersheds was conducted in Xinjiang since 1994. This project firstly emphasized natural vegetation restoration, later focused on forest plantation and engineering measurements. Currently, the soil erosion treatment area is 1.95×103 km2 per year. This study highlighted the importance and longevity of soil and water conservation, and offers some suggestions on ecological restoration and desertification treatment in arid areas.

Keywords：*Xinjiang, Soil water erosion, arid area, ecological restoration, soil and water conservation*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Furrow Cover Effects by Using Non-Woven Fabric on Reduction of Nonpoint Pollutant Discharge in Red Pepper Cultivation Soil

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The contribution of nonpoint pollutant discharges in agricultural sector to national nonpoint pollution account for five to ten percent due to use of livestock manure, liquid manure, and chemical fertilizer in agricultural sector of Korea. It is need to verify the effects of non structural method of reduction of nonpoint pollutant discharge such as soil surface cover, small scaled pond. Non-woven fabric is widely used as a soil cover material which reducing weed occurring and soil-borne disease such as phytophthora blight and bacterial wilt. This study was conducted to evaluate the furrow cover effects with non-woven fabric on reduction of nonpoint pollutant discharge in upland soil at Jincheon County, The North Chungcheong Province in the center of South Korea in 2013. The soil texture of the experiment plot was sandy loam and slope was eight degree. The area of each experiment plot was 150 ㎡. During the red pepper cultivation, the rainfall from May to October was 953mm. The amount of water discharge was 65 tone per hectare during these experiment period. The experimental plot consisted of chemical fertilizer, cow manure compost, and pig manure compost and the each nutrient input material treatment plot has control(no furrow covering) and non-woven fabric furrow covering treatment, respectively. The amount of nutrient application were chemical fertilizer of 190-112-149(N-P-K)kg/ha, cow manure compost of 29.18 tone/ha, and pig manure compost of 7.83 tone/ha, respectively. The amount of total nitrogen discharge of rainfall runoff from no furrow covering treatments were in order of chemical fertilizer, cow manure compost, and pig manure compost and total phosphorus were in order of pig manure compost, cow manure compost, and chemical fertilizer. The amount of total nitrogen discharge of rainfall runoff from non-woven fabric furrow covering treatment were in order of chemical fertilizer, cow manure compost, and pig manure compost. The non-woven fabric furrow covering treatment reduced the amount of T-N discharge by 36.9～49.9 percent compared to no furrow covering treatment and reduced the amount of T-P discharge by 37.1～63.5 percent compared to no furrow covering treatment. The production of red pepper not showed significantly differences and there were no weed occurring in non-woven fabric furrow covering treatment plots. In conclusion, cover of furrow by using non-woven fabric in red pepper upland soil might be environment friendly upland management method to reduce nonpoint pollutant discharge from agricultural sector.

Keywords：*non-woven fabric, nonpoint pollution, nutrient discharge, red pepper, upland soil.*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Small Pond Effect on Reducing Pollutants Load from a Paddy Field with Livestock Manure Land Application

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This study aimed to develop an environmental-friendly best management practice (BMP) to reduce an agricultural non-point source (NPS) pollution load by agricultural activities. An eco-friendly way, small drainage pond, was suggested in this study to avoid direct drainage of agricultural runoffs and eventually reduce the amount of pollutants discharged into the surrounding aqua-environment. A small pond (12 m2) was constructed at the corner of a rice paddy field (1,715 m2) located in Suwon, Korea. Cultivated rice paddy field was treated with pig-based livestock manure as base fertilizer instead of chemical fertilizer. Water was allowed to drain only via the small drainage pond. Samplings were repeatedly made at two locations, one from an entrance and the other from an exit of a pond, during the rice cultivation period (May to September, 2013). Generally samplings were made only when runoff water drained through a pond, such as during and/or after rain (irrigation). The water quality analysis showed that all quality parameters (SS, CODMn, T-N, and T-P) were improved as water passed through the pond. The amount of runoff water was reduced by 67.8% during the rice cultivation periods. The loads of SS and CODMn were reduced by 89.3% and 82.0%, respectively. Also, the loads of T-N from rice paddy field and small pond were 0.22~3.71 and 0.00~1.47 kg ha-1. In case of T-P, the loads were 0.05~1.59 and 0.00~0.57 kg ha-1. Therefore, the amount of T-N and T-P were reduced by 82.6% and 85.6%, respectively. Our data implies that agricultural NPS pollution from rice paddy fields can be effectively managed when an appropriate drainage water management practice is imposed. In this presentation, it was suggested that an installation of a small drainage pond can be effective to prevent not only the nutrient loss from rice fields but also pollutant discharge to surrounding water environments.

Keywords：*Non-point source pollution, Rice paddy field, Small drainage pond*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Evaluation of Runoff and Soil Loss by Slope and Tillage Plan in Saprolite Soil

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Daegwallyeong region in Pyeongchang at Gangwon province is a typically highland agricultural areas. It is the characteristics of the mountain climate in located above sea level 800m. Precipitation is annual average about 1,890mm and is down about above 50% in intensively June and July, it is many areas with soil erosion. Surface-piled saprolite is frequently used to maintain the cultivated land in this phenomenon. Saprolite soil for reduction of crop damage by repeated cultivation and improvement of productivity have been utilized in highland cultivated land. This study was conducted to confirm effect of soil conservation after evaluating the rate of runoff and soil loss by cultivation time of crop(June～October), slope of cultivation land and cultivation plan in cultivation land of surface-piled sarprolite. The field(3.75 × 20m) is consist of respectively bare soil field, up and down field, contour field and plastic mulching field with up and down by 2, 7, 15 and 30% slope. It was planting with Chinese cabbage in mid-June and investigated the coverage of the crop.

This results, the rate of runoff and soil loss in accordance with slope and cultivation plan was investigated with respectively 74 - 96 and 75 - 98% in a intensive rainfall period of June to July for the entire study period. The rate of runoff and soil loss increased the higher the slope according to rainfall intensity, it was reduced the crop coverage increase in the second half of the planting. Soil conservation effect of cultivation plan is investigated with reduction of soil loss in 14 – 58% of contour field, 123 - 225% of up and down field and 84 – 310% up and down with plastic mulching for comparison with bare soil field by slope. soil loss of up and down field and up and down field with plastic mulching was higher by slope increase. As the slope increases to reduce the rainfall penetration of cultivation land soil, increasing the accelerated erosion due to rain, plastic mulching cultivation, increased loss of soil, especially. In the cultivation of crops, the plastic mulching have a number of advantages such as maintain soil moisture and weed control, but in terms of soil conservation, if necessary to limit the up and down with plastic mulching cultivation with more than 15% slope it is determined that the soil conservation effect is high.

Keywords：*Highland, Saprolite, Slope and cultivation plan, Soil conservation*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Evaluation of Soil Loss According to Surface Covering Methods in Potato Cultivation

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Potato was cultivated in slope land of highland areas during summer season when heavy rain falls so that soil loss occurs severely. Especially, soil disturbance by conventional tillage and exposure of topsoil before formation of potato canopy intensify soil loss. The aim of this study was to develop surface covering methods for reducing soil loss in potato cultivation. The experiment was conducted in 10% sloped lysimeter with treatments such as rye sod plot performed rye sowing and the ridge making simultaneously, and mulching plot with black polyethylene film. Amount of runoff water and eroded soil, and potato yield were investigated. Amounts of runoff water in rye sod plot showed 38% (118.3 m3 ha-1) decreasing effect compared with control (190.9 m3 ha-1) while polyethylene mulching plot showed 22% increase (233.7m3 ha-1) compared with control. Amount of eroded soil decreased by 45% (91.4kg ha-1) in rye sod plot but it increased by 8% in polyethylene multhing plot compared with control (167.7kg ha-1). However, yields of potato in these treatments were not significantly different. The results suggest that rye sod culture is very effective on soil conservation of slope land in potato cultivation.

Keywords：*Potato, Runoff water, Slope land, Soil loss, Surface covering*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Effects of Land Use Changes on Sedimentation Rates in the Henderson Creek Estuary, West Auckland, New Zealand

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Henderson Creek in West Auckland is an intertidal creek of an estuarine floodplain. Shallow creeks in the upper reachers of harbours adjacent to urban areas form an important resource for activities such as fishing and boating. Agricultural land use and urbanization of the Henderson Creek catchments has been shown to increase the peakedness and frequency of catchment high flows and sediment run-off to estuarine areas. We have reconstructed the recent history of sedimentation rates to the Henderson Creek estuary over the last 100 years and have examined trends with reference to land use changes. Four estuary sediment cores were obtained, and grain size of estuary sediment was analyzed and dated using 210Pb. The Auckland region has a temperate climate with a mean annual temperature of 15ºC and monthly averages fluctuating between 11 and 20ºC. Rainfall is relatively high with an annual average of 1240 mm, reaching a maximum in the winter month of July and a minimum in the summer month of February. The geology of the catchment includes two regional groups. Uplands are characterised by sedimentary and volcanic rock which consists of fine grained submarine volcaniclastic sandstone and siltstone (Sandstones and siltstones are easily eroded relative to harder volcanic rock). The lowland plain comprises alluvium which consists of Early Pleistocene non-marine, mainly alluvial sediments. European settlement around the estuary catchment started in the 1840s, and forest was clear-felled for timber production. Beginning during the 1870s, native vegetation began to regenerate in the forests, while the middle and lower reaches were developed for agricultural activities (viticulture, horticultural and growing crop), small scale urbanization and industrial activity. Major urbanization has undergone along the middle and upper reaches of catchment in the 1950s. This process has continued until present, expanding progressively upstream. The grain size showed that all points contained mainly silt. The average sedimentation rates for agricultural land use periods of catchments were 0.02-0.04 g/cm2/year for 1870s-1950s, and sediment transported from the catchment evenly accumulated over the estuary floodplain. In contrast, the average sediment rate in the estuary floodplain after 1950s was more than 3-7 times that before 1950s. The large-scale of farming and urbanization in the estuary catchment after 1950s accelerated sediment yield, which resulted in a large amount of sediment delivery into the estuarine areas. Agricultural land use and urbanization has brought about substantial environmental changes in estuary floodplain through continued infilling of shallow and rapid mangrove colonization of formerly bare intertidal sediments.

Keywords：*agricultural land use, urbanization, channelization, estuarine area, sedimentation rate, ^{210}Pb dating*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

The Water and Soil Environment at Pond Wetland in Agricultural Landscape, Korea

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This study was conducted to understand the water and soil properties to propose the promotion of vegetation environment at pond wetland. We selected 40 pond wetlands from agricultural landscape after consideration of surround land use.
As a result of a1 of water quality environment of the subject site for research, it has presented the need of management for having high pH density change for each survey period, and the reason for lowered figure of the dissolved oxygen is considered as have great reaction for the vegetation cove level. For the measure for any excess of COD and SS density average, it has prevented the water quality improvement plan as in dredging, removal of inner side sources, and removal of plant wastes. The cause exceeding the T-N density is determined as inflow of fertilizer ingredients and settling to disconnect the nitrogen fertilizer. As a result of the correlation a1 between the water quality environment and growth environment, the COD shows the trend to persuade in accordance with the connectivity of inflow structure and water resource that, as a plan to improve water quality, it has presented to refrain from the type without the inflow structure with the direct inflow of index water.

The contents of heavy metals of the pond is at the level yet to reach to the concerned level of the soil contamination and it is confirmed to be similar to the average of heavy metals in the paddy field soil of Korea and stated that there is a little water flow for zinc, lead, nickel and so forth to have less outflow of heavy metals.

The soil property distribution is confirmed to have the influence on unique environment and climate for the region. The soil phase distribution is analyzed as the similar level with the paddy soil.

As a result of the a1 on the soil chemical properties, pH is applicable for the weak acid but the acidity density of some subject site is statistically confirmed by discussing the rainfall collection and lapse of time. The organic matter contents are confirmed of high level in the closed water region of subject site for research and have presented the structural improvement to maintain the appropriate organic contents. The contents of the total nitrogen are proposed for removal and neglect of wetland plants for maintaining its appropriate level for places showing excess or insufficient trends.

After, we will conduct and discuss the relationship between vegetation, macro-invertebrate and soil, water environments, which will be used of the best practical management and restoration of wetland.

This study was supported by 2014 Post-doctoral Fellowship Program (Project No. PJ009412) of National Academy of Agricultural Science, Rural Development Administration, Republic of Korea.

Keywords：*Water quality, Soil heavy metal, Soil chemical, Soil physical*

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Analysis of Effects on Soil Erosion Reduction of Various Best Management Practices

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Recently, soil erosion from agricultural fields has causedvarious environmental problems which can weaken flood control capacity and speed up water quality degradation at receiving waterbodies. To solve these problems, Ministry of Environment (MOE) in South Korea have monitored forest land, agricultural field and eroded areas. With these endeavors, several Best Management Practices, such as silt fences and vegetation, have been tested and suggested. However, a lot of time and money are needed to monitor and determine site-specific BMPs. Thus, modeling skills are currently developed and enhanced to save time and money. In the study, five BMPs were applied to analyze and assess the effectiveness of each BMP using Soil and Water Assessment Tool (SWAT) model through the adjustment of USLE P value. Each BMP wasrespectively applied to the area where slope is 10 % and 20 % in Haeanmyeon watershed. As a result of simulation, bundle type vegetative canals showed the greatest efficiency for reduction of soil erosion. On the other hand, conventional flume pipe was the lowest. Based on these results, if bundle type vegetative canals are widely used in agricultural fields with steep slopes, soil erosion reduction of high efficiency would beexpected. Also, it can prevent water pollution and make positive effects about conservation of surface soil.

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[C3.2-1] Soil Erosion and Degradation on Agriculture Land

Research on Soil Storage Effect and Microbial Characteristics of the Slope Cropland-Mulberry System in the Three Gorges Reservoir Area

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Slope cropland with purple soil is the cradle of soil erosion which leads to non-point source pollution in the Three Gorges Reservoir Area. Mulberry is commonly grown in this area as economic crop. Planting mulberry as contour hedgerow can effectively reduce soil erosion and control non-point source pollution. Making use of surface runoff plots, the regulation of soil storage effect and microbial characteristics were studied. The results are as follows: Cropland-Mulberry system could improve the content of soil nitrogen, phosphorus, organic matter compared with Cropland-daylily system, Cropland-Honeysuckle system and conventional farming (CK). The soil storage distributive line became wavy after planting hedgerows. Flora were follow descend trends from the top of slope to the toe of slope. Microbial amounts of soil under hedgerows were higher than the amounts of soil far from hedgerows. Bacterium of T3 distributed stable along the length of the slope, and its actinomycetes remained at a high level, indicating that the soil microbial activity of T3 was active, and the soil was relatively fertile. Microbial biomass N of T5 were significantly higher than T3 and T6, indicating that the more root system developed the more microbial biomass N could be significantly improved, thereby increasing the potential nitrogen levels for the soil.

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Effect of Molybdenum and Silisium on Quality and Yield of Brassica Napus

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The aim of this research was to study the effect of different concentration of molybdenum(Mo) and silisium(Si) on the yield and quality of Brassica napus. A 3×3 factorial experiment consisting of three levels of sodium silicat(0,300 and 600 kg/ha) and three levels of amonium molybdate(0,20 and 40 kg/ha) arranged in a completely randomized block design with three replicates was carried out under field conditions in the Bostan Abad, Iran.Urea fertilizer applied 1000kg/ha in three levels of tillering, shooting and spike emergence .Data on plant growth yield and quality parameters were recorded by following the standard procedures. Plant height, number of seeds per silique, thousand grain weight, seed yield and protein content was measured. The results showed that the concentration of Mo increased in shoot of brasica napus after applied of ammonium molybdate. Application Amonium molybdate by increased number of seed per pod, gave a significant increase in yield as compared with the control treatment, but silisium treatment was not significant on yield of product.Seed yield increased 16.8 and 19.2% by usage 20 and 40 kg/ha ammonium molybdate than control treatment, whereas was no significant different among 20 and 40 kg/ha ammonium molibdate. The hightest of concentration of molybdenum in seed grained by 40 kg/ha ammonium molybdate treatment and protein content in seed .Straw yield enhanced in 300 and 600 kg/ha Sodium silica treatment by 16.65 and 18.2 % as compared with control treatment. Silisium stimulated growth of shoot and increased dry matter weight.

Keywords：*molybdenum, silisium, Brassica napus.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Investigatin of Nitrogen Use And Rial-Economic Efficiency in Brassica Napus Cultivation in Azarbayjan, Iran

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Nitrogen Use Efficiency (NUE) technology produces plants with yields that are equivalent to conventional varieties but which require significantly less nitrogen fertilizer because they use it more efficiently. In order to investigate the determine to fertilizer nitrogen use efficiency and rial- economic efficiency in brasica napus farms, an experiment was conducted as factorial based on randomized complete block design with six treatments and three replications in Bostanabad in Iran.The size of plots was 7×4 meters that consist of number of 21 row by distance 17.5 cm. The six treatments included:1-control(total macro and micro nutrient without Urea),2- 150 kg/ha Urea that used in three periods,3- 50kg/ha SCU(soufur coated urea) + 100kg/ha Urea,4- 150kg/ha SCU,5-150 kg/ha Urea that used in two periods, 6- 50 kg/ha NPK + 100kg/ha Urea. Nitrogen fertilizer Rial-economic efficiency was conducted on based world and subsidy costs. Results indicated that under nonsubsidy condition economic efficiency was 3.54 Rials by application of 150 kg/ha Urea in three periods wheras for 50kg/ha SCU + 100 kg/ha Urea was 3.23 .Also economic efficiency of treatment of 50 kg/ha Urea that was gained from NPK was 3.54Rials. In subsidy condition economic efficiency increased 5times in comparison to nonsubside condition. NUE technology has demonstrated significant yield improvements over the control variety using much less nitrogen fertilizer in fields.

Keywords：*Urea, Scu, use efficiency, economic, brassica napus.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Potassium and Rice with High N under Field Conditions

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We sought to address lodging of rice under commercial production conditions in south western Iraq through application of potassium (K) fertilizer. A local (Amber33) and semi-dwarf (IR52713) rice variety was planted at Najaf and Al Diwaniyah provinces and grown with or without 200 kg K/ha as K2SO4 (45%K). Basal N, P and S were applied to all sites. Growing season temperatures peaked at 46 °C at Najaf and 49 °C at Al Diwaniyah. Potassium application increased K concentration in soil by 14-110%, K uptake by grain and stem by 33-497% and 45-91% respectively, on average. At Najaf, K significantly increased the panicle number per m2, one thousand grain-weight, grain yield (26%) and straw yield (28-36%) in both cultivars. However there was no significant effect of K on plant height, number of filled grain, panicle length, and harvest index (HI). At Al Diwaniyah site, K application significantly increased grain and straw yields by 76-281% and 14-65%, respectively as well as HI. More significantly, K decreased lodging incidence. We hypothesize that the benefit of applied K arose through improved water relations in both rice varieties under adverse environmental conditions. Stomatal control is greatly affected by K nutrition in rice and improved K status increased the varietal ability to resist drought stress. As climate change increases the incidence of extreme temperature anomalies further research into the role of K nutrition in rice to mitigate yield damage is warranted.

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Molecular and Morphological Responses of Tomato Plants to Different Levels of Phosphorous Supply in Hydroponically Growing System

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Phosphorus (P) is absorbed by plants mostly as ortho-phosphate form (Pi), which are often low available in unfertile soils than the plant needs. In this research, we have used various levels of Pi for four weeks to feed hydroponically young tomato plants to evaluate morphological and molecular changes in response to Pi supply. Pi treatments affected growth, biomass, P uptake and P Content in the tissues and the expression of two Pi transporters genes, LePT1and LePT2. In the low Pi supply root hair density and length, total root length, specific root length and root to shoot ratio increased while biomass, leaf area, and root density decreased. Root morphology did not change significantly when the Pi supply was 0.5 mM or higher, while P level in roots or shoots did not increase significantly if it was above 1 mM in nutrient solution. Correlation between roots, P content and two Pi transporters activities showed that LePT2 transcription is inducted at less than 0.2 g P 100g-1 dry weight in roots while LePT1expression remains high upto 0.5 g P 100g-1 dry weight. Together, these results showed that the P content of roots and shoots are strongly correlated with supplied Pi concentrations. Responses of root to P stress were more intensity than shoot organs. Allocating more P in shoots than in roots in sufficient P supply in tomato indicated that leaves are cumulating organ for P distribution at high Pi condition than root organs.

Keywords：*Phosphorous Supply; Growth; Transporter Gene; Expression; RT-PCR*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Scrutiny of Interaction Between Iron Nano Chelate and Chlophony Hydrogel as a Superabsorbent on the Yield of Grain Corn (zea Mays L.) and Some Soil Chemical and Nutritional Properties in Saline So

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About one million hectares of lands in Khuzestan are salty and a great part of agricultural lands under cultivation of corn at the south of Khuzestan is located in this region. This investigation was conducted in a farm located in Ramhormoz in 2011 in order to investigate the interaction of iron nano and chlophony hydro-gel as a super-absorbent on the yield of grain corn (Zea Mays L.) and some chemical and nutritional properties of soil in rather salty soils in completely randomize design with four treatments and four repetitions experimental treatments consisted of: first treatment: conventional farmers (control), second treatment: iron nano chelate fertilizer (10 kgha-1), third treatment: super-absorbent polymer(40 kgha-1), fourth treatment : second treatment + third treatment. Results showed that the most increase in yield was obtained as a result of iron nano chelate consumption by 5517.667 kgha-1 and the least increase was seen in control treatment by 4256.33 kgha-1.The results of data variance analysis showed that iron nano chelate treatment and the treatment of simultaneous consumption nano and super-absorbent has a remarkable impact on weight features of a thousand grains, grains in ear and grains in ear raw. Raw in ear and bush height features were not considerable under the treatments. Chemical properties of soil including saltiness, acidity and saturation percentage were not remarkable in tow depths, except for saturation percentage that showed a significant difference, between super-absorbent treatment and control treatment in depth of 30-60 cm. All absorbance nutritional elements of soil were not considerable in the tow measured depths except phosphorus and manganese which showed remarkable difference in depth of 0-30 cm in level 5% of Duncan test. According to the results of this test and of nano and super-absorbent has a remarkable impact on weight features of a thousand grains, grains in maize and grains in maize raw. Raw in maize and bush height features were not considerable under the treatments. Chemical properties of soil including saltiness, acidity and saturation percentage were not remarkable in two depths ㄱ, ㄱ except for saturation percentage which showed a significant difference Between super-absorbent treatment and control treatments in depth of 30-60 cm. No absorbance nutritional elements of soil were considerable in the two measured depths except phosphorus and manganese that showed remarkable difference in depth of 0-30 cm in level 5% of Duncan test. According to the results ti the results of this test and computation of expenses of materials used in the test it is suggested to use iron nano chelate fertilizer in order to gain better yield in grain maize.

Keywords：*Fertility and Plant Nutrition, Iron nano chelate, Superabsorbent, Zea Mays, Saline Soils*

P4-228

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Combating Soil Properties Deterioration of New Established Rice Field by Using Biocharcoal in West Sumatra, Indonesia

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To get rid of food shortage and to compensate the land use change and declining of rice harvest area in Indonesia, the government has been established new rice field in various places. Since the productivity of the new rice filed is still below the average, their contributions were not significant to the total rice production as the whole. The main problem found in the new rice field are very low soil organic matter (SOM) extremely high of dissolve iron (Fe) and low content of available silica (Si). This condition created in unfavorable land condition and put rice plant under Fe toxicity and Si deficiency which are lead to poor growth and lower rice production. To combat this problem, a series of experiment which will provide a simple, useful and applicable technique is needed. The main purpose of this study is to find out the undemanding method to reduce the dissolve Fe in new rice field soils through application of bio charcoal and several ways of irrigation methods. The results show that variation of irrigation system and bio charcoal application affected the soil pH, redox potential, soluble iron, available phosphorous and silica content in rice field soil and rice productivity. bio charcoal application has significant effect to retard Eh value during the experiment. This result seemed affect another parameters in this study. The soluble iron content, available P and Si which has strong relation with the Eh value in the soil changed significantly with the changes of Eh. Indicating that, bio charcoal application might play the major role in all changes found in this research.

Keywords：*bio charcoal, food shortage, soil organic matter*

P4-229

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil Tillage, Integrated Nutrients and Crop Residue Management for Enhancing Soil Health and Crop Yields in Semiarid Subtropical Soil under Soybean-Wheat Rotation

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Continuing cereal-based crop rotations such as rice-wheat, intensive tillage and removal of postharvest crop residue (CR) for animal consumption and fuel, or its burning have reduced the organic matter content and productivity of irrigated semi-arid subtropical soils of South Asia. Identification of effective strategies for the management of tillage, integrated nutrients and CR could foster sustainable and environmentally sound agricultural systems. Conservation agriculture (CA) system has potential application in all agroecological zones to enhance food security for millions of smallholders in the developing world. However, there is a paucity of experimental data to support many of these claims in South Asia. To this effect, a 4-year field experiment was established with annual soybean-wheat rotation under subtropical climate conditions in the Indo-Gangetic Plains of Northwestern India to evaluate the integrated effects of tillage, CR retainment, mineral fertilizers and farmyard manure (FYM) on crop production, soil moisture storage, temperature dynamics, biological N2 fixation (BNF) and various physical, chemical and biological soil properties. The experimental soil was loamy sand, poor in organic C and low in available P. Sixteen treatment combinations involved recommended and 25% higher NP rates without or with 10 t FYM ha-1 and CR removed or incorporated in conventional tillage (CT) and retained on the soil surface in CA system. The results illustrated that (a) soybean yield was 2-6% higher in CA than CT in different treatments with and without CR, ((b) significantly higher uptake of N and P by soybean from CR-amended treatments of both CT and CA, which reflected its effect in improving the soybean yield, (c) CA conserved more water in soil profile than CT, however, the differences in soil moisture storage in CT vis-a-vis CA were not reflected in soybean yield presumably due to frequent wetting of soil by heavy monsoonal rains, (d) the wheat yield was highest in both CT and CA systems when grown with the application of 150 kg N and 33 kg P ha-1 without CR and was 7% higher in CA than CT, and (e) the irrigated soybean in the semi-arid subtropical soils could biologically fix 81-125 kg N ha-1 (68-85 percent of total N uptake), depending upon tillage and CR management. Significant increases in BNF by soybean were recorded when CR was retained on the soil surface of CA presumably due to better activity of rhizobia because of the relatively cooler rhizosphere environment. Soil temperature recorded daily during soybean and wheat crops demonstrated that the maximum soil temperature at 4 cm depth remained lowest in plots with CR retained on soil surface in CA as compared to bare soil surface leading to relatively cooler environment created by mulching effects of surface-retained CR.

Application of fertilizer N, P, FYM and crop residue (CR) significantly increased water stable aggregates and had profound effects in increasing the mean weight diameter as well as the formation of macro-aggregates, which were highest in both surface (85%)

and subsurface (81%) soil layers with application of 20 kg N + 60 kg P2O5 + 10 t FYM + 6 t Wheat Residue ha-1 applied to soybean and 120 kg N + 60 kg P2O5 + 3 t Soybean Residue ha-1 applied to wheat crop in CA, respectively, and were 83 and 77% in CT treatments after 2 years. The same treatment also enhanced total organic C (TOC) from 3.8 g kg-1 in no-NP-FYM-CR control to 5.8 g kg-1 in surface layer and from 2.7 to 3.6 g kg-1 in subsurface layer after 2 years leading to the 41% and 39% higher TOC stocks over CT-Control in 0-15 cm soil layers of CT and CA, respectively. The changes in TOC stocks after 4 years were 52% and 59%. Likewise, the labile C and N fractions such as water soluble C, particulate and light fraction organic matter, potentially mineralizable N and microbial biomass were also highest under this integrated inorganic and organic treatment under CA system. These results demonstrated that conservation agriculture integrating the application of inorganic fertilizer, organic manure and crop residue is the best management strategy for improving crop yields, soil health and sustainability of farming systems in semiarid subtropical soils.

Keywords：*Conservation Agriculture, integrated nutrients, soil profile moisture, soil temperature, reduced til*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Phosphorus Sorption Isotherm and External P-Requirements of Some Soils of Southern Ethiopia

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Determination of the P-sorption/adsorption characteristics of soils is important for economic fertilizer application and to recommend appropriate management strategies for high P-fixing soils. Thus, the objectives of this study were to evaluate P-sorption characteristics of soils occurring in some areas of southern Ethiopia and identify factors contributing to P sorption. Composite surface (0-20 cm) soil samples from 21 sites representing seven locations were collected and Processed in the laboratory. Two grams of the processed soil from each sample was equilibrated with 25 ml of 0.01M of CaCl2 in 50 ml capacity flasks to which 10, 20, 30, 40 and 50 mg P/L were added as KH2PO4 and the final volume was adjusted to 30 ml with 0.01MCaCl2 solution. The flasks were then shacked for 24 hrs. and the P in the neat supernatants were determined using ascorbic acid method. The adsorbed P was calculated as the difference between initial and final concentration of P multiplied by sample volume divided by the amount of soil added. The resulting data were fitted with Langmuir and Freundlich models/equations. The standard P requirement (SPR) for each soil was calculate from the models. The soils were also analyzed for their physicochemical properties and their relationships with P-adsorption data were determined by correlation and path coefficient analysis method. The results revealed that the P-sorption data were fitted well with both Langmuir and Freundlich models with r2 values of 0.93 and 0.99 respectively. But later model was found to best in describing P-sorption data. The adsorption maxima (Xm) and distribution coefficient (Kf) values of soils ranged from 833-1778 mg P/Kg and 237-1200 mg P/Kg based on Langmuir and Freundlich models respectively. The corresponding SPR values ranged between 54-667 mg/kg and 67-625 mg/kg respectively. Based on both models 43 % of the soils had SPR values <150 mg P/Kg and then were classified as low P-fixing soils and the remaining 57 % with SPR values >150 mg/Kg were classified as high P-fixing and Soil samples from Chencha area were found to be extremely high P-fixing soils (SPR = 667 mg P/Kg). Al, Fe and Clay contents of soils were found to be the major factor affecting P-sorption by soils studied in this experiment. It is concluded that P-sorption models can effectively be used to discriminate soils based on P-fixation ability and determine the amount of P-that should be added to soils as fertilizers.

Keywords：*P-fixation, External P requirement, Exchangeable Al, Fe*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Nutrient Buffer Power Concept' - A Revolutionary Soil Testing Procedure to Economize Fertilizer Use in Sustainable Agriculture Globally

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'The Nutrient Buffer Power Concept', a revolutionary soil testing procedure developed and tested over more than three decades after laboratory and field experiments in European, African and Asian soils, looks at soil testing to devise appropriate and accurate fertilizer recommendations for many field crops, such as, summer rye, wheat, and maize among cereals, red gram among pulses, white clover among fodder crops, and black pepper and cardamom among perennial spice crops, with a totally new perspective , as compared to routine 'text book' methods of soil testing. The center piece of the concept is the accurate quantification of a soil nutrient's buffer power, which is then integrated into routine soil test data, to derive appropriate and accurate fertilizer recommendations for the crop in question. The test nutrients were phosphorus, potassium and zinc, all taken up by plant roots, principally through the diffusive process. The analytical methods used to derive the accurate 'buffer power' of the nutrient in question, was, through the use of electro ultra filtration (EUF), which accurately measures the 'intensity' of the nutrient in question in the soil solution. Since the EUF method is unsuitable for the poor developing countries, the author has developed an 'adsorption-desorption equlibrium' technique, which is very cost-effective and very suitable for the funds starved developing countries. Experimental results showed that plant uptake of phosphorus, potassium and zinc, the principal elements under investigation, were closely related to their buffer power, with a coefficient of determination of as much as 98%. The routine soil test data had only a poor relationship. This author makes out a strong case for the adoption of this path-breaking technique on a global basis to economize fertilizer use, and help the poor farmers of cash starved nations of the developing and least developed countries of the developing world. The concept has received global scientific attention, from the International Fertilizer Industry Association in Paris, as the project was selected as the 'First Runner Up' for the prestigious International Fertilizer Award in 1999 and 'Second Runner Up' for the same award in 2001. And many national awards came the author's way. 'The Nutrient Buffer Power Concept' project was shortlisted for the very prestigious US $ 1 Million Rolex Awards For Enterprise 2012 of The Rolex Foundation, Geneva, for its originality from more than 3500 nominations worldwide and is the only project selected for this coveted distinction from the Asian continent. This author has been invited to contribute two chapters on the concept to the very prestigious Advances in Agronomy book publication.

Keywords：*Buffer Power, Phosphorus, Potassium, Zinc*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Correction of Zn Deficiency of Corn in Calcareous Soils of Thailand: Zn Sources and Application Methods

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A variety of zinc fertilizer sources are applied with varied responses on calcareous soils in Thailand. Seed treatment is an alternative method to deliver Zn to corn and alleviate Zn deficiency. To address this Zn delivery methods we conducted greenhouse studies on corn grown in three calcareous soils of Thailand to three Zn fertilizer sources (ZnSO4, ZnEDTA and Zn citrate). We also evaluated effectiveness of soaking corn seed in three concentrations of ZnSO4 (0.4, 0.8 and 1.6%) prior to planting compared to soil applied methods. Applications of zinc increased the growth, dry matter yield and zinc uptake of corn with few differences observed among the types of fertilizers. Seed soaking with ZnSO4 solution also increased Zn uptake, growth rate and yield comparable to soil-applied Zn. Seed soaking prior to planting is an effective and efficient method to supply Zn to corn grown in Zn deficient calcareous soils of Thailand.

Keywords：*Zinc deficiency, calcareous soils, corn, Zn source, Seed soaking*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Effect of Alley Cropping on Pistachio Growth in Temperate Region

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Although alley cropping is being proposed as an alternative to production system to support livelihood improvement through production of food, fodder and firewood as well as reduction of sediment and nutrients losses, it is limited particularly for semi arid regions due to the insufficient knowledge about management. We carried out this work to investigate the effect of soil moisture competition on the growth of pistachio trees in an alley cropping system where forage crops (vetch [Vicia sativa L.], barley [Hordeum vulgare L.] and vetch-barley mixture) are cultivated in spaces between tree rows of Pistachio (Pistacia vera L.). Soil moisture measurements were performed by TDR from sowing in November until late April, in which forage crops cut out since soil moisture had started to significantly decrease in forage crops plots. And the shoot length and diameter in one-year are measured and flower buds are counted before and after two-year experiment. The results showed that there were no statistical differences between the vegetative growth of pistachio trees in the vegetated plots and those in the control.

Keywords：*Alley cropping, forage crops, soil moisture competition, pistachio (Pistacia vera L.) growth*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Response of Hybrid Maize to Foliar Spray of Different Seaweed Extracts

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A field experiment was conducted at Zonal Agricultural Research Station, Vishweshwaraiah Canal Farm, Mandya, during the Summer 2012 to evaluate the effect of seaweed sap as a foliar spray on growth, yield and nutrient uptake by hybrid maize 'NAH 1137' (Hema). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications which consists of ten treatments viz; T1: 2.5% K* spray + RDF, T2: 5% K + RDF , T3: 10% K + RDF, T4: 15% K + RDF, T5: 2.5% G** spray + RDF, T6: 5% G + RDF, T7: 10% G + RDF, T8: 15% G + RDF, T9: RDF + Water spray (Control), T10: 7.5% K + 50% RDF. The plot size adopted for the experiment was 4.8m x 3.6m. The recommended dose of fertilizers (RDF) (150 kg N ha-1, 75 kg P2O5 ha-1 and 40 kg K2O ha-1) were applied for all the treatments through Urea, SSP and MOP. Before sowing 75 kg N, 75 kg P2O5 and 40 kg K2O ha-1 were mixed thoroughly in the rows and then two seeds of maize were sown per spot with a row spacing of 60 cm and plant to plant 30cm. Remaining 75 kg N was applied in two spilts at 30 and 45 days after sowing (DAS). Irrigation and other cultural practices were taken up as and when they are needed. Different concentrations of two seaweed saps (viz; Kappapyschus alvarezii (K sap) and Gracelaria edulis (G sap) were sprayed as per the treatment details at 20, 40 and 70 DAS.

During the harvest of the crop, the observations on growth parameters viz; plant height (cm), number of leaves per plant, cob length (cm), test weight (100 seeds weight) and yield parameters viz; grain and straw yield were recorded in each plot. The grain and straw yield were expressed in kilograms per hectare. The grain and straw samples drawn from each plot were dried, powdered and analyzed for various nutrient elements. The uptake of nutrient elements in grain and straw samples were calculated by using standard formulae. The soil samples collected before and after harvest of the crop were processed and analyzed for macro and micro nutrients by adopting standard procedures.

The results clearly revealed that significantly higher number of seed rows in a cob, cob length and test weight (100 seeds weight) were recorded where G sap and K sap were sprayed at 10% concentration along with RDF as compared to control (RDF + water spray), 7.5% K sap spray with 50% RDF and 2.5% K along with RDF. However, plant height and number of leaves per plant were non significant.

The grain yield of maize crop was significantly influenced by spraying of both the saps separately at varied concentrations. Significantly higher grain yield (8277.00 kg ha-1) was recorded where 10% K sap was sprayed with RDF followed by 5% G sap spray (8121.78 kg ha-1)

as compared to control. Among the K sap concentrations 10% K spray with RDF has given higher grain yield. However, further increase in the concentration of saps reduced the grain yield.

Similarly, significantly higher straw yield was noticed where 10% K or 10% G saps were sprayed along with RDF as compared to control. Application of 7.5% K spray with 50% RDF recorded on par grain and straw yield to that of control treatment, which clearly indicates the benefit of K sap spraying. Increase in the spray concentrations of K sap up to 15% and G sap up to 10%, increased the total nutrient (macro and micro nutrients) uptake by maize crop. However, reduction in nutrients uptake was noticed at higher concentration (15%) of G sap spray. After harvest of the crop there were no significant changes in available nutrient status of the soil except for available N, where 7.5% K spray with 50% RDF was significantly lowest compared to all other treatments. Hence, it is concluded that foliar application of K and G saps at 10 % concentration significantly increased the yield and nutrient uptake by maize crop which confirms that both the seaweed saps can be used as a supplemental fertilizer.

*K : Kappapyschus alvarezii

**G : Gracelaria edulis

Keywords：*Hybrid maize, Foliar spray, Kappapyschus alvarezii, Gracelaria edulis, Response*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Seaweed Extract on Growth, Yield and Nutrient Uptake by Wetland Rice

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A field experiment was conducted at Zonal Agricultural Research Station, Vishweshwaraiah Canal Farm, Mandya, during the Summer 2012 to evaluate the effect of seaweed sap as a foliar spray on growth, yield and nutrient uptake by wetland rice. The experiment was laid out in Randomized Complete Block Design with three replications which consists of twelve treatments viz; T1: 2.5% K* sap spray + RDF, T2: 5% K + RDF , T3: 10% K + RDF, T4: 15% K + RDF, T5: 2.5% G** spray + RDF, T6: 5% G + RDF, T7: 10% G + RDF, T8: 15% G + RDF, T9: RDF + Water spray (Control), T10: 7.5% K + 50% RDF, T11: 15% K (root dipping) + RDF + only 2nd & 3rd Spray of 15% K, T12: 15% G (root dipping) + RDF + only 2nd & 3rd Spray of 15% G. The recommended dose of fertilizers (RDF) (100 kg N ha-1, 50 kg P2O5 ha-1 and 50 kg K2O ha-1) were applied as per the package of practice for all the treatments through Urea, SSP and MOP. Twenty five days old seedlings (Cv. Tanu) were transplanted at a spacing of 20 x 10 cm. Before transplanting, rice seedlings were dipped in 15% K and 15% G saps separately for respective treatments and used for transplanting. Different concentrations of two seaweed saps (viz; Kappapyscus alverzii (K sap) and Gracelaria edulis (G sap) were sprayed as per the treatment details at 10, 25 and 60 DAT.

During the harvest of the crop, the observations on growth and yield parameters were recorded from each plot. The grain and straw samples of each plot were drawn, dried, powdered and analyzed for various nutrient elements. The soil samples collected before and after harvest of the crop were processed and analyzed for macro and micro nutrients by adopting standard procedures.

The results of the study clearly indicated that numerically higher plant height, number of productive tillers, number of grains per panicle, number of leaves per hill were recorded with application of 15% K sap and 5% G sap spray with RDF as compared to control (RDF + water spray) and root dipping during transplanting with K and G saps at 15% concentration along with RDF followed by two sprays at 25 and 60 days after transplanting.

Significantly higher grain yield of rice was recorded (4947.81 kg ha-1) with 5% G sap spray with RDF followed by 15% K sap spray with RDF as compared to control and 7.5% K sap spray with 50% RDF. Application of G sap up to 5% concentration increased the grain yield, however, further increase in the concentration up to 15% reduced the grain yield of rice. Root dipping with 15% G sap with RDF followed by two sprays at 25 and 60 days after transplanting has given numerically higher grain yield (4763.18 kg ha-1) as compared with control and root dipping with 15% K treatment. Similar to that of grain yield, straw yield also increased numerically due to K sap spray with RDF from 2.5% concentrations up to 15% concentration and G sap spray with RDF up to 5% concentration compared to all other treatments. However, further increase in concentration of G sap numerically reduced the straw yield. Similar to that of grain yield, higher straw yield was also noticed in root dipping with 15% K sap followed by two sprays at 25 and 60 days after transplanting (8472.98 kg ha-1) as compared to root dipping with different concentrations of G sap spray with RDF. Significantly higher uptake of both macro and micro nutrients in grain and straw was noticed with 15% K and 5% G sap spray with RDF compared to control. Post harvest soil samples showed significantly higher N, P, K status with 15% K and 5% G sap sprayed treatment, However, micronutrient status did not show any difference. It is concluded that among the two saps, G sap (5% spray) was found to be superior in getting higher rice yield and similarly root dipping with G sap (15%) was found to be superior in achieving higher grain yield of rice as compared to K sap.

*K : Kappapyschus alvarezii

**G : Gracelaria edulis

Keywords : *Rice, Growth and yield, Nutrient uptake and seaweed extract*

P4-236

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Impact of Rural Eco-Sanitation Systems on Land at Ancharahalli, Doddaballapur Taluk, Bangalore, South India

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Land is the most important basic natural resource. It is a dynamic and complex combination of geology, topography, hydrology, soil and flora and fauna and influences every sphere of human activity .Different sectors including agriculture, industries infrastructure and power projects put forth competing demand for land. Subsistence farming practices, accelerated soil and water erosion, erratic rainfall, increasing population and high density of livestock population has all contributed to unsustainable land use that has lead to degradation of this valuable resource in Karnataka.

Introducing source separation concepts in municipal wastewater management does allow adequate treatment of the different flows according to their characteristics. This is the key to technical solutions for the efficient reuse of water, energy and fertilizer. Separate collection and treatment of toilet waste in households, which contain almost all pathogens and nutrients, are the first and major step. The range of toilets with very low dilution is from vacuum- over urine sorting to dry toilets. Innovative sanitation systems have been introduced in several projects and have proven feasibility. Fresh water consumption can be reduced by 80% while nutrients can be recovered to a large extent. Source control can be advantageous also for hygienic reasons: low volumes are far easier to sanitize. There are experiences with Urine-sorting systems, vacuum-biogas systems and many more available. New ideas as the black- and grey water cycle system are presently researched. These modular integrated systems do have the potential to be installed in densely populated urban areas without the need for central water and wastewater infrastructure. Only recent advances in membrane technologies allow this development.

Rural eco-sanitation project in Ancharahalli village of Doddaballapur Taluk, in Bangalore Rural district of Karnataka, South India is implemented in 2010. About 85 households are located in four clusters and generate around 40 KLD of mixed waste water. The present study is carried out to know the impact of these sanitation systems on the ground/land .The soil samples from the site were brought by using the core cutter. In the top layer of the soil bed is found to have moisture content is 11.30% similarly as the test results the moisture content of middle layer and bottom layer is found to be 4.59% and 8.47% respectively. The total average moisture content is found to be 8.12%. The field density of soil is an important parameter for soil engineers. The results for field density are found to be1.72gm/cm2 and the result for dry density is 1.59gm/cm2. Permeability in the study area varied from 4.05 to 6.03 m/day. The soil samples were collected in horizontal & vertical (up to a depth of 3m from ground level) directions for chemical analyses of micro & macronutrients, which are found to be more than the allowable limits. The full length paper explains the mitigative measures to be followed to maintain the nutrient status of the soil for better agricultural yields.

Keywords：*Permeability, Micro-macro nutrients, On-site sanitation systems, Urnanisation , Eco-san*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil Quality, CO2 Emissions and Yields in Irrigated Cotton-Based Cropping Systems Sown in a Vertisol with Subsoil Sodicity

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Comparative studies of soil quality and energy use in two- and three-crop rotations in irrigated cotton (Gossypium hirsutum L.)-based cropping systems under varying stubble management practice in Australian Vertosols are sparse. Our primary objective was to quantify selected soil quality indices (salinity, sodicity,SOC exchangeable cations, nitrate-N, pH), crop yields, and greenhouse gas emissions in four irrigated cotton-based cropping systems sown on permanent beds in a Vertisol with subsoil sodicity near Narrabri in north-western NSW. Results presented in this report pertain to the period from June 2005 to May 2011. The experimental treatments were: cotton-cotton, cotton-vetch (Vicia benghalensis L.), cotton-wheat (Triticum aestivum L.) where wheat stubble was incorporated, and cotton-wheat-vetch where wheat stubble was retained as in-situ mulch. Vetch was terminated during or just prior to flowering by a combination of mowing and contact herbicides, and the residues retained as in situ mulch. Soil pH, EC1:5, SOC, Cl-, NO3--N, exchangeable cations, ESP, ESI (=EC1:5/ESP), and EC1:5/ESC (exchangeable sodium concentration) was evaluated in samples taken from the 0 to 1.2 m depth before sowing cotton during late September or early October of each year. Compared with sowing cotton every year, including wheat in cotton-based cropping systems improved cotton yield, and reduced soil quality decline, emissions of carbon dioxide equivalents (CO2-e) per unit area and minimised CO2-e emissions per unit of cotton yield. Including vetch in the rotation was of negligible benefit in terms of yield and CO2-e emissions/unit of yield. The rate of soil quality decline was unaffected by including vetch in a cotton-wheat rotation but was accelerated when included in a cotton-cotton sequence. Among all cropping systems, soil quality was best with cotton-wheat and cotton-wheat-vetch but poorest with cotton-vetch. Although CO2-e emissions associated with growing a hectare of cotton could be reduced by growing vetch because of substituting fixed atmospheric N for N fertiliser derived from fossil fuels, this advantage was partly negated by the emissions from farming operations associated with growing a vetch crop. Relative to a 2-crop rotation (1 cotton: 1 rotation crop), negligible benefits in terms of yield, soil quality and greenhouse gas emissions accrued from a 3-crop rotation (1 cotton: 2 rotation crops). In addition to the cropping systems, soil quality indices and yield were significantly influenced by irrigation water quality and climatic variability.

Keywords：*Vertisol; Haplustert; Permanent bed; Mulch; Rotation; Wheat; Vetch.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Nutrient Fluxes and Soil Characteristics in Various Land Use in a Super Wet Tropical Rain Forest, West Sumata, Indonesia

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Study about nutrient characteristics of soils in relation to nutrient fluxes was conducted on four land uses in a super wet tropical rain forest, West Sumatra. Soil characteristics and nutrient fluxes varied among the land use type. The range of nutrient characteristics under four land use type were 4.60 - 7.01 % and 0.4 - 0.60 % for total carbon and total nitrogen and were 9.80 - 24.59, 0.68-2.07 and 0.30 - 0.8 c mol(+) kg -1 for Ca, Mg and K, respectively. The highest content of soil nutrient status was found under mixed garden (MG), while the lowest soil nutrient status found at PF. This result indicated that the MG with various vegetation types contributed in enriching and maintaining the nutrient status in soil via nutrient fluxes. Total N, exchangeable Ca, Mg and K tended to decrease with soil depth of each land use type. The average leaf litterfall production of the study site was estimated as 12,62 Mg ha-1 y-1 with the range were 9,49-16,28 Mg ha-1 y-1. The annual nutrient fluxes in this study site were found to vary significantly among the land use types. The potenecy of nutrient flux to soil system via litterfall was highest at MG follow by CP and CMP. Spatially, the nutrient content in soil were closely related to the land use type and land coverage. It was suggested that the nutrient characteristics of soils under various land use types in a super wet tropical rain forest region in West Sumatra were significantly affected by the nutrient fluxes with different land coverage.

Keywords：*Keywords: Nutrient fluxes, land use, nutrient characteristics, super wet tropical rain forest, West*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluation of Peri-Urban Fluvisols with Gis for Dry Season Maize Production in South Western Nigeria

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The need for food security during the dry season in the urban metropolis in south western Nigeria has resulted to more wet lands being brought into cultivation during the dry season for arable crops especially maize. Without proper assessment and management production in such soils will be futile. Hence this study was conducted to assess the suitability of wet land for maize production during the critical dry season. The area was sampled using stratified grid sampling to cover the entire representative area selected for the study. The following soil parameters were determined: nitrogen, potassium, phosphorus, cation exchanged capacity, soil texture and soil pH. The spatial analyses in GIS environ were carried out such as overlay and inverse distance weighted techniques to assess the suitability and nutrient availability in the study area. The study area is divided into four suitability classes: highly suitable moderately suitable, marginally suitable and not suitable based on crop requirement of Maize. The CEC varies between 15.76-17.77cmol/kg, P varies between 0.31-0.44mg/kg, while N varies between 0.06-0.26% with mean of 0.18% and average of 1.75% for OC. The soil is moderately homogenous with low to medium variability except K which was high (49%). The properties reflect the depositional origin of soil regolith being high in cations while low Nitrogen and P could be attributed to intensive cultivation and tendency of N to be easily lost due to leaching and erosion in the marginally suitable area. Appropriate application of fertilizer will improve the fertility of such area for optimum maize production. While the area classifies as not suitable has tendency to be waterlogged which could result to total soil loss. The study shows that without proper agricultural management techniques there will be uncertainties in the yearly production of maize in the study area.

Keywords : *fluvisols, land suitability, food security, soil management, soil fertility, Maize*

P4-240

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Application of Liquid Calcium Carbonate Micron Particles on the Furrow as Affecting the Soil Phosphorus Availability and Common Bean Yield

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The common bean (Phaseolus vulgaris L.) crop has great economic importance to Brazil because the cultivated area during the 2012/2013 harvest was 3.16 million ha-1, which yielded 3.32 million Mg ha-1. Tropical soils such as the Brazilian Cerrado or the African Savannas are naturally acidic because leaching of basic ions from high rainfall, which result in reduced soil fertility. In these areas satisfactory cash crop grain yields are dependent of performing proper liming and soil fertilization. Soil acidity is one of the main limiting factors of crop yields in many parts of the world. Lime application is a cheap and effective way to increase soil pH. However, the reactions that raise soil pH after lime application occur slowly. Because of this, lime application close to the crop sowing day may not raise the soil pH and provide increases in some nutrients availability. While the conventional liming has a particle size of 50% < 0.3 mm and 50% > 0.3 mm the micron particle has a size between from 0.0001 to 0.0002 mm. Another difference is because the micron particle normally is applied in a solution with water, which probably makes the reaction with the soil faster. In this sense it is likely that the liquid liming application will provide faster soil reaction in the soil furrow. However, from the best of our knowledge there are no virtual researches about this topic. The aim of this study was to evaluate the effect of the liquid application of calcium carbonate micron particles in the sowing furrow on the pH, the concentrations of Al, P, K, and Ca, and the base saturation in the soil and on the yield components, grain yield, concentration, and grain content of common bean.
The trial was conducted for two years (2010 and 2011) at the Guaribas Farm, located in the city of Unai, MG, Brazil. The experimental area was grown for four years in the NTS, with corn cultivated in summer and common beans in the winter season. The soil was a sandy clay loam (kaolinitic, thermic Typic Haplorthox) with 500 g kg-1 clay, 300 g kg-1 silt, and 200 g kg-1 sand. The experimental design was a randomized block design with four replications in both years. The treatments consisted of six doses of calcium carbonate (0, 1050, 2100, 4200, 8400, and 12 600 g ha-1) applied in the sowing furrow (0.03 m deep together with the common bean seed). The plots were 40 m2 (10.0 m x 4.0 m). The used area of each plot was the two central rows, disregarding the 0.50 m on each side. A 4.5-cm-diameter galvanized-steel auger was used for sampling at depths of 0 to 0.10 and 0.10 to 0.20 m at 15 and 30 days after calcium carbonate application. For each layer, eight subsamples were collected from under the common bean plant rows and in the middle of the inter-rows (0.25 m from the plant row) of each plot. For each location (in-row and between rows), the eight subsamples were combined into a composite sample. The composite samples were air dried and sieved (2 mm mesh) and later analyzed to determine the pH (CaCl2 0.01 mol L-1), P, Al, Ca, and exchangeable K, as well as the calculated base saturation (V%) and aluminum saturation (%). It was also evaluated the yield components, grain yield, concentration and content of P in common bean grains
Our results indicate that the calcium carbonate increased the pH (from 4.8 to 5.3 at 0-0.10 m deep layer) and the P concentration in the soil (from 70 to 80 mg dm-3 at 0-0.10 m deep layer) until 30 d after application. The concentration of Ca, K and the base saturation of the soil were not affected by the addition of calcium carbonate. The concentration (from 4 to 4.3 g kg-1) and content (from 1,500 to 1,870 g ha-1) of P in the grain and grain yield (from 3,500 to 4,100 kg ha-1) of the common beans increased with increasing concentration of calcium carbonate. The use of calcium carbonate micron particles in the sowing furrow is a new and effective practice that increases crop yield in no-tillage systems.

Keywords：*Phaseolus vulgaris, liming, fertilization, Cerrado Region*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Levels of Ammonium and Nitrate in the Soil and Upland Rice Development as Affected by Cover Crops

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An important point to be considered in the no-tillage system (NTS) is the nature of the cover crop used. Besides, the decomposition of cover crops present on the ground may provide a greater availability of nutrients. The objective of this study was to evaluate the effect of cover crop species on the levels of nitrate and ammonium in the soil under no-tillage and conventional tillage systems, as well as upland rice yield.

The field experiment was conducted in Santo Antonio de Goias, GO. The regional climate is tropical savanna, Aw according to the Koppen classification. There are two well-defined seasons, normally dry from May to September (autumn/winter) and rainy from October to April (spring/summer), usually the growing season. The experimental design was randomized blocks with five cover crops with three replications. Each plot measured 6.0 m x 10 m. The cover crops used to grow rice in the no-tillage system were as follows: 1 fallow (spontaneous vegetation); 2 - Panicum maximum; 3 - Brachiaria ruziziensis; 4 - Brachiaria brizantha; and 5 - millet (Pennisetum glaucum). The soil sampling was performed with an auger on the upland rice sowing day (30 days after cover crop desiccation) and five additional times (7, 14, 21, 28 and 35 days) in all treatments and replications. Thus, eight sub-samples were collected in each composite sample from each plot at a depth 0-10 cm, which were homogenized by hand, labeled, wrapped in plastic bags, kept in a cooler with ice and sent to the lab for analysis. The analyses of mineral N were performed the same day of soil sample collection. From each soil sample, a representative aliquot of 20 g was removed and mixed with 60 ml of extraction solution KCl 2 mol L-1. After shaking for an hour and decanting the solid material, the supernatant was filtered using filter paper. This supernatant was used to quantify the levels of nitrate and ammonium. At the beginning of rice development (30 days after cover crop desiccation) and every 7 days (same day sampling of ammonium and nitrate in the soil) a total of seven assessments (0, 7, 14, 21, 28 and 35 days after rice sowing) were collected, and the dry matter of the cover crops was evaluated. The manual harvest of upland rice was conducted when approximately 90% of panicles had grains of typical mature coloration. Therefore, the grain yield was measured (unhulled grain weight collected at three central rows of five meters in each split-plot, eliminating 2.5 meters on each side of the plots from the usable areas, correcting their moisture content to 130 g kg-1 and converting to kg ha-1).

In this study, it could be observed that cover crops Brachiaria brizantha, Panicum maximum and Brachiaria ruziziensis in the NTS nd B. brizantha and fallow incorporated in the CTS favored higher levels of nitrate in the soil. On the other hand, B. brizantha and fallow in the CTS and millet and P. maximum in the NTS favored the buildup of high levels of ammonium in the soil. The tillage system and the nature of cover crops could be used to achieve the desired levels and forms of nitrogen in the soil. Plowed millet and fallow had the statistically highest upland rice yields. However, plowed fallow that causes soil disturbances and is therefore not eligible for the no-tillage system does not seem to be a good option. On the other hand, the worst rice yields were found under cover crops Brachiaria brizantha, Panicum maximum and Brachiaria ruziziensis in the NTS (2356, 2857 and 2177 kg ha-1, respectively). Moreover, those grasses may have some allelopathic effect that hampers aerobic rice plant development. Therefore, from the data obtained, Brachiaria brizantha, B. ruziziensis and Panicum maximum, despite their importance in NTS for producing large amounts of biomass, do not seem to be the ideal cover crop for upland rice. However, in an agricultural system, we could infer that before upland rice, it is important to introduce millet. After upland rice harvesting, perennial forage, such as Panicum maximum, Brachiaria brizantha or B. ruziziensis, could be introduced to achieve a great amount of cover crop in the beginning of the following rainy season and to cultivate another cash crop.

Keywords：*Brachiaria brizantha, Brachiaria ruziziensis, Panicum maximum, millet, fallow, soil management*

P4-242

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Common Beans Grain Yield as Affected by Phosphorus Fertilization in the Sowing Furrow and Foliar

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The common bean (Phaseoulus vulgaris L.) crop has great economic importance to Brazil , since the cultivated area in the 2010/2011 harvesting was about 4.01 million hectares , corresponding to production of 3.8 million tons of grains. Among the aspects to be improved in the crop is the management of the plant fertilization. The balanced and adequate supply of nutrients to the common beans by the use of fertilizer can provide significant increases in grain yield. In this sense , we have the phosphorus (P), an essential element in plant metabolism , which the response of common bean to the use of P in the soil is well-defined , contributing significantly to increasing grain yield , root development and favors the increase in the number of pods and grain mass. The need for P required by the common bean plants is less than that of potassium (K) and nitrogen (N), however, the amount applied is typically higher. This is due to the high rate of fixation in tropical soils, mainly caused by precipitation by Fe and Al, reaction with hydrous oxides of these metals and reaction with silicate clays. Because of this reason, the use of P from crops varies only from 5% to 25%. One option would be provide P through foliar fertilization, which could result in a reduction of the amount of P fertilizers applied to the soil, and can promote economic and environmental benefits, since P fertilizers are produced from the mineral reserves of non-renewable character. However, this practice is still carried out without scientific basis, making it difficult to obtain reliable results. The aim of this study was to test the hypothesis that foliar P application would increases the efficiency of utilization of P from soil by common bean fertilization.
The experiment was conducted at Embrapa Rice and Beans, located in the city of Santo Antonio de Goias , GO (16 ° 27 'N , 49 ° 17 ' longitude and 823 m above sea level) for three consecutive years 2009, 2010 and 2011. The climate is classified as Aw, tropical savanna , mesothermal , according to Koppen's classification. The region's historical average of precipitation (1983-2010) was 32, 8.3, 4.3 and 12.6 mm precipitated in the months of May, June, July and August, respectively, and average temperatures of 21.8, 20.6, 20.8 and 22.6 ° C in the same months, respectively. The soil is classified as Oxisol, clayey. The experiment was conducted in the area of no-tillage on straw of Urochroa brizantha. The experimental design was a complete randomized blocks, in a factorial design 4 x 4 with four replications. The treatments consisted of four levels of P applied to the soil (0, 40, 80 and 120 kg ha-1 P2O5) and four levels of foliar P applied (zero, 831.3, 1662.6 and 2493.9 g P2O5 ha-1). The dimensions of the plots were 4.5 m wide and 6 m long, resulting in an area of 27 m2. The application of P in the soil was held together with the application of N and K during the sowing of common bean. The foliar P was provided by commercial product ‘P51’, which containing 1% of N and 51% of P2O5, the doses of each treatment was split in two applications. The first application occurred when the common bean had three trifoliate leaves and the second with six trifoliate leaves. For foliar spray it was used a manual sprayer with constant pressure of CO2 with spray volume of approximately 100 L ha-1. It was evaluated yield components (number of pods plant-1, number of grains pod-1 and weight of 100 grains), grain yield and P content in the whole plant (grain + leaves + stem + roots + pods).
The Increased in the rates of P applied to soil and foliar provided increased in the number pods m-2, grain yield and P content in the common bean plant. The highest grain yield (3,446 kg ha-1) was obtained with the combination of 120 kg ha-1 of P2O5 in the soil with 1662 g of P2O5 ha-1 foliar. The crop response to the application of P in the soil was increased with foliar application.

Keywords : *Phaseolus vulgaris, mineral nutrition of plants, phosphorus, Cerrado.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluation of the Recovery 15n-Ammonium Nitrate in Capim-Marandu Grass Pasture and Corn Cultivated in a Crop-Livestock Integration

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The biggest limitation to the sustainable of the no-tillage system (NTS) in regions of dry winter is the low biomass accumulation during autumn/winter and winter/spring because of unfavorable weather conditions, such as low water availability and temperature. To minimize the problem is growing in Brazil the intercropping of cash crops such as corn, soybeans, rice and sorghum with palisade grass (Brachiaria brizantha cv. Marandu). However, in the intercropping may occur competition for nitrogen between intercropped species, affecting the yield of corn or forage or both. However, not always the corn has had its grain yield limited by the intercropping. Then we have the question if the residual nitrogen fertilizer applied to corn is sufficient to meet the demand from the forage specie that will develop in succession, since there are still no nitrogen fertilizer recommendations for this production system. Additionally, there is another question about the viability of nitrogen application on forage after corn harvesting and its effect on the following crops. The cultivation of cover crops in the off season preceding corn crop in NTS may be promising strategy for supplementation of nitrogen to the following crop. The quality and quantity of plant residue and availability of mineral N in the soil solution have direct influence on the use of nitrogen originating from these residues by following corn. The use labeled source of 15N constitutes the method to quantify more accurately the efficiency of nitrogen utilization. The study aimed at evaluating the total nitrogen accumulation and the nitrogen accumulated in the intercropping corn and B. brizantha evaluating the total nitrogen concentration from the fertilizer ammonium nitrate under different rates (15NH4NO3) applied in the forages plants after corn harvest, and the residual effect of this practice in the following corn crop in the next growing season.

The experiment was carried on at field conditions, at College of Agricultural Science, in Botucatu (SP-Brazil), in a structured Oxisol cultivated under no-tillage system. The climate of the area according to the Koppen climate classification is Cwa, altitude tropical with dry winters and hot and rainy summer. In the first year there was an annual average maximum temperature of 25.1 °C, minimum 16 °C and annual rainfall of 1330 mm. While in the second year there was an average annual temperature of 26.5 ° C, minimum 16.5 ° C and annual rainfall of 1396 mm. The experimental design was in completely randomized block in split plot design. The main plot were two modalities of crop system (intercrop corn and B. brizantha simultaneously, intercrop corn with B. brizantha sowed at corn topdressing fertilization). The subplots were four nitrogen rates (0, 30, 60 and 120 kg ha-1 of N). In the sub plots were allocated micro parcels in which it was applied enriched ammonium nitrate (15NH4NO3) with the same nitrogen rates.

The time of intercropping deployment significantly affected dry matter production, amount of nitrogen in the plant derived from the fertilizer and efficiency of nitrogen utilization by forage plants; The nitrogen application in autumn on B. brizantha implemented by the intercrop with corn, both at sowing and in nitrogen fertilization, provided increased productivity of forage up to a dose of 60 kg ha-1; The higher accumulation and nitrogen use efficiency of fertilizer use by B. brizantha coming from both intercropping times occurred at 160 days after fertilization, regardless of N rates; The residual nitrogen, applied in B. brizantha, did not affect the nitrogen nutrition of the following corn, but increased the grain yield at doses of 60 and 120 kg ha-1 of N, when the corn was grown on straw from the intercrop deployed at corn topdressing fertilization. Based on our results, it can be inferred that the earlier intercrop allowed higher dry matter production of the grass. On the other hand, the intercrop deployed later allowed producing higher grain of the following corn after forage fertilized with nitrogen.

Keywords：*Zea mays, Brachiaria brizantha, no-tillage system, nitrogen fertilization, sustainability.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Phosphate Fertilization in the Soil and Penergetic Application in the Grain Yield of Common Bean

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The development of technologies that provide higher availability of P to plants could provide reducing the amount of P fertilizers applied to the soil, causing economic and environmental benefits, since these P fertilizers are produced from mineral reserves of non-renewable character. The Penergetic technology consists of applying Penergetic products K and P from bentonite clay subjected to application of electric and magnetic fields. These products, according to the manufacturer, are used 1. As bioactivator of soils (Penergetic K applied to the soil) that enhances and balances the microbial activity in the soil and 2. As bioactivator of plant, which provides more energy to the photosynthetic process and facilitates interaction + plant microbe beneficial. There are already promising results of the use of these products in wheat, vegetables, common bean, potato and barley. However, despite of these results there are still many questions regarding the use of this technology. There are virtually no studies that seek to correlate the application of Penergetic with P fertilizer. So we started with the hypothesis that the application of Penergetic (P and K) will provide greater utilization of P from the soil and will provide the highest grain yield of common bean with the application of lower doses of the nutrient. The objective was to determine the grain yield and yield components of common bean as affected by P fertilization and applying Penergetic K (soil) and P (plant).
The experiment was conducted at Fazenda Guaribas, Unai, Minas Gerais State, Brazil, in the years 2012 and 2013. The site had soil type Oxisol, loam with clay loam. The climate of the region is classified as Aw, tropical savanna, mesothermal, according to Koppen's classification. The region 's historical average of precipitation (1983-2010) is 32, 8.3, 4.3 and 12.6 mm precipitated in the months of May, June, July and August, respectively, and average temperatures of 21.8, 20.6, 20.8 and 22.6 °C in the same months , respectively. The experiment was conducted in the area of no-tillage after soybean cultivation. The experimental design was a randomized complete block design in factorial design 4 x 2 with eight replications. The plot dimensions was 7 m long x 2 m wide. It was considered useful plot the two central rows disregarding 0.50 m from each end. The treatments consisted of four levels of P applied to the soil (0, 40, 80 and 120 kg ha-1) in the presence and absence of Penergetic application. The application of Penergetic was done in two steps: 1. 250 g ha-1 of Penergetic-K applied right after the desiccation of cover crops in the soil, one day before sowing common bean, and 2. 250 g ha-1 of Penergetic-P at the V4 vegetative stage of common bean plants.
The application of Penergetic regardless of the combination with the P doses provided greater values of grain yield of common bean than those treatments without the product. Corroborating this information it appears that when applied Penergetic the agronomic efficiency of P application was much higher than that of non- application of the product, especially in the year 2013, with had much greater efficiency at lower doses of P. For treatments with Penergetic notes a significant increase in productivity up to a dose of 82.2 kg P2O5 ha-1, reaching 5313 kg ha-1 of grains. On the other hand, without the application of penergetic response to application of P was linear, and the maximum yield was 3903 kg ha-1 of grains. Based on the results it can be inferred that the application of Penergetic allowed highest yield with lower dose of applied phosphorus. This result may indicate that there was greater availability of P to plants when applied Penergetic possibly from the soil colloids and organic or part due to increased microbial activity in the soil. It is necessary to development further studies to confirm these hypotheses, since farmers are using these products and reporting positive increments in crop grain yield and as observed in this experiment.

Keywords：*Phaseolus vulgaris, phosphorus, uptake efficiency, costs reduction*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Previous Intercropping Corn with Palisadegrass in a Tropical Region as Affecting Soil Fertility and Annual Crops Nutrition and Grain Yields

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The use of cover crops and crop rotation are important practices aiming a sustainable agriculture production. The temporary introduction of perennial forages such as palisadegrass [Brachiaria brizantha (Hochst. ex A. Rich) Stapf] in traditional grain production areas could increase soil quality (physical, biological, and fertility) and breaks the cycle of pests, diseases, and weeds of the following crops with positive effect on the grain yield. The objective of this study was to evaluate the effect of the introduction of perennial forage as a previous cultivation in the soil fertility and on the five followed cash crop nutrition and grain yield in a tropical region.

The experiment was conducted in Botucatu, State of Sao Paulo, Brazil (48° 26 - W; 22° 51 - S; 740 m above sea level). A dry winter and hot and rainy summer typifies the tropical climate (Koppen classification Cwa). The long-term annual average (1970/2006) of temperatures are a maximum 26.10 C, minimum 15.30C and average 20.70C, with and annual average rainfall of 1,358.6 mm. The soil is a sandy clay loam, (kaolinitic, thermic Typic Haplorthox) with 630, 90 and 280 g kg-1 of clay, silt and sand, respectively, which was under NTS. The area was under NTS for five years. It was a five crop-growing experiment. 1. Soybean [Glycine max (L.) Merr.] in the spring-summer for two growing season (2004/2005 and 2005/2006); 2. White oat (Avena sativa L.) during two growing season (2005 and 2006) in the fall-winter; and 3. Corn for one growing season (2006/2007) in the spring-summer. The experimental design was a randomized complete block with 2 treatments and twelve replications (blocks). The treatments consisted of two previous crops: 1. corn monoculture and 2. corn intercropped with palisadegrass. Each plot consisted of ten (soybean), twenty (white oat), or seven (corn) 20m-long and 5.6 meters wide rows. Data samples were collected in the central rows, and 0.5 m from the end of each plant row and two, for soybean and white oat, and one, for corn, external rows constituted the edge. Soil chemical characteristics (pH, SOM, Presin, H+Al, Kex, Caex, Mgex, CEC, and S-SO4-2) were determined at layers 0-0.05, 0.05-0.10, 0.10-0.20 and 0.20-0.40 m only once. This determination was done on Dec. 2004, 60 days after previous crop desiccation. It was collected eight sub-samples for each composite sample in each plot. It was evaluated the leaves nutrition, yield components, and grain yield of the following cash crop (soybean, white oat and corn). Besides crop system efficiency (CSE) for all cash crops were evaluated by the ratio between kg of grain per kg of fertilizer applied of each crop (soybean and corn crops). As white oat was not fertilized we calculated the CSE by the formula ESC = kg of soybean grain + kg of white oat grain per kg of fertilizer).

Our results suggested that the use of corn and palisadegrass intercropped as a previous crop allowed increase the soil fertility with significant higher values of pH, SOM, P, K, Ca, Mg, S and CEC than in the soil under corn monoculture. Growing soybean, white oat and corn on palisadegrass (from corn and palisadegrass intercropped) allowed the significant highest cash crop leave nutrition and grain yield than on the fallow (from corn monoculture). Our results allow inferring that the introduction of perennial forage for short period of time in grain production area provided many benefits which could be seen on the three following growing season. Our trial showed that crop-livestock integration allows producing more foods in the same area with benefits to the environment and increased profits, allowing farmers to diversify activities in a sustainable agriculture system.

Keywords：*Crop-livestock integration; no-tillage system; perennial forage; crop system; crop rotation; sustain*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Zinc, Copper, Boron and Iron Requirement of Upland Rice Grown on a Brazilian Oxisol

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Deficiency of micronutrients increasing in field crops, including upland rice in recent years. The objective of this study was to determine requirement of zinc (Zn), copper (Cu) boron (B) and iron (Fe) for upland rice grown on a Brazilian Oxisol. The levels used were: Zn (0, 10, 20, 40, and 80 mg kg-1), Cu (0, 5, 10, 20 and 40 mg kg-1), B (0, 5, 10, 20 and 40 mg kg-1) and Fe (0, 250, 500, 1000, and 2000 mg kg-1). Plant height, straw yield, grain yield, panicle number and grain harvest index (GHI) were significantly improved with the addition of these micronutrients. Root growth was also improved with the application of micronutrients, except with the addition of B. Maximum grain yield was obtained with the addition of 51 mg Zn, 24 mg Cu, 5 mg B kg-1 and 283 mg Fe kg-1 soil. Similarly, maximum straw yield was obtained with the addition of 38 mg Zn, 17 mg Cu, 6 mg B kg-1 and 1500 mg Fe kg-1 soil. Maximum plant height was obtained with the addition of 54 mg Zn, 10 mg B kg-1 and 1197 mg Fe kg-1 soil. Copper did not affect plant height significantly. Maximum panicle number was obtained with the addition of 22 mg Cu kg-1, 3 mg B kg-1 and 1100 mg Fe kg-1 soil. Zinc did not affect panicle number significantly. Maximum GHI was obtained with the addition of 61 mg Zn kg-1, and 8 mg B kg-1. Zinc was having linear increase in GHI in the range of 0 to 80 mg kg-1 and Fe was having negative relationship with GHI.

Keywords：*grain harvest index, Oryza sativa, Oxisol, yield and yield components*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Nutrient Uptake and Use Efficiency by Tropical Legume Cover Crops at Varying Ph of an Oxisol

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Oxisols comprise large soil group in tropical America. These soils are acidic and having low fertility. Use of tropical legume cover crops in cropping systems is an important strategy to improve fertility of these soils for sustainable crop production. Data are limited on nutrient uptake and use efficiency of tropical cover crops under different acidity levels. The objective of our study was to evaluate growth and nutrient uptake parameters of 16 tropical legume cover crops under three soil pH (5.1, 6.5, and 7.0) of an Oxisol. Shoot dry weight was influenced significantly by pH and cover crop treatments and their interactions, indicating that cover crops used had differential responses to changing soil pH levels. Overall, shoot dry weight decreased when soil pH was raised from 5.1 to 7.0, indicating acidity tolerance of cover crops. Nutrient concentration (content per unit of dry weight), uptake (concentration X dry weight) and nutrient use efficiency (dry weight of shoot per unit of nutrient uptake) varied significantly among cover crops. The variation in nutrient uptake and use efficiency among cover crop species was associated with variation in shoot dry matter production. Significant variation among crop species in dry matter production and low C/N ratio (average value of 14.25) suggest that cover crops which produced higher dry matter yield like white jack bean, gray mucuna bean, black mucuna bean, mucuna bean ana, and lablab are important choices for planting in tropical soils to recover large amount of macro and micro nutrients and prevent in their leaching in soil plant systems.

Keywords：*Plant nutrition, Cerrado, shoot dry matter, C/N ratio*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Establishment and Validation of Soil Quality Indicators by Participatory Method for Rural Settlements in Southern Bahia, Brazil

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This research aimed to adapt and apply, in the field with farmers, methodologies of empirical evaluation on indicators of soil quality and compare them with the laboratory evaluations. The study was developed in Cocoa Region of Bahia, Brazil in two rural settlements, Settlement Project Freedom ASTRAL in Marau, and Association of Producers and Farmers Union and Labor - APAUT in Ilheus, which were evaluated in different land uses, including crops of cocoa, cassava, coffee and pasture. The farmers of the settlements APAUT and ASTRAL were able to identify / describe / interpret the attributes related to the quality of cultivated soils in different land uses. Empirical methods promoted interaction between farmers and technicians, providing opportunities for dialogue on the phenomena related to the soil. By Wilcoxon test the indicators of soil quality organic matter and soil cover showed very close scores between the empirical evaluation and the technical evaluation. By Spearman correlation coefficient was found low associations between empirical evaluations and technical indicators for microbial activity, moisture, structure and erosion in APAUT, and indicators of organic matter, compaction and structure in ASTRAL. For the factors extracted by the Factor Analysis, there were positive correlations to the indicators of soil microbial activity, soil cover, structure, organic matter and moisture with the functions of quality and soil conservation, and negative correlations of the indicators compaction and erosion with these functions.

Keywords：*Management and soil conservation, Etnopedology, Tropical land uses, Cocoa region of Bahia.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Sustainability of Cassava (manihot Esculenta Crantz) under Continuous Cultivation without Plant Nutrition: Two Decades Experience in an Ultisol of Kerala, India

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Tropical tuber crops are one among the major food crops, which can contribute to the food, nutritional, economic and employment security of more than 500 million people globally. Among these, cassava is primarily significant, due to its high yield potential, tolerance to vagaries of weather especially drought, less incidence of pests and diseases, high tuber starch and better information on the physico-chemical properties of cassava starch to be modified into several value added products. The research experience over half a century about the plant nutrition of cassava points to its high and positive response to manures and fertilizers. In India, the cultivation of this crop is confined to the southern parts where it is used for both human consumption and industrial purposes including biodegradable plastics.

This paper describes the research result from a long term fertilizer experiment in cassava initiated at CTCRI in 1977 and still in progress indicating the capability of the crop to sustain by producing substantially good yield under continuous cultivation in the same field without any manures and fertilizers (absolute control-AC). A comparison of the existing package of practices (POP) involving the application of organic manure as FYM @12.5 t ha-1 + NPK @ 100:50:100 kg ha-1 with AC for a period of more than 20 years (1991- 2013) though revealed significant difference between the practices with respect to the parameters studied, the yield during these years was maintained to the tune of 10-15 t ha-1 which was about half of the yield (55%) recorded with POP. The yield over these years under AC and POP ranged as 6.14- 24.86 and 12.71- 34.89 t ha-1 with average yield to the tune of 14 and 26 t ha-1 respectively. This sustenance of the crop without nutrient addition can be attributed to the high leaf dry matter (3 tha-1) production and high leaf N (3-5%) coupled with leaf shedding character which in turn can nourish the soil both physically and chemically for better tuberization and tuber bulking. The BC ratio arrived was 1.25 and 1.09 respectively for POP and AC and the quality parameters viz., starch, cyanogenic glucosides and cooking quality did not show any significant difference. However, the tuber bitterness due to cyanogenic glucosides was comparatively lesser in AC as the N application through FYM (0.5%N) as well as chemical fertilizers (urea-46%N) under POP have contributed to a higher cyanogen content. In the case of starch, a slight improvement was noted with POP than AC, being the effect of fertilizer (MOP) K in activating the starch synthatase enzyme.

The soil chemical properties viz., pH, organic carbon, available N, P, K, Ca, Mg, micronutrients viz., Fe, Cu, Mn and Zn were nalysed initially before the start of the experiment and after each seasons. The acidic soil pH was maintained all through these years to almost the same status as 4.5-5.0 with no significant difference between POP and AC. The organic carbon status indicated a tremendous increase in POP than AC with respect to initial status to the tune of 60-70% and can be attributed to the luxuriant vegetative growth under POP coupled with leaf shedding. As regards to available N, though the soil status was low initially, compared to AC, in POP, the increase was marginal though the leaves contain high N. The heavy P build up noted with continuous application of P @ 50 kg ha-1 in the tricalcium form under POP was much higher to the range of 50-60% than AC. Since K is significant with respect to tuber formation and bulking, the K status has not enhanced significantly with POP maintaining the status in the low to medium as that of initial. The content of secondary nutrients Ca and Mg and micronutrients viz., Fe Cu, Mn, Zn and B also was maintained in POP but depleted heavily in AC. The total plant uptake pattern of these nutrients over these years showed significant difference between POP and AC resulting very high yield compared to the sustainable yield under AC. Hence, the study over these years, clearly revealed the efficiency of cassava to sustain yield under continuous cultivation even without any plant nutrition as well the positive and strong response of the crop to fertilizers and manures as evident from the yield under AC and POP during these years.

Keywords：*Absolute control,package of practices,tuber yield,cyanogenic glucosides,starch,BC ratio*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Efficient Recycling of Agricultural and Market Wastes by Vermicomposting

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The effective and hygienic disposal of degradable agricultural and market wastes by vermicomposting is a viable input for sustainable agriculture. A large number of chemical and bio chemical changes take place during vermi composting. A number of parameters have been used to assess the quality and maturity of composts. Hence the present study was conducted to monitor the changes in maturity indices i.e. total organic carbon, total nitrogen, C:N ratio, formation of humic substances and humification index during conventional composting and vermi composting of various organic residues i.e. sugarcane trash, weeds, vegetable market wastes and rice straw. Earth worm species Esenia foetida was used for vermi composting @ 1 kg / ton of organic residue while application of 1% nitrogen as urea and 2 % single super phosphate were used as additives for conventional composting. The compost samples at 15, 30, 45 and 60 days interval in composting and 15, 30, 45, 60 and 110 days interval for under conventional composting were used for chemical analysis and isolation of humic substances. The results revealed the completion of vermicomposting within 60-65 days while conventional composting was completed in about 110 days. The total organic carbon and C:N ratio decreased with the composting period. How ever higher percent decrease was observed in vermicomposting as compared to conventional composting. The use of earthworms narrowed the C:N ratio to an extent of 62, 53, 49 and 68 percent in cane trash, weeds, market waste and paddy straw, respectively. The total nitrogen content increased during the composting process with higher increase being observed in vermicompost. It was revealed that percent increase of total NPK content in vermicompost over conventional compost was 11.85, 27.05 and 2.44 percent, respectively. Among the different sources total nitrogen content was higher in the compost obtained from vegetable market waste and were significantly lower in compost obtained from rice straw. The humic and fulvic acid production increased with incubation in both the methods of composting. Humic acid production was highest in the compost obtained from vermi composting of vegetable market waste followed by vermi composting obtained from weeds. While lowest percent of humic substances was recorded from compost obtained from sugarcane trash. Humification Index (HA/FA ratio) was lower in the compost obtained from rice straw and highest in the compost obtained from vegetable market waste. From the results it could be observed that vermi composting of various types of agricultural and domestic wastes cold offer a promising solution for efficient recycling of degradable wastes with in short period of time.

Keywords：*vermicomposting, marke waste, nutrient content.,*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Effect of Split Nitrogen Application on Protein Concentration of Wheat under Different Water Regimes

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Wheat was grown in 12 kg sandy loam soil in pots 105 cm deep. There were four KNO3 treatments: no N; 150 mg to topsoil at sowing; 75 mg to topsoil at tillering and 75 mg to topsoil at booting; 150 mg to subsoil (60 cm depth) after flowering. The effect of post-anthesis water stress was assessed by allowing the topsoil to dry and then supplying half the amount of water used by the well-watered control treatment at 60 cm in half the pots. Drying of the topsoil decreased grain yield but increased the GPC of wheat. Split N application at tillering and booting or subsoil N application after flowering produced higher GPC than other N treatments. The apparent contribution of remobilised N to grain was highest in the control plant and the plants that received 150 mg N in the topsoil at sowing (N1) but the differences between treatments were not significant at $P \leq 0.05$. Root length in the subsoil (60-80 cm) had increased by maturity. The concentration of NO3-N in the bottom of the pot was high with all of the N treatments (even with the N0 treatment) at tillering due to leaching. There was an interaction between N and water treatment with respect to water use efficiency. This indicated that the effect of N on water use efficiency differed with water treatments.

Keywords：*Split ,mineral N, grain protein, water regimes.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Response of Groundnut (arachis Hypogaea L) to Nutrients Constraints Identified by Gis Technique

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A survey was undertaken in a micro-watershed under northern transition zone of Karnataka, India with an objective of identifying soil fertility constraints by GIS technique and to study the response of groundnut (Arachis hypogaea L) to identified soil fertility constraints.

Surface soil samples at 10" (second) grid interval were collected from the study area for the assessment of soil fertility constraints. The sampling location was recorded by using GPS. After processing, the samples were analyzed for pH, EC, OC, N, P, K, S, Ca, Mg, Zn, Fe, Cu, Mn and B. Soil fertility maps were prepared for each of the nutrients by GIS technique using Arc GIS 10.0 software. Mapping of nutrients by GIS techniques revealed that major portion of the study area was deficient in available N, P, S, Zn and B.

After identifying fertility constraints, a field experiment was conducted during in the farmer's field. Various treatments imposed were Recommended Dose of Fertilizer (RDF) for groundnut, Soil test based RDF modification, and increase in N and P2O5 with Zinc and B in different combinations.

Groundnut variety GPBD-4 was used as the test crop. The experiment was laid out in Randomized Block Design with nine treatments and three replications. The soil of the experimental site was clay in texture. Observations on growth, yield and yield components were recorded at harvest of the crop. Based on the results following conclusions were drawn.

Application of 120% RD N and P2O5 + 80% RD K2O + 7.5 kg Zn + 0.3 kg B + 200 kg Gypsum recorded the highest plant height, number of branches at all the growth stages.

The dry matter production increased in all the treatments from early stage to harvest. Highest dry matter was recorded in the treatment which received 120% RD N and P2O5 + 80% RD K2O + 7.5 kg Zn + 0.3 kg B + 200 kg Gypsum.

The yield components viz., number of pods per plant, pod weight per plant, shelling percentage and test weight were highest with the application of 120% RD N and P2O5 + 80% RD K2O + 7.5 kg Zn + 0.3 kg B + 200 kg Gypsum.

Application of 120% RD N and P2O5 + 80% RD K2O + 7.5 kg Zn + 0.3 kg B + 200 kg Gypsum recorded significantly higher total ptake of N, P, K, S, Zn and B by groundnut at harvest..

Available N, P, Zn and B in post harvest soil were higher in the treatment T9 (140% RD N and P2O5 + 60% RD K2O + 10 kg Zn + 0.4 kg B + 200 kg gypsum). Available K and S were highest in the treatment receiving RDF modification by Soil test.

Keywords：*Groundnut (Arachis hypogaea L), Nutrients constraints, GIS*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Crop Water Productivity of Sugarbeet as Affected by Tillage under Mesa Irrigation System

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Today's greatest global challenge of irrigated agricultural is to produce more food and fiber for less amount water, which can be accomplished by maximizing crop water productivity (CWP). A 3-yr field study was conducted to evaluate and compare the effect of conventional tillage (CT) and strip tillage (ST) practices on crop water use (CWU) and CWP of sugarbeet (Beta vulgaris L.) on a clay loam soil under mid-elevation spray application irrigation system in the northern Great Plains. Seasonal CWU and CWP for sugarbeet root and sucrose yields were determined for the 2006, 2007 and 2008 growing seasons according to the water balance and CWP equations under CT and ST practices. No significant differences due to tillage were found for CWU of sugarbeet for 2006, 2007 and 2008 growing seasons. In 2006, CWP for root yield was significantly greater in ST relative to CT due to wind damage early in the spring which reduced sugarbeet plant population in the CT. The mean value of CWP for root yield across three growing seasons was 10% greater for ST than for CT. Similarly the CWP for sucrose yield for three seasons and their average has similar trends with the CWP for root yield. Based on three seasons results, the ST system used 0.0093 ㎥ (2.5 gallon) and 0.061 ㎥ (16.12 gallon) of irrigation water less than CT system to produce one kilogram of sugarbeet root and one kilogram of sucrose yield, respectively, throughout the growing season. Results also showed that the ST system reap approximately $0.08/㎥ of applied seasonal water more than the CT system to irrigate sugarbeet. We concluded that ST system can be used to produce sugarbeet root yield and CWP comparable to CT or even in some instances better than the CT system.

Keywords：*Water productivity, Drainage, soil water content, evapotranspiration*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Yield, Water and Nitrogen Use of Spring Maize with Straw Mulch under Flat Bed And Ridge-Furrow Planting in Northeast China

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Seasonal drought is a restrictive factor for maize production in northeast China. Reports showed that straw mulch could decrease evaporation from soil surface and retain more water. Field experiments were conducted from 2011 to 2012 to study the effects of straw mulch under flat bed planting (FP) and ridge and furrow planting (RFP) on maize yield, soil water and nitrogen status, evapotranspiration (ET), water use efficiency (WUE) and nitrogen use efficiency (NUE) of maize under rainfed conditions. Two FP treatments were bare flat bed planting (FBP) and flat bed planting with straw mulch (FMP). Two RFP treatments included plastic mulch on ridge with bare furrow (RFBP) and plastic mulch on ridge with straw mulch in furrow (RFMP). In no water-stress rainfall years, straw mulch increased the relative soil water content in root zone while reduced soil temperature in early season in both FP and RFP systems. In the FP system, straw mulch significantly reduced soil available nitrogen at jointing stage and filling stage, nitrogen mineralization through whole growth season and maize yield. However, straw mulch had no effect on ET and nitrogen uptake by maize, leading to reduction of WUE and NUE by 21% and 24% respectively. In the RFP system, straw mulch had no effect on soil inorganic nitrogen conditions, ET, yield, WUE and NUE. Therefore, in black soil region of semi-humid northeast China, straw mulch both under FP and RFP systems were not recommended to use in no soil water-stress rainfall years.

Keywords：*straw mulch, flat planting, ridge and furrow planting, maize, yield, water use efficiency, nitrogen*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Insitu Assessment of Soil Nitrate-Nitrogen in the Pigeon Pea-Groundnut Intercropping-Maize Rotation System: Implications on Nitrogen Management for Increased Maize Productivity

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Assessment of soil nitrate nitrogen (NO_3-N) was conducted in a pigeon pea-groundnut intercrop maize rotation cropping system at Chitedze Agricultural Research Station (S 130 59' 23.2", E 0330 38' 36.8") in the 2012/2013 cropping season. In the 2011/2012 cropping season, eight treatments replicated three times in a randomized complete block design, with monocultures and intercrops of either of the two pigeon pea varieties, long (ICEAP 04000) and medium duration (ICEAP 00557) plus groundnut (CG 7) were planted. At harvest, the legume biomass was ploughed into the soil in some of the treatment plots. Maize was then planted in the 2012/2013 cropping season and NO_3-N data was collected from emergence over a period of three weeks. This was done before top dressing with urea. The results of the study seem to suggest that there was high NO_3-N in the soil solution in all the treatment plots over the study period (106.4 mg l-1 to 463.1 mg l-1). It was observed however, that the level of soil NO_3-N in most cases was statistically the same ($p>0.05$) across the treatment plots. In general, mean soil NO_3-N was higher in the sub than top soil. This was attributable to the soil texture which is predominantly sandy clay loam with low to medium level of SOM, both in the top (mean=0.9-1.6%) and sub soil (mean=1.1-1.6%). Leaching of $NO3^-$ is high under such soil conditions. It is likely that the level of mean soil NO_3-N, into the season, in treatment plots which had no biomass buried under would decline faster than in treatment plots where biomass was incorporated, mostly due to uptake by the maize crop and leaching losses. This may last longer into the season for the latter treatment plots, but may not last until the end of the cropping cycle. For the Malawian smallholder farmers it implies that for this cropping system, N supplement from mineral fertilizer is not optional if reasonably high maize yield is to be realized.

Keywords：*Groundnut biomass, Intercropping, Nitrate-nitrogen, Pigeon pea biomass*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Municipal Solid Waste Compost Improves Soil Fertility in Rice-Rice Cropping System

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The fertility status of Bangladesh soils is low mainly due to low organic matter levels. Soil organic matter plays vital role in maintaining soil aggregation, aeration, water availability, buffer capacity and the supply of mineralizable nutrients. The scope of organic matter improvement through FYM, cowdung, green manuring or crop residue application is very limited in Bangladesh. Waste generation in the municipal areas is increasing everyday in Bangladesh and its management is an acute problem. Composting of municipal solid wastes can solve the problems of both waste management and soil fertility improvement. The experiment was conducted in 2010 and 2011 in the silt soils of Bangladesh (AEZ 9) with the objective to assess the effects of applied MSW compost on soil properties in the rice-rice cropping system. The experiment comprised 10 treatments- T0 (control) , T1 (recommended dose of NPKS fertilizers, RDF) , T2 (RDF, nitrogen from urea super granule), T3 (compost @ 5 t ha-1 + 75% N + 50% PKS) , T4 (compost @ 10 t ha -1 + 50% NPKS) , T5 (compost @ 15 t ha -1 + 25% NPKS) , T6 (compost @ 10 t ha -1 + 25% N),T7 (compost @ 15 t ha -1), T8 (compost @ 20 t ha -1) and T9 (compost @ 4 0 t ha -1). Nitrogen, phosphorus, potassium and sulphur were supplied from prilled urea and urea super granule, triple super phosphate, muriate of potash and gypsum, respectively. MSW compost was applied as per treatments to the 1st, 2nd, 3rd and 4th crop. Randomized complete block design was followed and the treatments were replicated thrice. Two rice varieties BRRI dhan29 and Binadhan7 were used in the study following the rice-rice cropping pattern. The soil samples were collected from the experimental plots after harvesting of the 4th crop and analyzed for soil properties. An increasing trend of soil organic matter accumulation with the application of MSW compost at higher rates was observed in the rice-rice cropping syatem. MSW compost increased the porosity, pH and the water-holding capacity of soil but the values for bulk density and particle density were decreased. Soluble salts content, total N, available P, exchangeable K and available S content of soils increased due to application of MSW compost with or without fertilizers. Heavy metals like As, Cd, Cu, and Zn content in soil increased as compared to control soil while the values for Co, Cr, Ni and Pb decreased. All the values were within the permissible limits. E. coli and Salmonella were absent in the soils treated with MSW compost. Nitrogen fertilization exerted a decreasing effect on the organic matter content of soil. The study indicates that continuous application of MSW compost with or without fertilizers improves soil fertility in the rice-rice cropping pattern.

Key words: Municipal solid waste compost, fertilizer, soil fertility, heavy metal, cropping pattern

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Aerobic Rice Production System (arps): Improving Productivity in Water-Scarce Areas of Central Luzon, Phillipines

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On-farm study on rice-based cropping system following recent water-saving technologies for rice production which includes ARPS-ARPS, ARPS-alternate wetting and drying (AWD) and existing or Farmers' Practice (FP) was conducted in different rice ecosystems that are naturally known as water-scarce areas to improve productivity and profitability.

Experimental site in Guimba, Nueva Ecija is located at the tail-end portion of irrigation system. ARPS was identified as the suitable cropping system during the wet season. ARPS-ARPS was not established during the second cropping due to the availability of water in irrigation canals and occurrence of rainfall, thus dryland preparation was not possible. Accumulated yield for FP was higher by about 61% and 41% compared with ARPS-ARPS and ARPS-AWD treatments. Water productivity, however, showed that FP consumed more water compared with ARPS-ARPS and ARPS-AWD to produce a kilogram of rice by 73% and 68%, respectively. The total labor requirement in terms of man-days is reduced by 16% and labor productivity is increased by 20% in adopting the ARPS technology compared to FP during WS.

In Sta Ignacia, Tarlac, the area is serviced by small farm reservoir (SFR), the highest accumulated yield was obtained in ARPS-AWD plots. Practice on AWD after ARPS resulted to 6.14% and 23.89% higher yield as compared with FP and ARPS-ARPS plots, respectively. Lower yield in ARPS-ARPS plots during the dry season was attributed to the drying-up of the SFR where the supply of water for irrigation is taken. It is recommended that ARPS will be followed during the wet season and this production system is also possible if there is available SFR with sufficient water to supply its water requirements especially at the reproductive stages.

Areas with shallow tube well in Abucay, Bataan was also considered as one of the experimental area. Accumulated yield of ARPS-AWD was 6.95 t ha-1 while FP had an accumulated yield of 5.96 t ha-1. The yield showed that ARPS-ARPS and ARPS-AWD as newly introduced rice production systems in the area had increased yield by 14% against FP.

Rainfed lowland areas in San Ildefonso, Bulacan showed that FP had the highest yield data during the wet season, but not significantly different from the two treatments. However, water productivity is higher at ARPS-AWD plots by 14% as compared with the FP plot.

Results of this study is very essential for the recommendation of location-specific farming system for the different rice ecosystems for improved water, land and labor productivity as well as increased annual rice production and farmers' income.

Keywords：*Aerobic rice production system, alternate wetting and drying, farmer's practice, water productivity,*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Long-Term Potassium Fertilization Effects on Quantity-Intensity Relationships and Potassium Buffering Capacity of Wetland Rice Soil

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Potassium (K) fertilizer recommendation for rice cultivation in Bangladesh, usually based on the exchangeable K status of soil, often does not match well with crop K requirement, particularly in the long run. Gradual soil K depletion, even with recommended K fertilizer application became a growing concern and appeared as a challenge in sustaining crop yield and soil fertility in Bangladesh. The availability of K to plant strongly depends on K intensity (I) in the soil solution, capacity or quantity (Q), and renewal rate in the soil solution. The Q/I parameters in most of the rice soils received little attention. The present research aimed to (i) study the effect of long-term potassium fertilization on the changes in soil K fractions and their distribution through rice soil profile, (ii) study the Q/I parameters for K in this rice soil, (iii) characterize the Grey Terrace soil for K supplying capacity under long-term continuous rice cropping and K fertilization. The study involved laboratory experiments on potassium fractionation and Q:I parameters on the soils from long-term K management experimental field. The long-term K management experiment received K application from 0 to 80 kg/ha/season, with an interval of 20 kg/ha, for 16 seasons in 8 years. The results of the laboratory studies showed that long-term K management demonstrated depletion of solution K, exchangeable K (EK) and non-exchangeable K (NEK) in K omission plot. Depletion zone of solution K and exchangeable K extended to 30 cm and that for non-exchangeable K extended up to 10 cm depth in 8 years. Solution, exchangeable and non-exchangeable K depleted by 5, 32 and 14%, respectively in the depleted zone compared to the stable soil zone.Quantity-intensity study showed a linear relationship for both K omission and K applied soils. Omission of K decreased the equilibrium K concentration ratio (CR_0K) compared to K fertilized soil and slightly decreased labile K (K_L) and non-specifically available K ($-\Delta K_0$) but had no effect on specifically available K (Kx). The K omission increased the potential buffering capacity (PBC^K) compared to K applied soil. Potassium management had little effect on equilibrium exchangeable K (EK_0), the proportion of added K converted to exchangeable pool (α) and non-exchangeable pool (β). However, equilibrium solution K (CK_0) in K omission soil was lower than the K applied soil. The β was higher than α. The PBC^K for non-exchangeable pool was also higher than the exchangeable pool both in K omission and K applied soils. Potassium management influenced critical solution K (CKr) and critical exchangeable K (EKr) but had no effect on minimum exchangeable K (Emin). The Emin was very close to EK. So, NEK pool could contribute to the plant K nutrition. The values of CR_0K ranged from 0.00013 to 0.00076 in the K mission soil 0.00039 to 0.00083 $(mol\ L^{-1})^{1/2}$ in the K applied soil. However, the greater CR_0K found at greater soil depth irrespective of K fertilization. The K_L pool was mainly controlled by specifically available K (Kx). The PBC^K ranged from 133-155 and 126-160 $(cmol\ kg^{-1})/(mol\ L^{-1})^{1/2}$ in K omission and K fertilized soil, respectively. Estimated EK_0 at different depth of soil varied from 0.139 to 0.195 and 0.145 to 0.211 $cmol\ kg^{-1}$ in K omission and K applied soil, respectively. The CK_0 varied from 0.0023 to 0.0089 in K omission and 0.0044 to 0.0090 $cmol\ L^{-1}$ in K applied soil. The value α was 43.46 to 46.62% and β was 49.31 to 52.29%. The CKr ranged from 0.0022 to 0.0079 $cmol\ L^{-1}$ (K_0) which increased with K fertilization up to 0.0038 to 0.0090 $cmol\ L^{-1}$. The EKr of K_0 and K_{80} soil were ranged from 0.137 to 0.198 and 0.147 to 0.212 $cmol\ kg^{-1}$, respectively. The Emin was 0.109 to 0.168 and 0.108 to 0.154 $cmol\ kg^{-1}$ in K_0 and K_{80} soil, respectively.

Keywords：*Quantity-intensity, K supplying capacity, PBC, CR, EK_0, CK_0, EKr, CKr, Emin*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Progress of Research on Chinese Stabilized Fertilizer

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Fertilizer is one of the largely consuming means of agricultural production contemporarily; where China becomes a leading country globally on fertilizer production and consumption. In developed countries, fertilizer's utilization rate can reach up to 50% to 60%, which the utilization rate of nitrogen can reach up to 50% to 70%; in China, the utilization rate for nitrogen fertilizer reaches merely 30% - 35%, which is significantly 15% to 20% lower than the developed countries. The great amount of fertilizer application with low fertilizer utilization rate and loss of fertilizer in China has already resulted in a series of negative environmental impacts such as eutrophication in surface and underground water body; NO_3^--N content in vegetables exceeded safety limit; greenhouse gas emission such as N_2O, NO increases. For the purpose of avoiding and mitigating these environmental issues, China raises investments and efforts on fertilizer research, after years of persisted research and refinement, stabilized fertilizer progressed in great improvement and become a leading force among new type fertilizers.

Urease inhibitor and nitrification inhibitor are the core technologies for stabilized fertilizer. In China, the research on urease inhibitor starts relatively later than developed countries. Since from 1980s, Chinese Academy of Science, Shenyang Institute of Applied Ecology started systematical researches on urease inhibitor, current focuses on research and application are HQ, PPD, NBPT and TU. For nitrification inhibitors, the researches started from the end of 1960s. Currently, the most broadly used nitrification inhibitor is DCD; however, China starts to import new and high efficient nitrification inhibitors from overseas in recent years, such as DMPP.

For the transformation of nitrogen, either urease inhibitor or nitrification inhibitor takes role in a certain transforming process, whereas the functioning period of urease inhibitor is relatively shorter, and is easily affected by soil property and broader environment, its effect on nitrogen transformation after nitrogen transformed into ammonia is relatively smaller, even may stimulates other transformation such as nitrification or de-nitrification and causes N loss. The nitrification inhibitor inhibits the transformation from NH_4^+-N to NO_3^--N, and stores more nitrogen in soil in NH_4^+-N form, thus increases the probability for ammonia evaporation. To sum up, single inhibiting additive in fertilizer is always not achieving anticipated optimal results, thus, the research focus on stabilized fertilizer shifts from single type to compound type.

Currently, by utilizing urease and nitrification inhibitors to control nitrogen transformation, for the crops with growing period less than 130 days, the stabilized fertilizer can achieve once application and avoids top application, raises nutrient utilization rate by 30 -40%, increases average yielding by 8 -18%, decreases N_2O emission by 46%, and reduces nitrate leachate by 63%.

The stabilized fertilizer market in China is continually developing and refining, in year 2011, the world's first stabilized fertilizer

standard came in force in China (Standard No. HG/T 4135-2010), which reveals Chinese stabilized fertilizer market is stepping up into a new era, and consolidated Chinese Academy of Science, Shenyang Institute of Applied Ecology's leading position in this field. Till now, the stabilized fertilizer shares 85% of total controlled/slow released fertilizer market, more than 50 fertilizers enterprises participated in producing and spreading stabilized fertilizer, annual production reaches 1.2 million tones, creates direct margin of 11.83 billion RMB, reduces fertilizer cost approximately 3.25 billion RMB, and accumulated increase on yield accounts 8 million tones.

This paper concludes the researches on stabilized fertilizer in China, explains the progress of research and production status on the stabilized fertilizer's core urease and nitrification inhibitor, and systematically introduces the spreading status and field results of stabilized fertilizer in China.

Keywords：*stabilized fertilizer; urease inhibitor; nitrification inhibitor; spreading and application, field r*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Potentiality of Plant Products as Nitrification Inhibitors

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It is widely realized that while the use of fertilizer is necessary for high agricultural productivity, there are a variety of associated ill effects on the environment. Nitrogen (N) is the most yield limiting nutrients in crop production. It is required in high quantities in soil and is easily lost from the soil via denitrification, volatilization, leaching and run off. Because the fertilizers are manufactured from non-renewable energy source, greatest attention is required for its management. Estimates indicate that recovery of applied urea-N by Kharif (summer) crops is India is 30-40% and it can be as low as 20% in low land paddies.

Addition of a nitrification inhibitor to soil with ammonium containing fertilizer or urea retard nitrification and minimizes leaching of N as NO3 and gaseous loses of N as NO, N2O and N2 via dentrification. Various chemicals have been tested in the past as nitrification inhibitors and their efficacy in retarding N losses from the soil-plant system. However, large scale use of nitrification inhibitors in field level has never been done, due to lack of research, ignorance among the farmers, poor extension programme and absence of regulatory control on its use in agriculture. Moreover, extra expenditure on nitrification inhibitors has added to their unpopularity in India and other developing countries.

Some natural product based botanical nitrification inhibitors (Azadirachta indica) have been prepared and tested in India especially those prepared from Neem (cakes and oil base products). However, they have been tried only in experimental stage and could not be popularized.

Sweetworm wood tree (Artemisia annua), and spearmint (Mentha spicata) and menthol mint (Mentha arvensis) oil and by-products have been found potential as nitrification inhibitors. Karanjin, extracted and prepared from the seeds, bark and leaves of karanj tree (Pongania glabra), though found to be a potent nitrification inhibitor has not been studied in details and nor used in large scale.

Fertilizer N is a precious input in agriculture. It is being produced from high value non-renewable energy and the fraction of unused fertilizer has great environmental concern. Use of nitrification inhibitors is, therefore, highly necessary for higher N use efficiency, its sustained use and optimum crop productivity. The paper will look in to the possibility of potential use of botanical nitrification inhibitors for a higher N use efficiency and sustainable crop productivity.

Keywords：*Biological nitrification inhibitors, nitrogen use efficiency, denitrification*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Modelling Long-Term Maize Response to Nitrogen Management under Semi-Arid Conditions of Eastern Kenya

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Drier parts of Embu County; Eastern Kenya continue recording agricultural productivity declines. Integrated soil fertility management (ISFM) and soil-water conservation (SWC) technologies have been developed, and tested, with standardized application procedures and rates aimed at optimizing overall yield productivity. Despite their significant impacts, high variability in local soil and climate contributes to large variations among replications of the expensive and limited (time/site/scenarios) experimental treatments and inconsistence in research results leading to poor comparability of results within-and-without different agro-ecological zones (AEZs) due to complex non-linear soil-climate-crop relations. Crop growth simulation models suitably complement experimental research, to support decision making regarding soil fertility and water management. This study evaluated the performance of the Agricultural Production Systems Simulator (APSIM) model based on a rain-fed randomized complete block experiment (2010-to-2013) at VLIR UOS research station, Machang'a in Embu County; and evaluated the long-term N management in maize production. The trials combined three and two level amendments each as follows; inorganic fertilizers (30 kNgha-1, 60 kgNha-1 and 90 kgNha-1), goat manure (30 kgNha-1 and 60 kgNha-1), Lantana (30 kgNha-1 and 60 kgNha-1), Tithonia (30 kgNha-1 and 60 kgNha-1), Mucuna (30 kgNha-1 and 60 kgNha-1; rotational with maize) and control (TSP 60 kgha-1); replicated three times. Half rate (30 kgNha-1) applications were complimented by half rate inorganic fertilizer application. Calibration and Validation was based on goodness-of-fit between observed and simulated parameters derived from residual-errors statistics; root mean square error (RMSE), square of the correlation coefficient (R2), and model efficiency (EF). APSIM simulations suitably predicted documented/observed maize crop-growth (Leaf Area Index; LAI, Grain yield, and biomass). Grain prediction was good (R2>0.87 and EF>0.9) but biomass was slightly over-predicted (R2=67 and EF=0.87). APSIM trendily predicted the observed higher grain yield in LR2012 compared to LR2010, despite better rainfall patterns in LR2010. 12-year, long-term factorial numerical experiment showed that moderate N application (40kg N ha-1) improves both the long-term average and the minimum guaranteed grain yield (2.5Mgha-1) without increasing inter-seasonal variability compared to 0N and 80N inputs. Although it does imply a lower average yield than at 60kgNha-1, application of 40 kgNha-1 appeared more appropriate for smallholder, subsistence farmers than the recommended 60kgNha-1 as it guaranteed higher minimum yield in extreme dry seasons, thereby reducing their vulnerability. These findings should be considered in conditions where P is added proportionally to N (P/N in the range of 20 to 30%).

Keywords：*APSIM, ISFM, Lantana, Manure, Modeling, Mucuna, Nitrogen, Tithonia*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Integrated Effects of Organic and Chemical Fertilizers on Some Micronutrients Concentrations of Rice Plant under Different Soil Water Conditions

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Rice is the important food of more than half the people in the world and is generally cultivated under waterlogged conditions. However, irrigation water deficiency existed in some regions of Asia and Iran, is threatening the usual system of lowland rice cultivation. Hence, there is a need for researching alternate water management practices that save water and at the same time increase water productivity. In order to develop the high intensive agriculture, more chemical fertilizers are applied to the soil that results in soil degeneration, environment deterioration and causes deficiency in soil micronutrients. On the other hand, lack of sufficient organic matter in soils of Iran is responsible for the poor biological, physical and chemical conditions of these soils. So, application of organic wastes in soil to supply at least a part of the plant nutrient requirement and improve the soil properties is important. However, the continuous application of organic wastes on soils may lead to the accumulation of soluble salts and heavy metals in the soils.

In a greenhouse research, the integrated effects of poultry manure, sewage sludge and chemical fertilizers on concentrations of copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), cadmium (Cd), and lead (Pb) in shoot and root of rice plant (Oryza sativa L. cv. Ali Kazemi) were studied in a loamy sand soil under different soil water conditions. The study was performed as a factorial experiment in a randomized complete blocks design including soil water conditions at three levels (continuous waterlogging, alternate waterlogging and alternate saturation) and source and amount of organic and chemical fertilizers at 10 levels (control, 100% chemical fertilizers, 20 g sewage sludge per kg of soil with and without 50% chemical fertilizers, 40 g sewage sludge per kg of soil with and without 50% chemical fertilizers, 20 g poultry manure per kg of soil with and without 50% chemical fertilizers and 40 g poultry manure per kg of soil with and without 50% chemical fertilizers) with three replications. The Fe, Mn, Zn, Cu, Cd and Pb concentrations of rice shoot and root were measured by wet digestion method and atomic absorption spectrophotometer instrument. Statistical analysis of data was performed using the MSTATC software and means were compared using Least Significant Difference Test (LSD) at $p \leq 0.05$.

The results showed that the continuous waterlogging increased shoot concentrations of Fe and Mn compared to alternate waterlogging and alternate saturation. The shoot concentrations of Cu and Zn in alternate saturation were significantly greater than the continuous waterlogging. Application of 20 and 40 g poultry manure per kg of soil prevented the growth of rice due to soil salinization; therefore, these treatments were excluded. This result showed that poultry manure should be used at lower amounts. Application of sewage sludge and increasing level of that increased the concentrations of Cu, Fe, Mn and Zn in rice shoot. In all treatments, Cd and Pb concentrations in shoot of rice plant were not measurable with atomic absorption spectrophotometry. The Mn concentration in rice shoot was greater than that of root while the Cu, Fe, and Zn concentrations in rice shoot were less than those of root. The highest concentrations of Cu, Fe, Mn and Zn in root and shoot of rice were observed at 40 g sewage sludge per kg of soil + 50% chemical fertilizers treatment.

Keywords：*Copper, Heavy metals, Iron, Manganese, Poultry manure, Sewage sludge, Zinc*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluation of Two Sources of Phosphorus and Micronutrients in Productivity and Technological Quality of Sugarcane

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Phosphorus is a macronutrient extracted in smaller quantities for sugarcane, is one of the most limiting nutrients for production, due to intensity of reactions of adsorption and fixation, especially in tropical soils, turning it unavailable for culture. In terms of micronutrients (boron, copper, iron, manganese and zinc), the response of the culture of sugarcane their use is still not unanimous. In some works have been shown positive responses, especially in expansion areas, soils of low fertility or in traditional cultivation areas in consequence of resource depletion. Associated with this, is uncommon the phosphorus and micronutrients application over ratoon in sector of sugarcane, which are applied only in the implantation or in the reform of the sugarcane, but it is not enough to guarantee the supply of nutrients at levels appropriate to the culture. Thus, this study aimed to evaluate the effects of two sources of phosphorus in fertilization of sugarcane ratoon over yield and technological quality of sugarcane. Therefore, an experiment was conducted in Porto Ferreira -SP in sugarcane mill of the Ferrari S/A, in December 2010, under Oxisol Distrophic medium texture, with the variety RB - 85 7515, the 4th harvest with no burning and mechanically harvested . The experimental design was randomized blocks with split plots totaling 40 experimental units. The main plots were the treatments corresponding to phosphorus sources: T1 - control (no fertilizer), T2 - 495 kg ha-1 of 21-00-14 formulation (ammonium nitrate + potassium chloride), T3 - 495 kg ha -1 of formulation 21-00-14 (ammonium nitrate + triple superphosphate + potassium chloride) and T4 - 495 kg ha-1 formulation 21-00-14 (YaraMila ™).

The treatments 3 and 4 differ by phosphorus source. The triple superphosphate is composed exclusively by salts of orthophosphoric acid (H3PO4), while the source of P YaraMila comprises about 70-80% of orthophosphate (readily soluble), and 20-30% of polyphosphates (solubilization more controlled). In subplots were applied secondary treatments with applying or not foliar micronutrients. The sources and doses used: Zn = 778 g ha-1 (oxides), B = 150 g ha-1 (borate monoetalomina), Cu = 110 g ha-1 (oxides), Mn = 331 g ha-1 (Mn carbonate) and Mo = 52 g ha-1 (sodium molybdate). Through the harvest of the experiment (August 2011) could be concluded that the ratoon canesugar answered significantly ($p<0.05$) to the application of phosphorus. The average yield of stalks rose from 45.6 Mg ha-1 (no phosphorus) to 56 Mg ha-1 (average production for the two sources of P). The gain was correspondent to 23% (11 Mg ha-1 of stem). The treatment 4 (polyphosphate YaraMila ™) promoted greater gain, around 27% (13 Mg ha-1 of stalks) compared to control and about 9% compared to treatment 3 (triple superphosphate). This increase afforded sugarcane extra production of 2.3 Mg ha-1. Phosphorus application increased significantly the concentration of P in the soil ($p <0.0001$). The treatments T3 (17.7 mg dm-3 of soil) and T4 (16.7 mg dm-3 of soil) were similar statistically but, they were higher than T1 (10.7 mg dm-3 solo) and T2 (11.1 mg dm-3 of soil). There were interaction among the phosphorus and micronutrients treatments for foliar concentration of P. The values of P in leaf were considered adequate or approximately adequate for culture presenting values between 1.72 and 1.86 g kg-1. The levels of micronutrients did not influence the productivity. The use of phosphorus as well as micronutrients affected the technological parameters of Purity, Pol, Fiber and ATR of ratoon cane.

Keywords：*Phosphorus, Micronutrients, Productivity, Technological Quality Of Sugarcane*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Performance Evaluation of Phonolite Rock as a Source of Potassium Conveyed the Mineral form and Enrichment of Filter Cake Applied in Ratoon Sugarcane

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Potassium is one of the most nutrients extracted by sugarcane and which operates in its main metabolic processes. Among the main sources used K2O is potassium chloride, which import by Brazil in the 2012 reached 92.4%. Thus, the study of alternative sources of potassium is an important tool for the elucidation of both new ways of handling, and for reducing the external dependency. In Brazil there are alternative sources of potassium such as phonolite, a rock composed of minerals rich in potassium, silicon and sodium as microcline (KAlSi3O8) ortoclasia (KAlSi3O8), andesite [(Na, Ca) (Si, Al) 4O8] and nepheline (Na, K, AlSiO4) from volcanic rocks located in Plateau Pocos de Caldas - Minas Gerais (Brazil). The rock has the following chemical composition: 52.44% SiO2, 23.37% Al2O3, 9.06% K2O, 8.4% Na2O, 3.85% Fe2O3, 2.84% CaO, 0.61% TiO2; 0.13% MnO, 0.10% P2O5. Thus, the present study aimed to evaluate the phonolite as a source of potassium fertilizer management of ratoon sugarcane, served in a mineral and enrichment of filter cake. Therefore, an experiment was conducted in plant Ferrari (White House - SP) in November/2011 in dystrophic red-yellow Haplortox, using the variety SP - 801 816, on the third cut, mechanically harvested without burning. The experimental design was a completely randomized design with 10 treatments, 4 replicates, a total of 40 plots. The treatments were: T1: control without K, T2, T3 and T4 = Mineral fertilizers to the source phonolite 8% at doses of 70, 100 and 130 kg ha-1 of K2O, respectively, T5 = Mineral fertilizers to the source phonolite 14 % at a dose of 100 kg ha-1 K2O T6 = mineral fertilization with KCl source at a dose of 100 kg ha-1, T7: filter cake enriched with KCl source at a dose of 100 kg ha-1 of K2O; T8, T9 and T10 = filter cake enriched with the source phonolite 8% at doses of 70, 100 and 130 kg ha-1 of K2O, respectively. All plots received 100 kg N.ha-1 and may be ammonium nitrate, MAP and Ajifer 7.5% N. The dose of phosphorus was 65.5 kg P2O5.ha-1, using as the source. After harvesting in October 2012, there was the following results: the average productivity of ratoon significantly increased with the use of potassium, regardless of source, dose or form of delivery. The average productivity of the treatments was 67.4 Mg ha-1 against 55, 7 Mg ha-1 in control stalks. There was no significant difference between the levels of potassium in the soil, with values of 1.1 and 1.0 mmolc of K.dm-3 soil, respectively for treatments versus control. As for the content of potassium in leaves significant difference, with values of 20 and 13 g of K. kg-1 of leaves, respectively for treatments versus control. Treatments conveyed the mineral form using as the source of potassium phonolite 8.4% showed no significant difference in production stems depending on the doses 70,100 and 130 kg of K2O.ha-1. For these treatments, the yield averages were: T2 = 60, T3 = 64 and T4 = 67 Mg.ha-1 of stem. However, to form serving Organomineral linearly increased the straw yield depending on potassium levels. For these treatments, the yield averages were: 67.8 = T8, T9 and T10 = 74.4 = 77.8 Mg.ha-1 of stem. Regarding sources of potassium, both applied as organic mineral and the dose of 100 K2O.ha-1, the source phonolite 8% (T9) was more efficient than the source KCl (T7). For these treatments, the average productivities form of 61.5 and 74.4 Mg ha-1 of stem respectively for the treatments T7 and T9. For these treatments, there was no significant difference between the levels of potassium in the soil (T7= 1.2 and T9 = 1.0 mmolc.dm-3 soil) and leaf (T7= 21.5 and T9 = 20 g of K. kg-1 sheets).

Keywords：*Phonolite rock, potassium, filter cake, sugarcane, nutrition mineral*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Shifting Cultivation and Alternative Farming Systems in the North Eastern Hills Region of India

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The North Eastern Hill Region of India has fragile, inaccessible, complex and diverse ecosystem. The region is, however, unique in terms of ecosystem, plant, animal and ethnic diversity. The region falls under high rain fall zone and humidity, undulating hilly topography with wide range of altitude and climate ranges from subtropical plain to temperate. Shifting cultivation is an important land use system in the region. The prevalence of shifting cultivation, raised bed along the slopes, and pervasive deforestation have caused grave degradation of soil water, flora and fauna. Alternate farming systems to shifting cultivation are being developed for attaining the production and productivity goals ensuring sustainable use of natural resources and high efficiency inputs. The studies on shifting cultivation on steep shops (44-53%) have indicated the soil loss to the tune of 40.9 tons per ha and the corresponding nutrient loss per ha area 702.9 kg organic carbon 145.5 kg of P2O5 and 7.1 kg K2O. The soil erosion from hill slopes (60-79%) under first year, second year and abandoned shifting cultivation was estimated to be 147, 170 and 30 ton per year. Watershed based farming system, appropriate soil conservation measures, mixed land use of agri-horti-silvipastoral system, subsidiary source of income through livestock rearing, creation of water harvesting and silt retention structures at lower reaches - these are the important distinguishing features of the suggested agricultural strategy on this hill slopes. A modified land capability classification for the region has been recommended for suitable land utilization.

Studies in watershed based farming systems have shown the scope of using step scopes for intensive crop production. Some of the potential farming systems such as agriculture on bench terraces, horticulture, agri-horti-silvipastoral systems etc. have been evaluated at the experimental watersheds for their long term runoff, soil loses, production behavior and so on. Watershed based farming system coupled with-mechanical soil conservation measures viz. contour trenches, contour bunds, bench terrace, half moon terrace, grassed waterways etc. retained maximum rain fall within the slope, safely disposing off the excess runoff from the slopes to foothills with non erosive velocity. Land use practices in micro watersheds with soil and water conservation measure were found very effective in retention of rainfall; rainfall retained in situ varied between 80-100% with soil erosion under permissible limits. Application of improved production technology and increase of cropping intensity by growing at least to high yielding crops have the possibility to increase the productivity of rain fed bench terrace 3 to 5 times more than that of sloppy land with no detrimental effects on natural resources. The trials conducted, have demonstrated that one ha of terraced land can sustain a family of five with 60 percent of yield, meeting the food requirements and marketing the remains for other needs. Introduction of remunerative horticultural crops can instill in the shifting cultivators long term interest to the land for settled agriculture. Subsidiary income can be obtained from rearing of life stock by feeding on the byproducts of crops and cultivated fodders, trees raised on the terrace risers, bund surface and very steep slopes unfit for cultivation. Construction of small earthen dams for water storage and silt retention at lower reaches of the watershed by utilizing local resources-earth, stones, human labor was able to store water for fish production or to recycle back for live saving irrigation.

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Management of Potassium Fertilization on the Nutrition of Maize Hybrids

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The world production of maize (Zea mays L.) was 170.4 million tons in 2011/2012, and the three largest producers were the United States, China and Brazil, accounting respectively for 35.5%, 21.8% and 6.3% of world production of this cereal and average productivity of 9.2, 5.7 and 4.2 tons/ha (FAO, 2013). The availability of nutrients is important factor in plant nutrition, which is reflected in plant development. Potassium (K) is the second macronutrient in content contained in plants, behind only on nitrogen requirement (N). The K increases the content of carbohydrates, oils and proteins, stimulates the formation of grains, decreasing the pith process, promotes the storage of sugar and starch and increases water use. The K is an enzymatic activator of hundreds of enzymes involved in the biochemical pathways such as: translocation of sugars; opening and closing of stomata; osmotic regulation; photosynthesis (Malavolta, 2006). Improved use of K in agriculture has a great potential to improve the overall productivity of maize production. The objective was to verify the effects of K doses of fertilization on soil fertility, as well as on the mineral nutrition and yield of maize hybrids. The work was performed at the University of Sao Paulo, in Pirassununga/Sao Paulo State/Brazil in low K availability soil (pH in CaCl2=5.1; P resin = 6.0 mg.dm-3; in mmolc.dm-3: S = 6.0, K = 0.4, Ca = 12, Mg = 7.0, Al = 1, H + Al = 22; Sum of bases (SB) = 19 and CTC = 41; organic matter =21g.kg-1; base saturation (V%) = 47%). Treatments were three maize hybrids: DKB390 ProR2 (H1), Pioneer 30F35 (H2) and Syngenta Status (H3) and 4 doses of potassium fertilization: 0, 65, 130 and 260 kg.ha-1 K2O, equivalent to 0, 50, 100 and 200% of the recommended dose with 4 repetitions. Sowing (6 seeds/meter and 0.8 m spacing) and fertilization were manuals. At the end of the cycle was evaluated maize yield (kg ha-1), and performed soil sampling to evaluate pH, K, calcium (Ca), magnesium (Mg) and V% in layers of 0.0-0.1m and 0.1-0.2m at 2 positions (crop row and interrow). The contents of K were determined in the indicative leaf of maize (IL). In R1, hybrids not receiving K fertilization showed chlorotic leaves and then necrotic, initially in the older ones. The K in IL also increased significantly with increasing K fertilization, adjusting to the quadratic model in all hybrids. The increased K2O in the fertilization promoted a significant K variation ($p < 0.01$) in the soil. There was significant difference between the K in the soil between layers and also at the sampling position (row and interrow), but the interaction between them was not significant. The K at the row position ascended according to the quadratic model for the doses studied. The Ca content in the soil responded significantly ($p < 0.01$) to the increment of K in the fertilization according to negative quadratic models; with significant difference between the layers evaluated and not significant for sampling positions. Xu et al. (2006) suggest that plant cells may require Ca2+ under conditions of K+ deficiency. The pH, V% and Mg of soil did not vary significantly ($p < 0.01$) with the increased K2O in the soil or the sampling position; however they varied significantly between the layers evaluated. The addition of potassium fertilizer promoted significant increase ($p<0.01$) on productivity of maize hybrids that responded according to the quadratic model for H1 and linear for H2 and H3, and according to the regression equation, maximum productivity of H1 was 6080 kg.ha-1 at 148.7 kg.ha-1 of K2O. The increased K in fertilization contributes to increase the concentration of potassium in the soil and plant and reduced Ca concentration in the soil; besides promoting a significant increase on maize yield in all hybrids.

Keywords：*plant nutrition, Zea mays L., macronutrients, yield*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Comparative Effects of Different Nitrogen Sources From Organic Manure and Urea Fertilizer on Soil Chemical Properties, Nutrient Uptake, Growth and Yield of Amaranthus Cruentus

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Amelioration of soil fertility problem in the tropics through inorganic fertilizer application is faced with much criticisms with respect to environmental and health concerns. Amaranthus cruentus L. is a highly cherished leafy vegetable in Nigeria. It requires an ample supply of soil nutrients for its optimum growth. A two- year field trial was conducted in the early planting seasons of 2005 and 2006 at the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria to evaluate the effects of different organic manure sources and an inorganic fertilizer on the soil chemical properties, nutrient uptake, growth, crude protein content and yield of Amaranthus cruentus. There were 16 treatments laid out in a randomised complete block design with 3 replications. Four sources of organic manure (cattle, goat, pig and poultry manures) and an inorganic fertilizer source (urea) were evaluated each at three nitrogen rates (30, 60 and 90 kg N/ha). Plots with no fertilizer application served as the control. Plants were grown and harvested once by uprooting at five weeks after planting (5 WAP). Soil chemical properties were determined after harvest from each treatment. Data were collected on growth variables (3 - 5 WAP), nutrient uptake and crude protein content of leaf at harvest as well as fresh and dry matter yield. Data were subjected to analysis of variance and means compared with Turkey's HSD at 5 % level of probability. The results obtained showed that the texture of the soil prior to experiment was loamy sand, strongly acidic [pH (H2O) 4. 76], low in organic carbon (11.5 g/kg), total N (1.18 g/kg), available P (12.00 mg/kg) and exchangeable cations. Application of fertilizer increased some of the soil chemical properties after harvest. Higher rates of organic manure and urea application significantly ($P< 0.05$) increased total N, organic carbon, exchangeable K, Na, and base saturation contents of the soil relative to the control plots. However, for available P, exchangeable Ca, Mg and ECEC only higher rates of cattle and pig manures caused a significant increase compared with the control. Total N varied from 1.18 to 1.90 g/kg with the lowest value obtained from the control plot while the highest value was obtained from the application of pig manure at 90 kg N/ha. The highest values of available P (18.25 mg/kg), organic carbon (20.93 g/kg), exchangeable K (0.117 cmol/kg), Ca (4.27 cmol/kg), Mg (2.60 cmol/kg) and Na (0.08 cmol/kg), and base saturation (89.00%) were obtained with pig manure amendment at 90 kg N/ha. The pH value of the soil was significantly increased in plots amended with higher rates of organic manure excepting goat manure. The soil pH varied from 4.82 to 5.64 after harvest. The exchangeable acidity (EA) value was highest (1.36 cmol/kg) in plots not amended with fertilizer followed by those amended with urea at 90 kg N/ha (1.25 cmol/kg). Among all the treatments, plots amended with pig manure at 90 kg N/ha had the best soil chemical properties. With the exception of goat manure, the application of either fertilizer type significantly ($P < 0.05$) enhanced the uptake of some major elements (N, P, K, Ca, Mg) compared with the control. The greatest nutrient uptake was obtained in plots amended with pig manure at 90 kg N/ha. Crude protein content of leaf was increased with fertilizer application, the highest being in urea (19.57 %) treated plots followed by pig manure at 90 kg N/ha (17.73 %). Amendment of soil with organic manure and urea significantly ($P < 0.05$) enhanced growth and yield of Amaranthus compared with the control plots. Higher rates of pig and poultry manure were as effective as higher rates of urea. The highest fresh and dry matter yield of 48.18 t/ha and 7.66 t/ha were obtained in plots amended with 90 kg N/ha of pig manure, respectively. The trial has illustrated that pig manure when applied at 90 kg N/ha could substitute urea fertilizer in the production of Amaranthus cruentus.

Keywords：*Amaranthus cruentus, organic manure,urea fertilizer, nutrient uptake, soil chemical properties.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Organic Farming for Sustained Soil Health in Sugarcane

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Under the context of environmental pollution, health hazards and great threat for soil sustainability, organic farming is gaining prominence even though it has merits and demerits in crop production. Organic manures have been found to enhance the efficiency and reduce the requirement of chemical fertilizers besides improving quality of produce and sustaining soil health. However, it is under belief that turning to organic farming would mean lower yield and lower profits; and it takes long time for build up of organic matter and thereby to provide nutrients to substitute totally the chemical fertilizers for achieving higher yields. Hence, the present study on "Organic farming research in sugarcane" is conducting from 2007 onwards at RARS, Anakapalle, Acharya N G Ranga Agricultural University, Andhra Pradesh, India in Inceptisols to study the feasibility of organic farming on sugarcane without using any chemical fertilizers/pesticides/fungicides. Complete package of practices were standardized during four years of study. Regarding nutrient management applied farmyard manure @ 25 t/ha as basal dose and vermicompost @ 3 t/ha at 60,90 and 120 days after transplanting. Sprayings of vermiwash (10 ml/lt) at critical stages of crop. Insitu green manuring of sunhemp between the lines and incorporation. Biofertilizer (azatobactor/ azospirillum) application for every alternate year. At cessation of mansoon application of trash compost @ 5 t/ha. As a check 100 % chemical fertilizer treatment also maintaining in another field with same soil texture. Results of the experiment revealed that organic farming is having positive effect on soil physical properties (viz., bulk density, water holding capacity and per cent pore space), soil biology and soil nutrient status. Initial soils are neutral in reaction with normal conductivity. The soil organic carbon (0.52 %) and available nitrogen (232 kg/ha) was low to medium in status and available phosphorus (40.80 kg/ha) and potassium (269 kg/ha) status was medium in range. After four years of study the organic carbon was raised to 0.55 %, available NPK status was 241, 47.10 and 274 kg/ha in organic farming plot where as in 100 % chemical fertilizer treatment the organic carbon status was slightly reduced (0.50 %) from its initial value and available NPK status was 232 kg/ha, 41.50 kg/ha and 270 kg/ha, respectively. Significantly highest counts of phosphorus solubolizing bacteria (102x105), Azatobactor (102x105), total bacteria (351x105) and fungi (150x105) was noticed in organic farming plot as against inorganic plot.

Keywords：*Organic farming, sugarcane, soil fertility, soil boilogy.,*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Maturity Indices for Evaluation of Quality Composts

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The recycling of crop residues and organic wastes through composting is the key technology for production of organic manures with in a short period. Compost quality is closely related to its stability and maturity. Different chemical and biochemical changes occur during composting, the choices of raw materials and the composting method have made it difficult to agree on methods for the practical assessment of maturity. Various parameters have been used to assess the quality and maturity of composts. Hence the present investigation was carried out at Regional Agricultural Research Station, Acharya NG Ranga Agricultural University, Andhra Pradesh during 2010 to monitor the changes in maturity indices i.e total organic carbon, total nitrogen, C/N ratio, humic substances and humification index during conventional method of composting and vermicomposting of different organic residues i.e sugarcane trash, weeds, vegetable market waste and paddy straw. The results revealed that the total organic carbon and C/N ratio decreased while total nitrogen and humic substances increased with the passage of time during composting in all the organic residues. Vegetable market waste recorded narrow C/N ratio with high total nitrogen content in both the composting methods. Where paddy straw recorded less nitrogen with wide C/N ratio. The highest humic substances were observed in vegetable market waste vermicompost followed by weed vermicompost. Minimum per cent of humic substances were recorded with cane trash and rice straw. Vegetable market waste recorded highest humic acid content (10.85 %) followed by weeds (10.40%), cane trash (9.85 %,) and rice straw (9.10 %) during vermicomposting. A well known index for humification is the HA/FA ratio, in both the composts paddy straw compost recorded low ratio and high ratio was recorded in vegetable market waste compost. During vermicomposting the HA/FA ratio varied from 2.91 (cane trash) to 3.45 (vegetable market waste) at 15 days and 3.72 (paddy straw) to 4.34 (vegetable market waste) at 60 days, where as in conventional composting it was ranged between 3.46 to 3.56 at 15 days and 4.23 to 4.55 at 110 days. Vermicomposting offers a promising solution for the recycling of organic wastes into valuable organic manure with in a short period of time over conventional composting.

Keywords：*composting, maturity indices, vegetable market waste, weeds etc*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Selected Non- Metals in the Mineral - Soil- Plant System (b-Si-P-S-F-Cl-Br-I)

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The greatest part of the periodic system of chemical elements is covered by metals, which are cationic in many cases, and can be grouped due to some similar properties. The non-metals are individuals, preferably anionic, and much more capable to form covalent compounds among themselves. Some of them are essential for living biota (P, S), others are beneficial (Si), others may be both essential and toxic (B, F, I), depending on the level encountered. In routine multi-element analysis, they are not frequently targetted because of their individual properties. Therefore, data are much more scattered in the literature than for metals.

This review about oecological cycling of non-metals in environmental matrices, particularly in soils, will start with an overview of analytical methods, which depend on the targetted non-metal, its speciation, and the matrix investigated. For solids, total digestion and selective leaching methods are available. In other methods, like neutron activation or X-ray fluorescence, the solids can be taken directly. Determination in solution can be done by classical methods, atomic spectroscopy, mass spectrometry, or ion selective electrodes. In the gas phase, enrichment by sampling techniques, as well as spectroscopic methods are in use. For the analysis of organics, chromatographic methods are preferable.

All this great amount of single data can be combined to get ideas of the levels of expected occurrence, from mean crust values via minerals and the sea, to soils and biota. For the cycling of silica, weathering processes of primary silicates need to be considered. Phosphates are mined for the production of mineral fertilizers. The sulfides are mined to explore the metals, not the sulfur. Though the halogenides and sulfates are rather soluble, there is also salt mining.

In soils and sediments, beneath total amounts, mobile fractions are usually investigated also. Water, unbuffered salt solutions as well as acid buffers or alkaline solutions, have been used, but there is no universal reagent to leach all non-metals simultaneously. This should model environmental mobilities as well as the soil to plant transfer. In routine soil analysis to determine fertilization needs, phosphate leachable in acetate-lactate pH 4,5, boron in weak acid extractant or water, and sulfate-chloride in the water extract, are usually done. Fluoride is regarded as a contaminant, and data have been got preferably from contaminated areas. Iodine and bromine speciation and respective data are still in the state of research. Total silica in soils is regarded not to be relevant, and soluble silica is important above all in the tropics.

Input to the soil is from atmospheric deposition, fertilization, and the irrigation water. Sources of aerosols are the erosion of rocks, soils, buildings, and streets, combustion processes, other industrial emission sources, as well as organic debris, and sometimes vulcanic activities. Close to the sea, there is also the sea-salt aerosol, formed from the splashing of fine droplets. Wet depositon leads to a washout of ammonium sulfates and halogenides from the atmosphere, whereas minerals are also subject to dry deposition. European deposition data for important non-metals are available from 1966 till current, they show a decrease for sulfates. For others, input from fertilizers to arable soils is substantially more than from atmospheric deposition, unless near sources of contamination. During coal combustion, sulfur leaves as SO2, chlorine largely as HCl, boron as B2O3, and fluorine largely as HF.

Because of respective environmental concerns about contaminations, a special emphasis is laid on the composition of coal and its combustion technology.

Mineral fertilizers are applied to soils according to their nitrogen and phosphorus contents. Boron data have been obtained routinely obtained as well. Sulfate and chloride have been determined only if labelled as such, and data about fluoride, bromide and iodide/iodate are scarce. Apatite as the main mineral for the production of mineral phosphates, can contain up to 2,6% of fluoride, and crucial dust emissions from around apatite processing sites have been reported. But rock phosphates also contain 305 mg/kg of boron in the median (range 43-454), as investigated in our lab, which is beneficial, particularly for flowering crops.

Recycling of manures, dungs, and composts to the soil is a good source of phosphorus, sulfur, and selenium; data about the halogenides are rare. The level of chloride in composts and wastes seems to increase with population density. Urban biowaste has to be controlled for outliers, i.e. wrong inputs which cause contamination, e.g. de-icing salt in winter time.

Vertical mobilities of dissolved species in the soil column govern the composition of ground water. Among the non-metals, chloride and bromide are regarded as non-retarded with respect to the downward water velocity, termed as conservative tracers. Borate is retarded only slightly, at all adsorbents possible. Phosphate, fluoride and sulfate migrations depend on the redox potential, pedogenic oxides, and pH resp. carbonates. Silicate can be assumed to be saturated with respect to silicic acid. Soil bacteria help to transform or incorporate sulfur, selenium, and phosphorus species.

In the hydrosphere, phosphate is essential for algal and macrophyte growth, and the most frequently encountered limiting nutrient. Excess phosphorus input leads to eutrophication (if the temperature is sufficient), and finally nitrogen is limiting. Soluble silicate is essential for diatomea. Many biota are adapted to a certain level of halides, and just a few can change between the sea and limnic environments.

For the soil to plant transfer via the roots, soluble forms are necessary. Whereas phosphorus and sulfur can be incorporated into proteins, silica is depleted in cell walls as biolits, to increase stiffness and to save the build-up of cellulose. Boron preferably moves to the blossoms, and gets extremely enriched in honey. For many crops, the needs are known, and the annual outputs have to be covered by fertilizations.

All these statements will be proven by data from Austria, ist neighbouring countries, as well from international references. From he lab of the author, a lot of data from fertilizers, soils, and green plants as well as food and feed are available.

Keywords：*boron, silicon, phosphorus, sulfur, halogenides; atmospheric deposition, fertilizer, mobility*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluation of Compost Tea on Yield Productions and Post-Harvest Soil Properties of Potato and Tomato at Mekelle, Northern Ethiopia

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Crops and vegetables need sufficient amount of nutrients in a usable form for their healthy growth and optimal yield productions. Soil is getting depleted its fertility which is the main constraint in the region. To overcome this, chemical fertilizers are the most used fertilizer types. However, successive application of chemical fertilizer needs high level of foreign currency as well as wasteful, costly and harmful to the environment. Hence, emphasis should be given to the locally available low cost organic fertilizers. Compost and its brewed, water extracts (compost tea) becomes the best alternative organic fertilizer available in our region. An experiment was conducted at Mekelle Agricultural Research Center testing site with an objective of evaluating compost tea on potato and tomato productions. This was evaluated using three treatment combinations of compost tea and two recommended chemical fertilizers and compost tea independently and the one with no fertilizer application laid out in Randomized Complete Block Design (RCBD) with three replications. Data on post-harvest soil properties and yield of each treatment were collected and analyzed. As a result, the analyzed post-harvest soil properties revealed that there was no significant ($p<0.05$) difference in all of the treatments in both potato and tomato. This is due to, the microorganisms found in quality compost tea were abled the crops to easily taking of the fertilizers through making favorable conditions for the crops root system to reach nutrients. Indicated that compost tea applied could not increase or decrease in amount of the soil quality parameters. In the contrary, application of 75 % of the recommended compost tea with combination of 25% of the recommended chemical fertilizers gives higher yield than the other treatments and lower yields were obtained from the non-fertilized plot for both potato and tomato. The less amount of compost tea applied the less amount of yield obtained or vise-versa. Hence, compost tea can be used as a substitute to the chemical fertilizers in a significant level when jointly used with the chemical fertilizers. Therefore, application of compost tea with combination of chemical fertilizers at a rate of 3:1 is recommended for significantly ($p<0.05$) higher production of potato and tomato. It can be recommended that compost tea should be produced in sufficient amount so that farmers can use it for their yield production combined with chemical fertilizers.

Keywords：*compost tea, chemical fertilizers, post-harvest soil properties, potato, tomato*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Availability of Manganese to Rice (oriza Sativa) in Mato Grosso - Brazil Soil

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Savana soils brazilian, where include Mato Grosso, are acids and low fertility. Correction of acidity by limestone is necessary and greatly used by productors, therefore it decreaseas availability of cations micronutrients, mostly manganese, which is severaly affected by pH. In natural conditions the availability of manganese is lower in these soils, and still is decreased by high pH. So it is necessary evaluate if this element constitute one limiting factor to crop production. The objective of this work was to check deficieny occurency this element when corrected soil acidity by carryng out one study on an Red Dark Oxisoil in Rondonopolis-MT, evaluating dosations of manganese: 0, 10, 20, 30, 40 kg/ha Mn by utilization of sulfato manganoso combined with three levels of liming: 0; 1,15 e 3,30 ton/ha filler limestone. It was evaluated the following parameters: crop production, relactive production, high plants, manganese in leaves, soil pH, exchangeable: aluminium, calicium and magnesium, base saturation. Treatments were arranjed in Factorial 5 X 3 in delineament of casualized blocs. Analysis of results showed that the level of manganese original in soil of 13 mg/kg was enough to supply plants of rice, and higher than critic level of 5 mg/kg, which was in accordance with fit level of this element in leaves of 72 mg/kg, and with the grain production that was not affected by fertilization, even in the higher dosation of limestone which increased pH to 5,6 and base saturation to 40%. So it is not necessary fertilization with manganese to rice crop in most soils of Mato Grosso, considering the soil utilized in this work is representative and one of lower natural fertility. Extractor utilized (Mehlich 1) was efficient to predict changes in avalilability of manganese in most situations, exception in high soli pH. Changes in Capacity Factor also was detected in acidity conditions, as evidenced by greater curve inclination . This fact occurs because of solubility and interaction with change complex is more intense in acidity conditions. Limestone increased grain production to higer level because of neutralization of aluminium and supply of calcium and magnesium, that was limiting production in natural conditions.

Keywords：*Soil fertility, plant respone, liming.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

African Traditional Vegetables as Agents of Integrated Soil Fertility Management-Crotalaria and Amaranth Farming

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The knowledge and understanding of African leafy vegetables had become minimised over time but in the recent past there is more interest in their research for their nutritive and medicinal values. Of value are those that have the potential to ameliorate soil nutrient levels. This is with the background that despite inorganic fertilizers having had a dramatic impact of agriculture in the world, the economic situation in sub-Saharan African calls for alternative methods of reducing soil fertility degradation. The use of leguminous vegetables may be a solution. The study looks at the potential contribution of a leguminous traditional vegetable, Crotolaria ochreleuca to soil nitrogen and its response to various nutrient additions. The crop was chosen for its vigorous growth and adaptability to many regions of Kenya. During the study which was conducted over two seasons, C. ochroleuca was grown under two treatments of inorganic fertilizer (IF) and organic fertilizer (OF) with a control in which there was no fertilizer applied (NF). Another non-leguminous vegetable, Amaranthus dubius (Amaranth) was grown under the same treatments for comparison purposes. Soil analysis was done before planting in the experimental plot and soil nutrients were again measured after harvest in the NF subplots. Growth parameters were measured every fortnight and these included leaf number, shoot length, dry weight and nodule number for Crotolaria. Results indicated that while the leguminous vegetable was not affected by external inputs with no significant differences between treatments and control. The non-leguminous vegetables responded well to both IF and OF treatments in all the measured parameters. This underlines the potential for improvements in soil nitrogen levels using leguminous vegetables especially as intercrops with the non-leguminous types.

Keywords：*ISFM, Crotalaria,Amaranth*

P4-274

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Does Compost Pelletization Improve Phosphorus Use Efficiency for Field Crops?

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BACKGROUND: Phosphorus (P) recovery and reuse from animal manure can help alleviate P loading in areas with large numbers of livestock. Animal manure has a high nutrient value and has been traditionally processed into compost for use as an organic fertilizer. However, application of animal manure compost is currently challenging because of its production, maldistribution, weight, and form. Pelletized compost is becoming popular because of its advantages over ordinary non-molded compost in terms of storage, handling, transport, and field application. In general, compost nutrients are not affected by the pelletizing process, but P use efficiency is affected by the higher density and lower surface area in compost pellets compared with the bulk material. We demonstrate that pelletization produces increased P use efficiency comparable with that of single superphosphate, probably by preventing soil P fixation (Arakawa, 2012). Although the phenomenon has been observed in some pot trials, further investigations under field conditions with various crops are necessary.
MATERIALS & METHODS: To evaluate the effect of compost pelletization on agronomic characters, yield, and P use efficiency, a homogeneous mixture of cattle manure and poultry manure compost was pelletized and used for the following experiments. Two field experiments were performed on an Andisol (volcanic ash soil) with high P sorption and with low available P. The abovementioned manure compost pellets (MCP), a non-molded mixture (NMM), and single superphosphate (SSP) were used as sole P sources. Equal amounts of P were applied to plots alongside non-P-fertilized plots. The whole plots were arranged in a four by four Latin square design. Pak-choi, sweet corn, and soybeans were grown in rotation on one field, and soybeans, Chinese cabbage, and sweet corn grown in rotation on the other field. The fertilizer application rate was determined by considering the nutrients derived from the compost and the locally recommended rate (from 100 to 150 kg P_2O_5 ha^{-1}). P use efficiency was calculated by subtracting P uptake of non-P-fertilized plants from P uptake of fertilized plants and dividing by P application rate.
RESULTS & DISCUSSION: As with previous pot experiments, some crops absorbed significantly higher amounts of P when P was applied in pellet form rather than in non-molded form.
- Sweet corn: Shoot yield and P uptake were significantly higher in MCP-treated plots than in NMM- or SSP-treated plots; however, ear yield was not significantly different between fertilized plots. In the first experiment, P use efficiency was highest in the MCP plot (6.2%), followed by NMM (3.9%) and SSP (3.4%) plots, and in the second experiment MCP (7.7%) was followed by SSP (6.8%) and NMM (4.8%).
- Pak-choi: P uptake was significantly higher in P-fertilized plants than in non-P-fertilized plants, however it did not significantly iffer between fertilized plants. P use efficiency was relatively low and ranged from 4.5% to 5.5%.
- Soybeans: Agronomic characters, yield, and P use efficiency were not significantly different between P-fertilized plants and non-P-fertilized plants. However, shoot weight in the flowering stage was larger in P-fertilized plants. P use efficiency was relatively low and ranged from 0.6% to 3.7% in the first experiment and from 3.7% to 8.4% in the second experiment.
- Chinese cabbage: Biological yield, marketable yield, and P uptake were significantly higher in MCP plants than in NMM or SSP plants. P use efficiency was highest in the MCP plot (42.3%), followed by SSP (33.8%) and NMM (28.0%) plots.
We conclude from this study that although compost P use efficiency can be improved by pelletization, agronomic characters and yield are not always improved.
The crops except Chinese cabbage absorbed less than 10 % of the phosphorus in this study. The next step is to examine whether compost pellets can reduce P application rates without deteriorating agronomic characters and yield.

Keywords：*animal manure , compost pellets, fertilizer efficiency, phosphorus*

P4-275

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Nutrient Management in Groundnut + Hybrid Bt Cotton (3:1) Intercropping System in Medium Deep Vertisol under Rainfed Farming Situation

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Groundnut (Arachis hypogaea L.) is a major oilseed crop, extensively grown as sole crop during rainy season under rainfed farming situations of Northern Transitional Zone (Zone 8) of Karnataka state (India). Competition from crops like hybrid Bt-cotton during recent years in the traditional groundnut growing area of the zone coupled with high cost of groundnut cultivation resulted in drastic reduction in the area and production of groundnut crop during rainy season. Intercropping of groundnut with high value crops like hybrid Bt-cotton, therefore, offered greater scope for retention of groundnut cultivation in traditional groundnut growing area. Results of the earlier studies carried out during the period from 2006 to 2009 in the zone indicated that groundnut (Spanish Bunch type) can be grown successfully and profitably as an intercrop with hybrid Bt cotton (3 groundnut :1 hybrid Bt cotton) (groundnut: 30 cm × 10 cm - hybrid Bt cotton: 120 cm × 60 cm) with a nutrient management practices involving application of 100 % recommended dose of NPK fertilizers (RDNPK) to the respective component crops (25 kg N, 75 kg P2O5 and 25 kg K2O/ha for groundnut and 80 kg N, 40 kg P2O5 and 40 kg K2O/ha for hybrid Bt Cotton) than either sole groundnut or sole hybrid Bt cotton. Since the said intercropping system involves a legume component (i.e., groundnut), there is possibility of reducing fertilizer requirements for one of the component crops of the system particularly to the groundnut crop. In view of the above, a field trial entitled "Nutrient management in groundnut + hybrid Bt Cotton (3:1) intercropping system" to study the effect of different fertilizer management practices on the total productivity of groundnut + hybrid Bt cotton (3:1 row proportion) (30 cm × 10 cm - 120 cm × 60 cm) intercropping system was conducted for three consecutive rainy seasons (2010-11, 2011-12 and 2012-13) in Vertisols (Medium black clay soil) under rainfed farming situations at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka. The chemical test values of the soil were 8.10 pH, 4.8 g organic carbon/kg, 252 kg available N/ha, 32.7 kg available P2O5/ha, 359 kg available K2O/ha. The total rainfall received in the crop growth period of groundnut during 2010-11, 2011-12 and 2012-13 was 550.2 mm (36 Rainy days) and 350.2 mm (39 Rainy days) and 296.2 mm (26 Rainy days), respectively; while the total rainfall received in the crop growth period of hybrid Bt cotton during 2010-11, 2011-12 and 2012-13 was 774.4 mm (50 Rainy days); and 579.9 mm (49 Rainy days) and 351.5 mm (28 Rainy days), respectively. The maturity duration of groundnut and hybrid Bt cotton crops in intercropping system were 84 and 264 days, 94 and 223 days; and 102 and 166 days during 2010-11,2011-12 and 2012-13, respectively. Mean of the three years data indicated that, in sole groundnut, nutrient management practices involving application of 100 % RDNPK produced 2.42 % and 2.71% higher dry pod yield over application of 75 % RDNPK (3548 kg/ha) and application of 50 % RDNPK (3538 kg/ha), respectively. In sole hybrid Bt-cotton cropping, nutrient management practices involving application of 150 % RDNPK produced 29.45 % higher seed cotton yield over nutrient management practices involving application of 100 % RDNPK (1898 kg/ha). In 3:1 groundnut + hybrid Bt-cotton intercropping system, higher groundnut equivalent yield (5226 kg/ha), seed cotton equivalent yield (4028 kg/ha), gross monetary returns (Rs. 1,80,243/ha), net monetary returns (Rs. 1,18,883/ha) and benfit:cost ratio (2.93) were obtained with the nutrient management practice involving the application of 75 % RDNPK to groundnut and 100 % RDNPK to hybrid Bt-cotton as compared to the application of either 100 % RDNPK to groundnut and 100 % RDNPK to hybrid Bt-cotton. Thus, in Vertisols (low available N. medium available P and high available K)of Northern Transitional Zone (Zone 8) of Karnataka state under rainfed farming situation, application of 75 % RDNPK to groundnut (18.75 kg N, 56.25 kg P2O5 and 18.75 kg K2O/ha) and 100 % RDNPK to hybrid Bt-cotton (80 kg N, 40 kg P2O5 and 40 kg K2O/ha) found more profitable and remunerative nutrient management practices for groundnut + Bt-cotton (3:1 row proportion) intercropping system.

Keywords：*Intercropping, Groundnut, Hybrid Bt cotton, Nutrient management*

P4-276

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Productivity of Groundnut in Vertisol (medium Black Clay Soil) as Influenced by Different Nutrient Management Practices during Post-Rainy/summer Season Under Irrigated Situation

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Groundnut (Arachis hypogaea L.) is grown as an irrigated crop during post-rany/summer season (December-May) in India. Under intensive cropping system, nitrogen, phosphorus and potassium (rates and time of application) play a significant role in growth and yield of groundnut. Although groundnut is a leguminous oilseed crop, requires mineral nitrogen (N) in addition to symbiotically fixed nitrogen. To meet the nitrogen requirement during early growth stages, it is applied as starter dose. Basal application of N (10 to 75 kg N/ha) in the form of mineral nitrogen fertilizers along with phosphorus and potassium fertilizers has improved groundnut yields. High yielding groundnut variety with higher harvest index (0.40 to 0.48) especially cv. TAG 24 requires higher amount of nutrients, especially nitrogen and phosphorus applied in optimum ratio. Recent studies have shown that increasing levels of NPK increased the pod yield of groundnut. Further, it is also reported that groundnut showed greater response to the top dressing of major nutrients (NPK) under intensive crop management. To increase the groundnut productivity, top dressing of NPK fertilizers in addition to the basal application can supplement the crop with required plant nutrients. Keeping in view of the above, a field experiment to study the effect of different nutrient management practices on the productivity of groundnut (Spanish bunch type with a maturity duration of 100 to 115 days) was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad on medium black clay soil (7.60 pH, 0.60 dS/m EC, 6.1 g organic carbon/kg, 257.00 kg available N/ha, 45.00 kg available P2O5/ha and 475.00 kg available K2O/ha) during three consecutive post-rainy/summer seasons (2009-10, 2010-11 and 2011-12) under irrigation. The experiment consisted of ten treatments and were 1) 100 % Recommended rates of nitrogen, phosphorus and potassium (RDNPK) (25 kg N, 75 kg P2O5 and 25 kg K2O/ha) as basal, 2) 100 % RDNPK as basal + Farm yard manure (FYM) @ 7.5 t/ha, 3) 75 % RDNPK as basal + 25 % RDNPK as top dressing at 30 days after sowing (DAS), 4) 75 % RDNPK as basal + 25 % RDNPK as top dressing at 30 DAS + FYM @ 7.5 t/ha, 5) 150 % RDNPK (37.5 kg N, 112.5 kg P2O5 and 37.5 kg K2O/ha) as basal, 6) 150 % RDNPK as basal + FYM @ 7.5 t /ha, 7) 100 % RDNPK as basal + 50 % RDNPK as top dressing at 30 DAS, 8) 100 % RDNPK as basal + 50 % RDNPK as top dressing at 30 DAS + FYM @ 7.5 t/ha, 9) 75 % RDNPK as basal + 75 % RDNPK as top dressing at 30 DAS, 10) 75 % RDNPK as basal + 75 % RDNPK as top dressing at 30 DAS + FYM @ 7.5 t/ha. Mean of the three years data indicated that different nutrient management practices had significant influence on dry pod and kernel yield of groundnut. Application of 150 % of recommended dose of NPK (RDNPK) produced higher dry pod and kernel yield (5046 and 3456 kg/ha, respectively) over application of 100 % RDNPK (4762 and 3271 kg/ha, respectively). Further, top dressing of NPK fertilizers at 30 DAS applied in different proportions (i.e., 50 or 75 % of RDNPK) at different fertilizers rates (100 % and 150 % RDNPK) increased the dry pod and kernel yield of groundnut over basal applications alone. Application of 75 % RDF as basal and 75 % RDNPK as top dressing at 30 DAS produced higher dry pod (5353 kg/ha), kernel yield (3680 kg/ha), net returns (Rs. 142,395/ha) and B:C Ratio (4.72) over application of either 150 % RDNPK as basal (5046 kg dry pod yield/ha, 3456 kg kernel yield/ha, Rs.132,634 net returns/ha and 4.52 B:C Ratio) or 100 % RDNPK as basal (4762 kg dry pod yield/ha, 3271 kg kernel yield/ha, Rs.124,999 net returns/ha and 4.50 B:C Ratio). Top dressing of 50 % RDNPK + basal application 50 % RDNPK and top dressing of 75 % RDNPK + basal application 25 % RDNPK found beneficial in increasing the productivity of groundnut in medium Vertisol with low available N, medium available P and high available K during post-rainy/summer season.

Keywords：*Groundnut, Post rainy season, Recommended dose of fertilizers, Basal application, Top dressing*

P4-277

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Productivity of Groundnut as Influenced by Water Soluble Foliar Grade Fertilizer During Rainy Season Under Rainfed and Post-Rainy/summer Season Under Irrigated Situations

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Groundnut (Arachis hypogaea L.) is grown as a rainfed crop during rainy season (June-September) and as a irrigated crop during rabi/summer season (December-May) in India. The productivity of groundnut during rainy season is generally affected by the rainfall (either dry spell or incessant rainfall or dry spell followed by heavy, incessant and untimely rainfall prevailing during the crop growth period); while the productivity of groundnut in post rainy/summer season is affected either by heavy irrigation or by the weather (cool temperature). In both the situations of farming, availability of essential nutrients (N, P, K and micronutrients) as per crop need may get affected and which in turn affects the crop yield. Under such situations, use of efficient fertilizers and methods of fertilization could meet the nutrients requirement of the crop. To increase the groundnut productivity, foliar spray nutrition (soluble fertilizers are delivered to the crop through foliar spray feeding system) of water soluble grade fertilizers in addition to the basal application of major plant nutrients (NPK) can supplement the crop with required plant nutrients. Keeping in view of the above-mentioned factors, a field experiment to study the effect of water soluble (100 %) foliar grade fertilizer (WSGF) on the productivity of groundnut (Spanish bunch type with a maturity duration of 105 days) was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (UASD) on medium deep vertisol (7.90 pH, 0.24 dS/m EC, 5.50 g organic carbon/kg, 217.80 kg available N/ha, 32.90 kg available P2O5/ha and 329.00 kg available K2O/ha) during rainy season of 2011 under rainfed situation and post-rainy/summer season of 2011-12 and 2012-13 under irrigation. The experiment consisted of twelve treatments. The 100 % WSGF was tried alone or in addition to the application of reduced levels (100 to 35 %) of recommended dose of fertilizers (RDNPK) or recommended dose of farm yard manure (RDFYM) + RDNPK at different rates (100 to 35 %). Results of the trial conducted during rainy season of 2011 under rainfed situation indicated that foliar application of starter dose of WSGF {11 % N (NH2), 36 % P2O5 and 24 % K2O + Fe: 800 ppm, Mn 400 ppm, Zn: 200 ppm, Cu: 50 ppm and Mo: 50 ppm} @ 2.00 % at 30 days after sowing (DAS) + Foliar application of booster dose of WSGF {8 % N (NH2), 16 % P2O5 and 39 % K2O + Fe: 800 ppm, Mn 400 ppm, Zn: 200 ppm, Cu: 50 ppm and Mo: 50 ppm} @ 2.00 % at 45 DAS and 60 DAS in addition to the nutrient management practices involving application of RDFYM and 100 % RDNPK (25 kg N, 75 kg P2O5 and 25 kg K2O/ha) produced 5.82 and 5.83 % higher dry pod and kernel yield, respectively, over application of RDFYM + 100 % RDNPK (4281 and 3362 kg/ha, respectively). Mean of the two years (Post-rainy/summer 2011-12 and 2012-13) data also revealed that foliar application of WSGF @ 2 % in addition to the nutrient management practices involving application of RDNPK + RDFYM produced higher dry pod and kernel yield (4884 and 3237 kg/ha, respectively) compared to the application of RDFYM + RDNPK only (4802 and 3081 kg/ha, respectively) and application of RDNPK only (4633 kg and 2982 kg/ha, respectively). At reduced basal dose of nitrogen (N), phosphorus (P2O5) and potassium (K2O) fertilizers in the form of urea (46 % N), single super phosphate (16 % P2O5) and muriate of potash (60 % K2O), respectively to the groundnut (i.e., from 100 to 35 % of the recommended rates) in addition to RDFYM, foliar application of starter dose of WSGF (11:36:24 + Trace elements) @ 2.00 % at 30 days after sowing (DAS) + foliar application of booster dose of WSGF (8:16:39 + Trace elements) @ 2.00 % at 45 DAS and 60 DAS found beneficial in increasing pod yield of groundnut during rainy season under rainfed situation and post-rainy/summer season under irrigated situation over treatments receiving application of basal doses of RDNPK + RDFYM alone.

Keywords：*Groundnut, Water soluble grade fertilizers, Rainy season, Post rainy season*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Productivity of Groundnut as Influenced by Different Ratios and Levels of Nitrogen and Phosphorus Fertilizers During Rainy Season Under Rainfed Farming Situation

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Groundnut (Arachis hypogaea L.) is a major oilseed crop, extensively grown as sole crop during rainy season under rainfed situation of Northern Transitional Zone (Zone 8) (assured rainfall zone) of Karnataka state. Nitrogen and phosphorus (rates and mode of application) play a significant role in growth and yield of groundnut. Groundnut being a leguminous crop, a major proportion of the nitrogen requirement is met through symbiotic fixation. At very high yield levels, the nitrogen requirement of nodulated groundnut can not be met from symbiotic N fixation alone. In order to meet the nitrogen requirement during early crop growth stages, it is applied as starter dose. Basal application of N (10 to 75 kg N/ha) in the form of mineral nitrogen fertilizers would improve groundnut yields. High yielding groundnut varieties with higher harvest index (0.40 to 0.48) require high amounts of nutrients, perticularly nitrogen and phosphorus. Recent studies have shown that increasing levels of N increase the pod yield of groundnut. Studies carried out at different centers of All India Coordinated Research Project on Groundnut (AICRP) and elsewhere in the world indicated that higher pod yield of groundnut can be obtained with higher N/P fertilizer ratios. Top dressing of N fertilizer (either through soil application or through foliar application) in addition to basal application of recommended dose of NPK (RDNPK) fertilizers (25 kg N, 75 kg P2O5 and 25 kg K2O/ha and 25 kg N, 50 kg P2O5 and 25 kg K2O/ha, for irrigated and rainfed situation, respectively) during peak flowering and pegging stages of the crop especially under high soil moisture situation found more advantageous. In view of the above, a field experiment to study the effect of nitrogen (N) and phosphorus (P2O5) fertilizers supplied in twelve different ratios (N/P fertilizer ratio of 0.00, 0.33, 0.39, 0.45, 0.43, 0.42, 0.54, 0.57, 0.64, 0.70 and 0.78) with constant rate of potassium fertilizer (25 kg K2O/ha) applied to the soil on the productivity of groundnut (Spanish bunch type) was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad on medium Vertisol (7.60 pH, 0.37 dS/m EC, 7.5 g organic carbon/kg, 212.80 kg available N/ha, 30.60 kg available P2O5/ha and 391.20 kg available K2O/ha) during rainy season (2011) under rainfed situation. To maintain the required fertilizer ratios of N/P in the trial, nitrogen fertilizer was applied to groundnut either as basal application (soil) alone or as basal application (soil) + top dressing through foliar application in the form of urea @ 2 % either at 45 DAS or at 45 and at 60 DAS. The required quantity of phosphorus fertilizers as per the N/P fertilizer ratio and a common rate of potassium fertilizer were applied at the time of sowing. The rainfall received during the crop growth periods of 0 to 30 days after sowing (DAS), 31 to 60 DAS and 61 to harvest of groundnut was 145.0 mm (16 rainy days), 99.4 mm (11 rainy days) and 114.8 mm (14 rainy days), respectively. The maturity duration of groundnut was 93 days. The results indicated that pod yield increased with increasing N/P fertilizer ratios from 0.00 to 0.78. The treatment receiving N/P fertilizer ratio of 0.57 (basal application of 20 kg N, 60 kg P2O5, 25 kg K2O/ha + foliar application of nitrogen @ 7 kg N/ha through urea at 45 DAS and foliar application of nitrogen @ 7 kg N/ha at 60 DAS) produced higher dry pod yield (4361 kg/ha) and kernel yield (3340 kg/ha) compared to the treatment receiving N/P fertilizer ratio of 0.33 (25 kg N, 75 kg P2O5 and 25 kg K2O/ha as basal application alone) (3944 and 3025 kg/ha , respectively) and N/P fertilizer ratio of 0.50 (25 kg N, 50 kg P2O5 and 25 kg K2O/ha as basal application alone) (4065 and 3132 kg/ha, respectively). The results of the investigation also revealed that in medium Vertisol (low available N, medium available P and high available K nutrients status), the productivity of rainy season groundnut particularly under high soil moisture situations could be increased by foliar application of urea @ 2 % at 45 DAS and 60 DAS in addition to the basal application of of NPK fertilizers.

Keywords：*Groundnut, Foliar spray, Urea, Diammonium phosphate (DAP), Ratios and levels of N and P fertilizers*

P4-279

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Productivity of Linseed as Influenced by Ratios and Levels of Nitrogen and Phosphorus Fertilizers During Post-Rainy Season Under Irrigated Farming Situation

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Linseed (Linum usitatissimum L.) is basically an industrial oilseed crop and has commercial and medicinal importance. Tolerance to biotic and abiotic stresses is very important characteristics of this crop. Because of this property the survival and cultivation of linseed is prevailing in a wide range of tropical, subtropical and temperate regions. Cultivars play important role in linseed crop production. Evaluation of different genotypes of linseed across linseed growing areas has led to the identification of high yielding location specific linseed cultivars in India. Among the high yielding cultivars, Indira Alsi-32 (RLC 81) has been identified for the Karnataka state. A cultivar would express its full potential only when backed up by good agronomic practices such as nutrient management particularly nitrogen and phosphorus. Linseed yields in India are low due to the non-practice of fertilization by the traditional growing farmers. Several studies have indicated that nitrogen (N) and phosphorus (P); and their ratios play a greater role in linseed production under most environments. In view of the above, a field experiment to study the "Response of linseed to different ratios and levels of nitrogen and phosphorus fertilizers under irrigation" with ten ratios of nitrogen (N) and phosphorus (P2O5) fertilizers (N/P ratios of 0.00, 0.75, 1.00, 1.20, 1.33, 1.50, 1.60, 2.00, 2.67, 2.67 and 3.00) with a constant potassium fertilizer rate (30 kg K2O/ha) was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (UASD) on medium black clayey soil (6.80 pH, 0.24 dS/m EC, 6.40 g organic carbon/kg, 263.20 kg available N/ha, 28.21 kg available P2O5/ha and 292.20 kg available K2O/ha) during post rainy season (2010-11) under irrigation. The present study was conducted with an object to know whether higher N/P fertilizer ratio is better over presently recommended N/P fertilizer ratio of 0.75 (60 kg N, 80 kg P2O5 and 30 kg K2O/ha). Rainfall received during the crop growth period was 24.0 mm (01 rainy day). A total of five irrigations were given during the growth period of linseed crop. The mean relative humidity, mean maximum temperature and mean minimum temperature during the crop growth period of linseed were ranged between 14.00 to 98.00 %, 24.8 to 36.4°C and 9.2 to 21.0°C, respectively. The maturity duration of the crop was 112 days. Seed yield of linseed increased with increasing N/P (P2O5 referred to as P) fertilizer ratio from 0.00 to 3.00. Nitrogen and phosphorus fertilization in N/P ratio of 1.50 with 60 kg N, 40 kg P2O5 and 30 kg K2O/ha fertilizer rate produced 11.64 per cent higher seed yield over the treatment receiving N/P ratio of 0.75 with 60 kg N, 80 kg P2O5 and 30 kg K2O/ha fertilizer rate (1753 kg/ha) and 23.78 per cent over the treatment receiving N/P ratio of 0.00 with 0 kg N, 0 kg P2O5 and 30 kg K2O/ha fertilizer rate (1581 kg/ha). Nitrogen and phosphorus fertilization in N/P ratio of 1.50 with 60 kg N, 40 kg P2O5 and 30 kg K2O/ha rate recorded higher harvest index (0.494), protein content (32.13 %), oil content (39.63 %) and oil yield (775 kg/ha) compared to the treatment receiving N/P ratio of 0.75 (present recommended N/P fertilizer ratio for linseed) and N/P ratio of 0.00. Economic analyses based on benefit: cost (B:C) ratio revealed that the treatment receiving N/P ratio of 1.50 with 60 kg N, 40 kg P2O5 and 30 kg K2O/ha fertilizer level was most economical with higher B:C ratio (2.86), higher gross monetary returns (Rs. 46,960/ha) and higher net monetary returns (Rs. 30,529/ha) compared to the treatment receiving N/P ratio of 2.00 with 40 kg N, 20 kg P2O5 and 30 kg K2O/ha fertilizer level (2.46, Rs. 38,968/ha and Rs. 23,139/ha, respectively) and N/P ratio of 2.00 with 80 kg N, 40 kg P2O5 and 30 K2O/ha fertilizer level (2.40, Rs. 40,080/ha and 23,406/ha). Total nitrogen (N), phosphorus (P2O5) and potassium (K2O) uptake at harvest were increased with the increasing N/P fertilizer ratio from 0.00 to 3.00. It may be concluded that productivity of linseed in medium Vertisol with low nitrogen and medium phosphorus nutrient status could be enhanced by nitrogen and phosphorus fertilization in N/P ratio of 1.50 (60 kg N, 40 kg P2O5 and 30 kg K2O/ha).

Keywords：*Linseed, Post rainy season, N/P fertlizer ratio*

P4-280

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Studies on the Effect Integrated Nutrient Management Practices on the Productivity of Groundnut (spanish Bunch) in Vertisol During Rainy Season Under Rainfed Farming Situation

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Groundnut (Arachis hypogaea L.) is grown as a rainfed crop during rainy season (June-September) in India. The productivity of groundnut during rainy season is generally affected by the rainfall (either dry spell or incessant rainfall or dry spell situation followed by heavy, incessant and untimely rainfall prevailed during the crop growth period) in addition to the type of nutrient management. Higher groundnut yields under such situations can be realized through the integrated nutrient management practices involving the soil application of organic manures in addition to soil and foliar application chemical fertilizers, perticularaly N and P. It is observed that under high soil moisture situation during rainy season, foliar application of either urea (46 % N) or diammonium phosphate (DAP) (18 % N and 46 % P2O5) in addition to the application of recommended rates of N, P and K fertilizers is beneficial in increasing yields of rainy season grain legumes (soybean, mungbean and blackgram). Keeping in view, a field experiment to study the effect integrated nutrient management practices involving foliar application of urea or DAP in addition the application of either organic manure (FYM) alone or recommended dose of fertilizers (RDNPK) alone or application both FYM + RDNPK on the growth and yield of groundnut (Spanish bunch type) was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (UASD) on medium Vertisol (7.90 pH, 5.3 g organic carbon/kg, 217.80 kg available N/ha, 32.90 kg available P2O5/ha and 329.00 kg available K2O/ha) during rainy season (2011) under rainfed situation. The rainfall received during the crop growth periods of 0 to 30 days after sowing (DAS), 31 to 60 DAS and 61 to 90 DAS and 91 DAS to harvest (93 days) of groundnut was 144.6 mm (16 rainy days), 78.6 mm (08 rainy days) and 126.8 mm (15 rainy days), and 0.2 mm (00 rainy days), respectively. Total rainfall received during the crop growth period of groundnut was 350.2 mm (39 rainy days). The mean relative humidity, mean maximum temperature and mean minimum temperature during the crop growth period of groundnut were ranged between 40.00 to 98.00 %, 23.8 to 32.8°C and 10.4 to 24.7°C, respectively. The maturity duration of groundnut was 93 days. Results of the trial indicated that application of FYM @ 7.5 t/ha along with the recommended dose of fertilizers (RDNPK) (25 kg N, 75 kg P2O5 and 25 kg K2O/ha) produced higher dry pod and kernel yield (3241 and 2604 kg/ha, respectively) compared to application of FYM @ 7.5 t/ha alone (2922 and 2328 kg/ha, respectively) and application of RDNPK alone (3122 and 2474 kg/ha, respectively). Foliar application of urea @ 2.00 % at 30 and 60 days after sowing (DAS) produced higher dry pod and kernel yield (3322 and 2662 kg/ha, respectively) compared to foliar application of DAP @ 2.00 % at 30 and 60 DAS (2917 and 2311 kg/ha, respectively) and control (3141 and 2480 kg/ha, respectively). Foliar application of urea @ 2.00 % at 30 and 60 DAS resulted in 15.66 % higher dry pod weight/plant over foliar application of DAP @ 2.00 % at 30 and 60 DAS (20.875 g). Foliar application of DAP @ 2.00 % at 30 and 60 DAS resulted in scorching, drying and dropping of leaves in groundnut. On the contrary, foliar application of urea @ 2.00 % at 30 and 60 DAS had no such adverse effects on groundnut and plants were lush green. Nutrient management practice involving soil application of RDNPK + foliar application of urea @ 2.00 % at 30 and 60 DAS produced highest dry pod and kernel yield of groundnut (3406 and 2714 kg/ha, respectively) compared to soil application of RDNPK alone (3220 and 2546 kg/ha, respectively). The study clearly indicated that foliar application of urea @ 2 % at 30 and 60 DAS + soil application of RDNPK (25 kg N, 75 kg P2O5 and 25 kg K2O/ha) found beneficial in maximizing yields of rainy season groundnut in medium Vertisol (low available N and medium available P). Further, the study also showed that foliar application of DAP @ 2.00 % at 30 and 60 DAS had adverse effects on the growth and yield of groundnut.

Keywords：*Groundnut, Diammonium phosphate (DAP) (18 % N and 46 % P2O5), Urea, Foilar spray*

P4-281

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Studies on the Effect of Ratios and Levels of Nitrogen and Phosphorus on the Productivity of Groundnut in Medium Vertisol During Rainy Season Under Rainfed Farming Situation

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Groundnut (Arachis hypogaea L.) is grown as a rainfed crop during rainy season (June-September) in Northern Transitional Zone (Zone 8) of Karnataka state (India). The yield of groundnut during rainy season is generally influenced by rate and type of fertilizers. At present nitrogen and phosphorus fertilizers to groundnut are applied in N/P (P referred to as P2O5) fertilizer ratios of 0.33 (25 kg N, 75 kg P2O5 and 25 kg K2O/ha) and 0.50 (25 kg N, 50 kg P2O5 and 25 kg K2O/ha). Groundnut shows a greater response to the application of nitrogen and phosphorus in N/P fertilizer ratio of 0.39 when nutrients are applied through diammonium phosphate (DAP) fertilizer (18 % N and 46 % P2O5). It is also observed that groundnut crop respond very well to the application of higher amounts of nitrogen in medium deep Vertisol with low available N and medium to high available phosphorus. Under such situation finding out the optimum ratio of N and P fertilizers along with kind of fertilizers to obtain higher pod yield of groundnut is very important. In view of the above, a field experiment to study the effect of different ratios and levels of nitrogen and phosphorus on the productivity of groundnut (Spanish bunch type) was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (UASD) on medium black clay soil (7.9 pH, 5.5 g organic carbon/kg, 0.24 dS/m EC, 217.8 kg available N/ha, 32.90 kg available P2O5/ha and 329.00 kg available K2O/ha) during two consecutive rainy seasons (2011 and 2012) under rainfed farming situation. The experiment consisted of twelve treatments with different ratios and levels of nitrogen and phosphorus. Different ratios and levels of N and P were tested with common rate of potassium fertilizer (25 kg K2O/ha applied as basal). Nitrogen and phosphorus fertilizers at different ratios and levels were applied to soil at the time of sowing (i.e., basal). The rainfall received in the crop growth periods of 0 to 30 days after sowing (DAS), 31 to 60 DAS and 61 to 90 DAS and 91 DAS to harvest (93 to 101 days) of groundnut was 144.6 mm (16 rainy days) and 107.8 mm (10 rainy days), 78.6 mm (08 rainy days) and 47.8 mm (09 rainy days), 126.8 mm (15 rainy days) and 131.0 mm (06 rainy days); and 0.2 mm (00 rainy days) and 8.4 mm (01 rainy days), during 2011 and 2012, respectively. Total rainfall received during the crop growth period of groundnut during 2011 and 2012 was 350.2 mm (39 rainy days) and 295.0 mm (26 rainy days), respectively. The mean relative humidity, mean maximum temperature and mean minimum temperature during the crop growth period of groundnut during 2011 and 2012 were ranged between 40.00 to 98.00 % and 23.00 to 98.00 %, 23.8 to 32.8°C and 23.5 to 31.7°C; and 10.4 to 24.7°C, and 14.9 to 21.5°C respectively. The maturity duration of groundnut was 93 and 101 days during 2011 and 2013, respectively. The results indicated that groundnut crop showed similar response to the fertilizer management practices (ratios and levels of nitrogen and phosphorus fertilizers) during both the years (2011 and 2012) of experimentation. Mean of the two years (2011 and 2012) data indicated that nutrient management practices involving application of nitrogen (N) and phosphorus (P2O5) in N/P fertilizer ratio of 0.39 (18 kg N, 46 kg P2O5 and 25 kg K2O/ha) produced higher dry pod and kernel yield (3369 and 2580 kg/ha, respectively) compared to application of nitrogen (N) and phosphorus (P2O5) in N/P fertilizer ratio of 0.33 (25 kg N, 75 kg P2O5 and 25 kg K2O/ha) (3179 and 2421 kg/ha, respectively) and application of nitrogen (N) and phosphorus (P2O5) in N/P fertilizer ratio of 0.50 (25 kg N, 50 kg P2O5 and 25 kg K2O/ha) (3155 and 2413 kg/ha, respectively). The study clearly showed that productivity of groundnut in Vertisol (low available N and medium to high available P) during rainy season under rainfed farming situation could be enhanced by application of nitrogen and phosphorus through DAP fertilizer in N/P ratio of 0.39 (18 kg N, 46 kg P2O5 and 25 kg K2O/ha).

Keywords：*Groundnut, Rainy season, Ratios and levels of N and P, Diammonium phosphate (DAP) (18 % N and 46 % P2O5)*

P4-282

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Influence of Landusetypes and Topography on Soil Quality in Southwestern Nigeria;implication for Soil Management and Crop Production

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Information on the influence of different Land use types and Topography on soil quality is crucial for best soil management practices and crop production. This study was therefore designed to evaluate the effects of different agricultural land use types and Topography on soil quality on a fifty hectares (50Ha) farm in Southwestern Nigeria. The land use types studied were oil palm, Teak, wetland Rice fields, cassava, maize and exhaustively cultivated vegetable field. Three topographic locations (Upper slope, middle slope and valley bottom) were also used as study sites. Surface (0.15cm) and profile soil samples were collected from the different land use types. The soils were analyse and classified according to USDA and FAO soil classification systems. The results of the study showed significant ($P< 0.05$) differences among land use types and topographic locations in terms of organic matter, particle size, soil pH, available P, Total N, cation exchange capacity(C, Exchangeable cations and electrical conductivity. Land use types located on the same soil type and topography were found to be significantly ($P< 0.05$) different with respect to all the soil properties studied. Different land use types had serious land degradation effects on soil physico chemical properties under the present cropping systems of the farm. It was also observed that it is better to group and manage soils located on the same land use type and topography together, because grouping areas with same soils for same management practices may not be possible and effective. The use of precision farming techniques which enable the farmer to monitor and differentiatlly manage small areas of the farm that have similar soil or plant characteristics is also discussed. Soil nutrients depletion followed the order Wetland rice field < oil palm < Teak < maize < vegetable field < cassava. Most of the soils evaluated were found not to be in a good state of health following the FAO guidelines for soil quality assessment. The implications of the influence of Land use types and Topography on soil management and sustainable crop production are discussed.

Keywords：*Soil Quality,Land use types,Topography,Soil Management,Crop production, Southwestern Nigeria*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Paracoccus Versutus, Elemental Sulfur, and Compost on the Ph and Available Sulfur Content of Calcareous Sandy Soils

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Sulfur, organic matter, and inoculation with sulfur-oxidizing bacteria are considered as amendments to reduce soil pH and consequently, increase the availability of plant nutrients. The present study was conducted to evaluate the application effect of elemental sulfur (S0) and compost on the pH and available sulfur content of calcareous sandy soils of UAE inoculated with Paracoccus versutus, which was isolated from UAE sandy soils and had the strongest of oxidizing ability to sulfur among sulfur-oxidizing bacteria. Soil samples were collected from Al Ain, Abu Dhabi and Al Dhaid soils, which have different soil characteristics, in UAE. CS2-soluble sulfur, which was produced in Japan, was used for sulfur element in this experiment. Paracoccus versutus, which was identified species through DNA sequence at NCCB, was used. The following experimental plots were arranged for each three kinds of soils. (1) Original plot; Only soils used (25g soil per one vessel); (2) Control plot; Soil + sulfur element (25g soil + 52mg-S); (3) Standard plot; Soil + sulfur element + sulfur-oxidizing bacteria; (4) Sterilized plot; Sterilized soil and sulfur + sulfur-oxidizing bacteria; (5) Compost plot; Soil + sulfur element + sulfur-oxidizing bacteria + cow compost and (6) Sterilized compost plot; sterilized soil, sulfur element and compost + sulfur-oxidizing bacteria. The 50ml of polyethylene vessel, which was sterilized in advance, were incubated for 16 weeks in an aseptic room controlled by 25oC and 65% relative humidity. Sterilized water was added properly to maintain the water field capacity throughout the experiment periods. Samples were taken at 0, 4, 8, 12 and 16 weeks after the initiation of the experiment and measured about soil pH and available SO4. In the control plot, though some slightly changes were found in soil pH and available SO4, their ranges of changes were not conspicuous comparing with those of original plots. In the standard plot, soil pH reduction and increases of available SO4 in soil were more conspicuous than the control plot. The fact means that sulfur-oxidizing bacteria, which are autotrophic bacteria, uses sulfur element only as substrate, so that pH reduction proceeded and available SO4 content increased resulting from sulfuric acid formation in soil. However, in this case any effects of other microbes in the soil, especially in the connection with indigenous sulfur bacteria on the activity of Paracoccus versutus inoculated, remain unclear. Therefore, the activity of Paracoccus versutus only in the soil was tested by providing the sterilized plot. The pH reduction and available SO4 content in the soil is not so conspicuous comparing with those of the standard plot except Al Dhaid soil. In Al Dhaid soil the effect of sterilization on the soil chemical characteristics was higher than the results in the standard plot. In the compost plot, there were significant effects by the application of compost on the soil characteristics. Compost application to soil, means not only providing nutrients salts enhancing soil microbes activities but also increasing soil holding moisture content. These better effects of compost application, however, refer to the increase of competition among soil microbes including Paracoccus versutus. Comparing the compost plot and the sterilized compost plot, we scarcely found differences between these both plots in pH reduction and available SO4 content in soils. The fact means there will not be so unfavorable effects on activities of Paracoccus versutus inoculated when compost materials are applied to soils. Hereafter, it will be needed to accumulate field experiments, where much more sever condition for soil microbes survival than the laboratory condition, to extent these techniques to practical fields.

Keywords：*Elemental Sulfur, sulfur-oxidizing bacteria, compost, calcareous sandy soils*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Studies on Soil Properties and Soil Fertility through Integrated Nutrient Management in Rice-Maize Cropping Systems of Bhadra Command Area of Karnataka

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Rice is the staple food grain contributing 45 per cent of total cereal production (89.5 million tons) of India (Kumar et.al. 2003). It is grown in varied eco-systems under diversified edaphic and biotic constraints with low productivity. It is grown in 40.96 Lakhs ha in Kharif and 1.78 lakh ha as Rabi/summer crop contributing 52 per cent of the cropped area with productivity of 0.69 and 2.35 t/ha respectively in Karnataka. This system has number of constraints such as lesser availability of labour force; poor economy of small and marginal holdings in addition to the effect of continuous submergence of land on soil properties. With introduction of light irrigated crop like maize in one season, some of the problems faced by the framers in irrigated area can be addressed. The net returns per unit amount spent can be enhanced by replacing the present rice-rice system with rice maize cropping sequence. Further continuous rice -rice system by producing methane gas will effect on climate and environment factors which lead to degradation in natural factors. Hence, Integration of inorganic and organic sources could supplement crop nutrition and sustain productivity (Hegde, 1992). Considering the above issues, the present investigation was laid out to find out the sustainable package of nutrient management for higher productivity and soil health over prolonged period.

The experiment was conducted concurrently for twenty three years (1988 to 2011) in both Kharif (rice) and summer (Maize) season in the Agricultural and Horticultural Research station, Kathalagere (Davangere dist). The soil was sandy loam with pH 5.56. The experiment was laid out in RBD with 12 treatments with four replications. The test variety was JGL in Kharif and Maize in summer season.

The recommended fertilizer dose was 100:50:50 for Paddy and 100:100:75 kg N P K/ha in summer seasons respectively. FYM, Paddy straw were the organic sources used as per the details of the treatment. The standard packages of practices were adopted. The yield attributes such as plant height, effective tillers/plant, panicle length, grain and straw yield were recorded from the net plot size of 6.9 x 8.4 m2.

Surface Soil samples were collected after crop harvest of summer crop (Maize), analysis was taken up for assessment of changes in chemical properties under cropping sequence using standard procedures.

Field experiments were conducted on to study the soil properties changes as influenced by integrated nutrient management practices in rice-maize cropping system over the two years at Agricultural and Horticultural Research Station, Kathalagere, under cropping system research. The experimental data revealed that all the soil chemical properties varied significantly due to the integrated nutrient supply in rice maize cropping sequence. Application of organics recorded higher soil organic carbon 0.61 to 0.75% in 2010 and 0.59 to 0.75% in 2011, available nitrogen 299.70 to 337.9 kg/ha in 2010 and 289.12 to 332.23 in 2011, available phosphorus 18.25 to 23.12 kg/ha in 2010 and 17.71 to 23.11 in 2011 and available potash 128.81 to 190.63 kg/ha in 2010 156.99 to 184.95 in 2011 as compared to initial status of soil and farmer's practice of rice cultivation during 2010 and 2011. EC was higher in all the values when compare to initial status of soil during both years. However, there is no much variation in soil pH among the treatments with slight improvement in pH values.

Moderate nutrient management at 75 per cent N P K to summer maize was second in grain yield (5015 kg/ha), straw yield (6162 kg/ha) in 2010 and grain yield (5157 kg/ha), straw yield (6667 kg/ha) in 2011. The nutrient uptake was significant and highest N 186 kg/ha, P 43 kg/ha and K 122 kg/ha in 2010 and highest N 154.91 kg/ha, P 32.58 kg/ha and K 109.23 kg/ha in 2011 is the best treatment (T9). The soil fertility management in terms of pH, EC, OC and available N, P and K recorded higher than Farmers practice during both years. Grain and straw yield of Maize was significant and highest with management of 50 per cent N P K coupled with 50 per cent N as paddy straw incorporation to Kharif rice followed by 100 per cent of N P K to summer maize during 2010 and 2011.

Keywords：*Key words: Integrated Nutrient Management, Rice, Maize, Cropping System*

P4-285

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Moringa and Fertiplus Influence Some Soil Chemical Properties and Yield of Garden Egg in Nigerian Agroecologies

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The deleterious effects of inorganic fertilizers on soil properties particularly on tropical environments has made organic manures an imperative in soil fertility maintenance. However, little is known about the potentials of Moringa oleifera and Fertiplus as soil conditioners for sustainable crop production. In this field study, we evaluated the efficacy of Moringa leaf and Fertiplus manure on some soil chemical properties and yield of Garden egg. A field experiment was conducted at the University of Agriculture, Makurdi (Lat. 70 45'N and Long. 8035'E) and the Cross River University of Technology Obubra (Lat. 6006'N and Long. 8018'E) during the 2009 and 2010 cropping season. A factorial combination of 0,5,10,20 t ha-1 Moringa leaves, 1,2 and 3 t ha-1 fertiplus manure and two varieties of garden egg - Gilo and Kumba were laid out in a Randomized complete Block Design and replicated three times. The experiment revealed that soil pH, OM, total N, available P, exchangeable cations and CEC were improved by the manure source at all rates over the control and the initial soil nutrient levels particularly Moringa treatments in both locations. Moringa 20 t ha-1 produced significantly ($P< 0.05$) highest dry matter (205.8 and 197.5 g/plant in 2009 for Makurdi and Obubra) respectively and (233.5 and 229.0 g/plant in 2010 for Makurdi and Obubra respectively) and highest fruit yield (7.22 and 6.68 t ha-1 in 2009 for Makurdi and Obubra respectively and 10.42 and 9.17 t ha-1 in 2010 for Makurdi and Obubra respectively) of the Garden egg. The least yield was in the control (1.18 and 0.92 t ha-1 in 2009 for Makurdi and Obubra respectively) and (3.32 and 2.97 t h-1) in 2010 for Makurdi and Obubra respectively The crop yield was significantly ($t < 0.05$) higher in Makurdi than Obubra. Moringa Oleifera leaf (20 t ha-1) is therefore suitable as a soil conditioner to improve soil chemical properties and increase yield of garden egg in the Nigerian Guinea savannah and rainforest zones.

Keywords：*Moringa,Fertiplus, Garden egg. Guinea savannah.rainforest and soil chemical properties*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Use of the Method of Soil & Plant Diagnostics to Predict the Protein Content of Wheat Grains

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Introduction

The studies to predict the content of protein and gluten in the grain crops pursue two main directions: the climatic and the physiological. The main feature of the physiological direction is determination of the relation between the content of chemical elements in plants and that in the grain (Boldyrev,1964). The purpose of the studies is to determine the complex of the parameters (indicators), which can be used to predict, at the booting stage of winter wheat, the protein content of grain grown on calcareous black soil.

Methods

The experimental database was formed directly on commercial fields in the Rostov Region. For this purpose, we used the method of small plots (2×2 m^2). At each plot at the stage of booting, soil and plant samples (tops) were taken, and biometric monitoring of the plants' growth and development was performed. At the stage of complete ripeness, the grain yield was determined. The soil and plant samples were prepared for analysis by the generally accepted methods. The Energy Dispersive X-ray Fluorescence Method was used for the plant samples to identify 15 macro- and microelements (EDXFM …, 83). The data obtained were interpreted following a new method with the use of the integrated data processing system (IDPS) formulas (Recommended Methods…, 1989)

Results

In order to develop a system of indicators showing the nutritional status of the plants on the studied black soil, the IDPS formulas were elaborated and analyzed. These formulas are distinguished in that they show the diagnostic value of the nutritional elements by the degree of deviation of their availability index from the normal level, depending on the variation (decrease or increase) of the factor taken as the.

The normal level is designated with the index equal to 1. If the index of an element is less than 1, it means that availability of this element in the plant is lower than the accepted normal level, and if the index is more than 1, the availability is excessive.

Based on the data obtained, the protein content of winter wheat grains depends, above all, on the degree of nitrogen deficiency N↓ and on stability of its balance against Fe, P, Mn↑. The list of system indicators for prediction of protein in plants on calcareous black soil includes up to 19 items. In the soil these are the content of mobile P_20_5 (Pp) and exchange K_20 (Kp) in the arable stratum, and their ratio Kp/Pp, and the ratio between phosphorus (Pp) to humus (Pp/G). The indicator elements in plants at the stage of booting are N, Cl, K, P, Ca in %, and Mn, Fe, Zn in mg/kg of dry weight, as well as their ratios in the accepted units of measurement: N/P, N/K, Mn/N, Fe/Zn, N/Ca, and the weight of one green plant (g) at the stage of booting. The above list of indicators for quantitative prediction of the possible protein content of the ripe grain can be used to develop several highly consistent regression models. Based on out data, early monitoring of sewn wheat for the content of protein in the grain at harvesting is possible using the following model:

Prot, %=+12.7-0.31Pp+0.06Kp+1.55Pp/G+0.54N-0.73N/K-4.2Cl-0.012Mn-0.74P+0.011Fe/Zn F= 3.5, r^2=0.8

This model is designed for application to conditions with significant variation of the soil parameters and is best suited for the agrochemical features of calcareous black soil related to plant nutrition. The less the number of the indicators in the regression, the narrower is the area of consistent prediction.

Conclusion

In the Southern Russia conditions, early prediction of the winter wheat grain quality is possible long before harvesting, based on the methods of soil and plant diagnostics and multiple regression models. In the case of calcareous black soil, an important factor for prediction of the protein content of the winter wheat grain is the balanced content of nitrogen in the plants, at the stage of booting, with reference to Mn, P, Fe.

Keywords：*Diagnostics, black soil, fertility, plant chemical composition.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Zn Deficiency Tolerance in Lowland Rice: Effect of Zn Deficiency on Grain Yield and Grain Zn under Different Soil Environments

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Background: Zinc (Zn) deficiency is the most widespread micronutrient disorder in lowland rice (Castro, 1978) caused by the reduced conditions that develop soon after flooding, which make Zn unavailable for plant uptake. Visual Zn deficiency symptoms in rice such as leaf bronzing, stunted growth, and in some cases, death of seedlings can be observed several days after transplanting (Neue et al., 1998). Severe Zn deficiency can also delay maturity and ultimately result in poor yield. The common soil conditions contributing to Zn deficiency in lowland rice include low total Zn concentration, high pH, high organic matter content and continuous flooding (Dobermann and Fairhurst, 2000). Soil Zn deficiency in cereal-cultivated areas matched well with widespread Zn deficiency in humans globally. Moreover, routine consumption of cereal-based diets is one of the main reasons for Zn deficiency-induced malnutrition in humans.

An investigation was carried out to characterize rice genotypes contrasting in Zn deficiency tolerance and grain Zn under different soil environments.

Methodology: The experiment was carried out in the 2012 wet season in five different field sites in the Philippines with varying soil conditions: IRRI farm with Maahas clay soil, Tiaong with soil high in bicarbonate levels, Bay with soil high in organic matter, Bohol with calcareous soil, and Bukidnon with iron-toxic soil. Fourteen rice genotypes contrasting in Zn efficiency and grain Zn were transplanted in each site with two Zn treatments imposed: Z0: no Zn applied and Z1: seedling root dipping in 4% ZnO slurry for 15 minutes one day before transplanting. Destructive plant sampling was done at 0 DAT and 14 DAT to determine crown root development and biomass accumulation at each site with respect to Zn treatments. Grain yield at maturity was recorded for each site at the end of the season. Initial available zinc was determined from flooded soil at each site using DTPA-TEA extraction and atomic absorption spectrophotometry analysis. Grain Zn was analyzed at the IRRI Analytical Services Laboratory using inductively coupled plasma-optical emission spectrometry.

Results: Initial available soil Zn was <0.6 ppm in Tiaong, Bay, and Bukidnon; 1.0 ppm in Bohol; and 2.0 ppm in the IRRI farm, suggesting that, except for the IRRI farm, all the other sites were Zn-deficient for rice growth. Crown root development during the first 14 DAT was higher in Z1 than in Z0 across all sites. The significant positive correlation between the sites for crown root development indicated a low GxE interaction for this trait. Zn-deficiency-tolerant genotypes such as A69-1 and IR55179 produced significantly more roots than Zn-deficiency-sensitive genotypes such as KP and TCC266 at Z0 in all sites.

The IRRI farm, with sufficient Zn, recorded significantly higher yield than all other sites. Among the Zn-deficient sites, Bay recorded the lowest yield, irrespective of Zn treatment. IR55179 showed the highest yield in the IRRI farm, Bay and Bohol, whereas A69-1 was among the top three yielders in Bay and IRRI. Zn biofortification breeding lines such as IR68144 and

IR91143AC showed grain Zn higher than the target Zn (30 mg kg-1) at IRRI (Zn-sufficient site) and also at Bohol (moderately Zn-deficient site) but not at Bay (severely Zn-deficient site).

Conclusions:

1) Zn-deficiency-tolerant genotypes produced higher crown root number than did Zn-deficiency-sensitive genotypes.

2) The elite genotypes showing Zn-deficiency tolerance across different Zn-deficient soil environments can be further used in crop development for Zn-deficient areas.

3) IR68144 and IR91143AC could be ideal donors for breeding Zn-biofortified lines for Zn-sufficient and moderately Zn-deficient conditions.

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Keywords：*Rice, Grain Zn, Zn deficiency tolerance, Zn efficiency, Crown root number*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Reducing Egypt Rock Phosphate Use in Zea Mays Cultivation on an Acid Soil Using Clinoptilolite Zeolite

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Insufficient supply of P for initial growth of crops does not only limit N availability but it also leads to poor yield of crops. In acid soils of the tropics, P is fixed by high amount of dissolved aluminium and iron. Suppression of these cations is important so as to ensure adequate supply and readily available P for crops uptake. A number of studies using zeolites as an amendment in the fertilization programs of crops have improved crops production, nutrients uptake, and use efficiency. However, there is dearth of information on the use of clinoptilolite zeolite to reduce P fixation not to mention reduction of N, P, and K fertilizers use in agriculture. This study was conducted to: (i) determine dry matter production, nutrients uptake, and use efficiency of Zea mays (Hibrimas variety) by including clinoptilolite zeolite in the fertilization program of Zea mays planted on an acid soil, and (ii) determine the effect of including clinoptilolite zeolite in the fertilization program of Zea mays on selected chemical properties of an acid soil. Egypt rock phosphate (ERP), urea, and muriate of potash (MOP) were used in this study. Twenty five percent of the recommended N, P, and K fertilizers for Zea mays were replaced with clinoptilolite zeolite. Standard procedures were used to determine soil pH, exchangeable ammonium, available nitrate, available phosphorus, exchangeable aluminium, iron, cations, and organic matter before and after planting. Zea mays were harvested at taselling stage and measured for dry matter production, nutrients uptake and use efficiency. The effect of clinoptilolite zeolite application with 75% of fertilizers (E2) and 100% fertilizers (E1) were statistically similar for selected soil chemical properties, dry matter production, nutrients uptake, and nutrients use efficiency except for N. Nitrogen use efficiency for E2 was better than that of E1. These findings suggest that substituting 25% of N, P, and K fertilizers with clinoptilolite zeolite is more beneficial compared to 100% application of these fertilizers. Clinoptilolite clinoptilolite zeolite's strong affinity for monovalent cations ensured timely availability of P by exerting more soil exchange sites to occupy Al^{3+} and Fe^{2+}. At least three cropping cycles are recommended to confirm the findings of this study. It is also essential to estimate the economic benefits of including clinoptilolite zeolite in Zea mays cultivation. These aspects are being investigated in our on-going field experiments.

Keywords：*Zeolites, acid soils, nutrient use efficiency, fertilizers management, rock phosphate*

P4-289

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Nitrogen Mineralization from Organic Matter Applied to Soil Under the Condition of Organic or Conventional Management

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Introduction

During the "organic transition" period, a period of about 3 years after switching from conventional to organic management, lowered yields compared with those in conventional systems have often been observed. The period with low yields can be a cause of hesitation for farmers to start and/or continue organic management, though yields may finally recover. The yield recoveries have been attributed to gradual improvements in soil properties, such as soil microbial activities to mineralize N or to suppress plant disease. To clarify whether yield recoveries during organic transition is caused by improved N mineralization by soil microorganisms, we investigated various soil enzyme activities and N mineralization rates after adding organic matter (fish meal or rice bran meal: N availability being different) to soils sampled from identically managed organic and conventional plots.

Materials and Methods

A field experiment was conducted in a Hapludands field located in Tsukuba, Japan. The management system used in this study was 1-year rotation of lettuce and carrots, having two replicates. Lettuce and carrots were grown 3 times from 2009 to 2011. The key comparison was between the organic system (Org.) and the conventional system (Conv.). These two systems were managed identically after the experiment began in January 2009 with the exception of fertilizer application and fungicide, insecticide or herbicide application. Organic systems had subplots with (+S) or without (-S) soil solarization before carrot cropping.

Soil was sampled from the Org.(+S), Org.(-S) and Conv. plots during the third carrot cultivation in September 2011. Since soil from the above plots showed high N fertility, poor soil (low fertile soil) was also sampled from the plots in which no fertilizer or no manure had been applied for 30 years.

Ten mg N of fish meal or 10 mg N of rice bran was added to 20-g soil samples with moisture adjusted to 60% of the maximum water holding capacity and the samples were mixed. Some samples were not treated with organic matter. Each sample was incubated at 30 oC for 0, 1, 2, 4, 8 and 16 weeks, and the inorganic nitrogen content was determined after extraction with 2 M KCl. Soil dehydrogenase, β-glucosidase, β-galactosidase, α-glucosidase, cellulase and protease activities of the incubated soil samples were determined.

Results and Discussion

Nitrogen in fish meal (N 9.1%) was mineralized rapidly in each soil sample, and fertilization or soil solarization history (Org.(+S), Org.(-S), Conv. and poor) did not affect the N mineralization rate. Mineralization of N in rice bran (N 2.2%) was slower than that in fish meal. Soil in the Conv. plot showed the same N mineralization rate from rice bran as that in soil in the Org.(-S) plot, indicating that chemical fertilizer application and pesticide application did not inhibit the mineralization of N. On the other hand,

soil in the Org.(+S) plot showed a slower N mineralization rate from rice bran than the rates in Conv. soil and Org.(-S) soil (29% and 68% of Conv. and Org.(-S) at 4 weeks and 8 weeks, respectively). The results suggested that soil solarization reduced N mineralization rate from rice bran. Poor soil without fertilizer and manure application history also showed a slower N mineralization rate from rice bran than the rates in Conv. soil and Org.(-S) soil, and the rate was the same as that in Org.(+S) soil. Therefore, it was thought that N mineralization in poor soil is slow even though the soil has no soil solarization or sterilization history.

Each enzyme activity in Org.(-S) soil was higher than that in poor soil without fish meal or rice bran application. However, addition of rice bran promptly increased each soil enzyme activity in both Org.(-S) soil and poor soil, and each activity level in poor soil became similar to that in Org.(-S) soil.

The fact that N mineralization rate from applied organic matter in conventional soil (fertile) was the same as that in organic soil suggests that N mineralization rate during organic transition is sufficiently high in fertile soil. However, slow N mineralization from applied organic matter observed in poor soil might be a cause of low crop yield during organic transition, though soil enzyme activity in poor soil was promptly enhanced by the addition of organic matter.

Keywords：*N mineralization, soil enzyme, organic management, fish meal, rice bran meal*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Productivity and Crop Growth Performance of Diversified Intensive Rice-Based Cropping System

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Crop diversification is one option to solve increasing water scarcity and limited expanding land area for crop production. The study was conducted to determine the productivity of rice, maize, and mungbean grown in diversified intensive cropping system. The two cropping systems: dry seeded rice-mungbean and maize-dry seeded rice, were implemented uniformly management to get non stress environment. Crop growth, yield components, and yield data were collected in the each 5 m2 area of 27 grid sampling location. Dry seeded rice had reasonable high yield in both cropping system (5.5 Mg ha-1 and 5 Mg ha-1 respectively). Maize-rice cropping system had higher system productivity and water use efficiency than rice-mungbean cropping system.

Keywords：*dry seeded rice, diversification, water use efficiency*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Assessment of Soil Chemical Indicators in Coconut Growing Boron Deficient Entisols

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Boron is an essential micronutrient for sustainable production in coconut, an essential oil seed crop of tropical hemisphere. This is the micronutrient which is removed in highest proportion from the nut portion. Boron is essential for the enhancing oil content in nuts as well as maintaining the quality of copra. Boron is required for pollen viability and pollen tube development. It is also essential for oil production and maintainance of copra quality. Somasiri et al. (2003) found that nuts removed a higher quantity of boron (0.26 kg ha-1) than from other plant parts and found that there is a deficit between the removal of boron from coconut field and the input by fertilisers and organic mulch, application of boron to yielding palms is needed for maintaining the productivity. In general wide spread deficiency of boron is observed in Entisols.

The deficiency symptoms of boron in coconut include leaf fasciation, button shedding, inflorescence necrosis and its die back as well as malformed kernels. The present experiment was formulated with eighty coconut palms showing deficiency symptoms of various grades. The ranking was done based on the extent of deficiency symptoms shown by these palms. Soil samples were collected from two depths (0-25 cm and 25-50 cm). The palms were put into five categories with ranks ranging from 1 to 5. The ranks were assigned based on the increasing order of the intensity of symptoms exhibited by the palms. Soil and leaf samples were analysed for major, micro and secondary nutrients. Analysis of leaf samples revealed that palms put in the category I had boron content ranging from (10.25 mg per kg) whereas those palms which are in the higher categories have boron concentration less than the critical level of 10 mg per kg.

The organic carbon content in the surface soil was 0.32% whereas in the sub surface soil it was found to be 0.259%. Soil reaction was acidic with surface pH of 5.45 and subsurface pH of 4.9. Both exchangeable calcium and magnesium are in the lower range category in the surface as well as in the sub surface region of sampling. The nutrient status of the soil were 131.62 ppm in the surface soil and 75.77 ppm in the sub surface soil for calcium and 55.99 and 42.38 ppm in the case of exchangeable magnesium. The available phosphorus content was 16.13 ppm in the surface soil and 10.39 ppm in the sub surface soil. Hot water extractable boron was found to be 0.606 ppm in the surface soil where as it was 0.278 ppm in the sub surface soil. Other micronutrients such as Fe, Mn, Cu and Zn were in the sufficiency range.

Analysis of leaf samples using the index leaves (14th leaf in the case of mobile nutrients and youngest fully opened leaf in the case of Ca, B, Fe and Mn) were carried out in the experiment palms. It was observed that the average of total boron content in the index leaf samples of all the palms were below the critical level of 9.76 mg per kg. The nutrients were in the sufficiency range with regard to the primary nutrients N, P and K. With regard to the content of potassium the range was below the optimal level. The average sulphur content in the index leaves was 0.089 per cent. The content of other nutrients were Fe(100.44 mg per kg), Mn (71.17 mg per kg), Cu (3.81 mg per kg), Zn (12.71%), Ca(0.135%) and Mg (0.159%).

It can be seen that the coconut growing entisol which was selected for the present study have got an acute deficiency of boron. being an exhaustive crop of boron, the nutrient has to be supplemented along with the regular application of fertilisers and organic manures.

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Nitrogen and Phosphorous Rates on Fertilizer Use Efficiency in Lettuce and Spinach

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In this study, Lettuce (Lactuca Ssativa) and Spinach (Spinacea OOoleracea) were used as a case study vegetable crop to compare models for estimating Fertilizer Use Efficiency based on nitrogen and phosphorous fertilizer and nitrate concentration. Field studies were conducted to measure yield, nitrate, Fertilizer Use Efficiency, response to applied Nitrogen and phosphorous fertilizer in two plants. The area was located between 25°, 21- E longitude and 51˚, 38- N latitude in the North of Varamin city, (Tehran province, Iran) in the alluvial plain of Varamin. Soils family were fine, mixed, active, thermic, typic haplocambids based on Soil Taxonomic system (1999). Plants were received five rates of Nitrogen (0.0, 150, 200, 250 and 300 kg Nha-1) as a urea in split applications and five rates of Phosphorous (0.0, 37.5, 50, 62.5 and 75 kg P2O5ha-1) as a triple super phosphate (TSP). Data for plant fresh mass (tonha-1) and Nitrate uptake (nitrate) (mgkg-1) were recorded. Models were described the data for cultivar quite well, with correlation coefficients of 0.80 and above. All of models for Lettuce and Spinach production were compared graphically and analytically. The model coefficients were then used to make improved estimates of fertilizer recommendations for field production of Lettuce and Spinach in Iran. Results showed that most suitable mode for prediction of fertilizer use efficiency was Y=16.77+0.0522N+0.0576P (R2=0.81) in lettuce (N: kg ha-1 and P: kg P2O5ha-1 in lettuce. Based on we could predicted fertilizer use efficiency that help to agricultural practice management until nitrogen and phosphorous fertilizers used suitable and avoid leaching of nitrogen in lettuce culture.

Keywords：*Fertilizer use efficiency, Lettuce, Spinach*

P4-293

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Influence of Potassium Nutrition on Yield and Quality of Cauliflower (brassica Oleracea Var. Botrytis) in Eastern Region of India

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Introduction - Potassium is involved in large number of physiological activities in plants like osmo-regulation, cation-anion balance, protein synthesis and activation of enzymes (Singh. 2012). Deficiency of K drastically reduces the yield of cauliflower and deteriorate its quality (Jifon, J.L. and Lester, G.E. 2009). In recent decades crop quality improvement is gaining importance for human welfare through mitigation of malnutrition and increased farm income.

Keeping these view an experiment was carried out at different Farmers' field of Jharkhand state to evaluate the best dose; time and method of K-application for yield, nutrient concentration and bio-chemical properties of cauliflower. Benefit cost ratio of the applied fertilizer was also worked out.

Methods & material - The experiment was conducted at four different location of farmers field of Jharkhand (State of Eastern India) during June 2011, to 2013 under rainfed condition three consecutive years, comprising five treatments viz farmers fertilization practices (FFP) i.e. without K. K2 (60 kg ha-1)as basal, K3 (30 kg as basal + 30 kg ha-1 after 25 days of transplanting of seedlings), K4 (90 kg K/ ha-1 as basal) and K5 (45 kg K ha-1 as basal + 45 kg K ha-1 after 25 days of transplanting of seedlings) were laid in randomized Block design. Nitrogen and phosphorous were applied as per the state recommendation (N:P:100:60Kg/ha). Di-ammonium phosphate, Urea and Muriate of Potash (KCl) were the source of N, P and K respectively. Nursery of cauliflower (Var - N.S. Atishighra) was raised in 5th June and 20 days old seedlings were transplanted every year. Harvesting of Cauliflower was started from 2nd week of August and completely harvested at end of August. The nutrients content of curd were analysed, for N by Kjeldahl method. Phosphorus, K and S were determined after digestion in di-acid (HNO3 : HClO4) adopting standard procedure. (Jackson 1973).

Total carbohydrate content was determined by using Anthron method as described by Hedge and Hofrieter (1962). Determination of reducing sugar was done using Dinitrosalicylic (DNS) acid method (Miller, 1972). While volumetric a method was used for the determination of ascorbic acid. (Sadasivam and Balasub ramanian, 1987) Total soluble solid (TSS) content was measured with the help of hand held refractrometer (0-30) (Mccolum 1963). Folin - Ciocalteu method was used for the determination of total polyphenol content of the curd as described by Mallic and Singh (1980

Results and discussion - A significant difference among rates and times of K application was observed on marketable curd yield and bio-chemical properties of cauliflower. Application of K irrespective of the time and doze increased the yield of cauliflower as compered to farmers fertilization practices (FFP).. Maximum curd yield (30.0 t/ha-1) was obtained with the application of 150% K (90 k/ha-1) applied in two splits (50% at basal and 50% at flowering stage). In general split application of K was superior to that of

basal application. Only in absence of K (FFP) the yield of Cauliflower (18.1 ton/ha-1) decreased drastically. The curd did not attain full size and weight at lower level at K and there by higher % of marketable curd (98%) recorded under higher level of K as compared to that of without K. This may be attributed to the reason that potassium has a crucial role in translocation and storage of assimilates and maintenance of tissue water relation (Marschner, 1995).

Application of K2O gradually improved the bio-chemical properties of cauliflower. Phenol content of curd of Cauliflower varied from 108.32 9 (-K) to 209.12 (l 150% K as basal) mg/100gm. (Table -1) and Carbohydrate content ranged from 4.46 to 5.87 per cent whereas TSS varied with the application of K from 6.5 to 7.4o Brix. Other biochemical characters viz Ascorbic acid and crude fibre varied from 25.71 to 45.57 mg/100g and 2.0 to 3.0 per cent respectively. Reducing and non-reducing sugar were obtained at higher level of K application which ranged from 4.11 to 4.88 and 0.68 to 0.72%. Nutrient concentration, N, P and K of curd of cauliflower were determined. Which were varied from 1.86 to 2.17, 0.48 to 0.56 and 1.71 to 2.79 respectively. . The application of Potassium to the cauliflower was highly economical . and sixty five per cent response of K application over FFP were observed (Table-2)

CONCLUSION

It may be concluded that split application of K at 90 kg ha-1 (50% as basal and 50% at flowering stage) in addition to limiting nutrients (N at 100 kg ha-1 and P at 60 kg ha-1) is essential for obtaining potential yield and improved quality of cauliflower in eastern India.

ACKNOWLEDGEMENTS

Authors are grateful to the International Potash Institute, Switzerland for the financial support provided for this research.

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Phosphorous Simple Effect on Agronomic Characteristics of Lettuce & Spinach

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This research shows statistical models that may be helpful to comparing simulations with measured variables in lettuce and spinach. This model has been developed to predict the growth and nitrate content of filed lettuce and spinach. Vegetables such as Lettuce and Spinach that require fertilization for optimum yield and quality are ideal candidates for such study. In several studies, the models also described plant N uptake as well as yield [Overman et al. 1994]. The levels of nitrates and nitrite in vegetables and fruits are important parameters indicating the environmental pollution of foods, and nitrates and nitrite in suitable mediums may lead to carcinogen consolidation. The objective was to demonstrate the utility of the models to describe response of lettuce and spinach to apply phosphorous based on agronomic characteristics.

Keywords：*Phosphorous, Agronomic Characteristics, Lettuce, Spinach*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Phosphorus Adsorption Behaviour in Selected Cinnamon (cinnamomum Zeylanicum Blume) Growing Soils in Sri Lanka

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Phosphorus (P) deficiency is one of the prevalent soil nutrition problems in wet zone soils of Sri Lanka due to acidic nature and abundance of Al+3 and Fe+3 ions. A study was conducted to determine the nature of P adsorption in six cinnamon growing locations (i.e: Matara, Kamburupitiya, Akuresse, Malimbada, Weligama and Dondra) in Matara district. In order to ascertain the relationship between yielding capacity of cinnamon and phosphorus adsorption characteristics, soil samples were separately collected from high yielding and low yielding cinnamon plantations from each location. A laboratory experiment was conducted to determine P adsorption behaviour in sampled soils. Phosphorus was added at the rate of 100, 200, 400 and 600 µgg-1 of soil. Result showed that P adsorption increased significantly with increasing levels of added P. Soil P adsorption were comparatively low in high yielding sites of Matara, Akuresse, Malimbada and Dondra locations when compared with low yielding sites. Phosphorus adsorption data were fitted to Langmuir and Freundlich adsorption isotherms. The sorption parameters [P adsorption maxima (b), bonding energy (k), buffering capacity (k*b)] were determined from the Langmuir adsorption isotherm. Low yielding site in Akuresse reported the highest P adsorption (89.57%) and highest P adsorption maxima of 526.32µgg-1. Lowest P adsorption (57.36%) and lowest P adsorption maxima of 204.08µgg-1 were reported in high yielding site in Matara. Buffering capacity was low in all high yielding sites than low yielding sites. The maximum buffering capacity (500mlg-1) and minimum buffering capacity of 80mlg-1 were observed in low yielding and high yielding site in Matara respectively. Low yielding sites of six area show high P fertilizers requirement due to high buffering capacity.

Keywords：*Phosphorus deficiency, Phosphorus adsorption, Buffering capacity, Freundlich and Langmuir adsorption*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Long-Term Effects of Applied Organic Manures and Inorganic Fertilizers on Yield and Soil Fertility in a Wheat-Rice Cropping Pattern

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Integrated use of chemical fertilizers with organic matter can help for a sustainable and, environmentally sound agriculture production in soils low in organic matter. A 16 years study with rice and wheat cropping pattern was conducted on a sandy loam soil at Wheat Research Centre, Nashipur, Dinajpur, Bangladesh to investigate the direct, renewed and residual effect of organic manures in combination with chemical fertilizers on crop productivity and soil fertility. The experiment was laid out with nine treatments in a randomized complete block design. The treatments were: 1) absolute control (no fertilizers, no manures), 2) 100%NPKSZn of recommended dose, 3) 75%NPKSZn of recommended dose, 4) 75%NPKSZn+ farm yard manure (FYM) applied in wheat (a direct effect for wheat and residual effect for rice), 5) 75%NPKSZn+FYM applied in both wheat and rice (a renewed effect for both continuing crops), 6) 75%NPKSZn+FYM applied in rice (a direct effect for rice and a residual effect for wheat), 7) 75%NPKSZn+ poultry manure (PM) applied in wheat (a direct for wheat and a residual effect for rice), 8) 75%NPKSZn+PM applied in both wheat and rice (a renewed effect) and 9) 75%NPKSZn+PM applied in rice (a direct effect for rice and a residual effect for wheat). The results indicated that a wheat yield-increasing trend was observed for the PM treatment both as direct and residual. However, a yield-declining trend was observed in the control. There was no definite wheat yield trend for the other treatments. No definite rice yield trend was observed irrespective the treatments. The results showed that organic manures had direct and residual effects on both rice and wheat yields, but the effect of PM was dominant. Plots with FYM plus 75% NPKSZn produced equivalent or higher yields as plots applied 100% NPKSZn indicating that FYM can substitute for 25% of the inorganic fertilizers. Organic manure application in dry land winter crops like wheat performed better than organic manure application in wetland summer crop like rice. The results also showed that OM application in both crops was not encouraging. The highest mean yield of wheat and rice was recorded in PM treatment as direct in wheat and in both crops, respectively. The total (wheat + rice) highest yield was 8,715 kg ha-1 year-1 recorded in PM as direct in wheat treatment. The soil analysis data after 3 crop cycles indicated that pH was unchanged in control and inorganic fertilizers treatments, but increased in plots with added organic manures with dominant trend in PM plots. Percent reduction of OM in plots with inorganic fertilizers treatments was observed and the range varied from 13 to 19%. However, the increasing trends of OM was observed in plots organic manures receiving treatments in the ranged of 7 to 39%. An increasing trend was prominent in PM application treatments. Percent total N was unchanged in integrated use of OM with inorganic fertilizers, but reduced in control and inorganic fertilizers receiving plot treatments. The content of available P was increased dramatically in PM applied plot treatments. It was unchanged in 100% NPKSZn and FYM plots, but reduced in control and in 75%NPKSZn. Exchangeable K was reduced in control and inorganic fertilizer treatment, but was sustained in others. The available S was sustained irrespective the treatments. The soil analysis data after nine crop cycles showed that %OM, %total N, exchangeable K and available P were reduced further in inorganic treatments and increased in OM receiving treatments. The pH was substantially increased in PM receiving treatments compared to initial and all other treatments. There were no changed of soil pH, %OM, % total N, P and K after 12 crop cycles compared to 9 crop cycles although increasing trends was observed in OM matter receiving treatments. After 12 crop cycles, available S was increased in all treatments and similar in control and 75%NPKSZn treatments than initial. Soil bulk density was decreased and total porosity was increased as a result of organic manure application. However, decreasing trend of bulk density and increasing trend of total porosity were dominant with poultry manure application than FYM.

Keywords：*Wheat, rice, organic matter, nitrogen, potassium, phosphorus*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Dolomite on Yields and Nutrient Availability in Maize-Rice Cropping Pattern in Acid Soils of Northwest Bangladesh

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The aim of this investigation was to study the effect of different levels of dolomite on crops yields, soil pH, exchangeable K, Ca and Mg, available p, Zn, Cu, Mn and Fe content of soil in acid alluvial of northwest Bangladesh. The experiment was conducted in six experimental sites following wheat-rice cropping pattern during 2005 to 2007. The lay-out was kept undisturbed throughout the experimental period to know the effect of applied lime on crops yields and nutrient availability. Prior to sowing 1st crop (wheat) liming was done once with 5 levels of dolomite 0, 1, 2, 4 and 6 t ha-1. Soil pH values were monitored at 1, 2, 3, 6, 12, 18 and 24 months after liming. Besides, the soils from individual plots of all sites were analyzed for nutrient status after 6, 12, 18 and 24 months of liming. Addition of 1 t lime ha-1 provided a yield increase of maize by 38% (2.29 t ha-1) as direct effect and 35% (2.19 t ha-1) as residual effect over no lime. On an average (over the season and sites) the 1 t lime ha-1 as residual effect gave 13% (0.42 t ha-1) yield advantage of rice compared to control. The reduced soil acidity and Al, Fe and Mn toxicity accompanied with enhancing P, Ca and Mg availability as a consequence of liming enhanced the crop growth and increased yield contributing characters which resulted in higher yield.

Keywords：*Dolomite, soil pH, nutrient, maize, rice*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Limestone Soil Dust on Some Plant Species

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It has been observed for significant effects on plant height, cover and number of leaves at bulk cement industrial area Maihar, Satna District, Central India. The plants identified for study are Azadirachta indica (L.) A.Juss, Dalbergia sissoo, Delonix regia and Carissa carandas L.. There is significant changes in plant cover and height has found but wide changes have been identified in number of leaves. It has been observed that the plant species A.Indica showed ($p<0.003$), D.Sissoo ($p<0.006$), D.Regia ($p<0.02$) and C. Carandas ($p<0.07$) in number of leaves respectively. It has been identified that the cement dust has shown a significant effect on plant growth. A.Indica and D.Sissoo has been found less effected by cement dust where as C. Carandas has been found highly effected and D.Regia has found moderately effected and it has also been found that the C. Carandas has shown less survivable rate.

Keywords：*lime stone soil, dust, plant growth*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Relationship Between Native Potassium in Soil with Yield and Quality of Sugarcane

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Potassium is one of the three major plant nutrient elements which play a number of important roles in plant growth and crop productivity. Among the various roles, it is well known in maintaining the moisture in the plant as well as translocation and storage of sugar within the plant hence it is termed as a quality element. Potassium is the most abundant cation accumulating in the cell sap of sugarcane plant. A healthy sugarcane crop indeed contains generally more than 200 kg K ha^{-1} in its aerial parts. In this context present study pertains to the inventory of native potassium status in soil and plant. The soil under sugarcane were classified into low, moderate and high potassium status and the correlation studies with leaf potassium, yield and quality parameter and their interrelationship with yields and juice quality were carried out. Total 161 surface soil samples (0- 22.5 cm) were collected before planting of sugarcane and thereafter soil and leaf samples at 120 days of planting from sugarcane fields. A set of 99 fields were monitored for recording cane yields and juice quality. The results revealed that available potash content in the soils was in the range of 191.0 to 820.4 kg ha^{-1} before planting. The results indicated that soils having low potassium (191.0 to 266.6 kg ha^{-1}) did not show any significant positive or negative relationship with leaf blade K, yield and juice quality parameter. However the soils having moderate (286.16 to 549.40 kg ha^{-1}) potassium status at both initial and at earthing up stage showed positive significant correlation with leafblade (r = 0.387 ** & 0.460**) indicating increased K content in leafblade with increased status of native potassium in soil. The cane yield was positively correlated (r = 0.779**) with the native soil K content however, the juice quality parameter viz. brix, pol and sugar recovery showed significant positive correlation with initial soil K. It revealed that yield and quality of sugarcane improves with increased levels of soil K in the moderate K group soils. In soil group having high K content (568.4 to 809.2 kg ha^{-1}) showed positive significant relationship (r = 0.887**) between native K and cane yield but not significantly correlated with sugar recovery. The declined juice in high K soils might be due to the luxury consumption of potassium in plant that depresses the recovery.

Keywords：*Sugarcane, Native potassium, Sucrose*

P4-300

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Multi-Tier Soil Fertility Evaluation Rating For Citrus

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The precision of diagnosing nutrient constraints in perennial crop like citrus using soil available pool of nutrients has often been questioned on account of its reproducibility over space and time. Unfortunately, no other alternative soil fertility indices have shown any promise to predict the productivity potential of citrus orchards. In this background, attempts were made to develop multiple tier soil evaluation rating for citrus. Data were generated for as many as 60 Nagpur mandarin(Citrus reticulata Blanco) orchards (7-21 years age) budded on rough lemon (Citrus jambhiri Lush) rootstock grown predominantly on smectite rich black clay soils (Entisol, Inceptisol, and Vertisol) with ustic and hyperthemic soil moisture and thermal regime, respectively. Various parameters comprised of : fruit yield, soil available nutrients (N,P,K,Fe,Mn,Cu, and Zn), microbial population (bacterial count and fungal count), microbial biomass nutrients (Cmic, Nmic, and Pmic), and soil enzymes (urease, alkaline phosphatase, and dehydrogenase).

These orchards expressed the fruit yield variation of 25.8-38.0 kg tree-1 with the mean yield of 41.6 kg tree-1. The available nutrient supply viz., 98.4-132.8 mg kg-1 N (mean 110.6 mg kg-1), 11.3-16.2 mg kg-1 P (mean 14.2 mg kg-1), 134.3-189.4 mg kg-1 K (mean 161.3 mg kg-1), 9.4-19.3 mg kg-1 Fe (mean 11.4 mg kg-1), 8.2-12.4 mg kg-1 Mn (mean 9.6 mg kg-1), 0.80-1.50 mg kg-1 Cu(mean 0.90 mg kg-1) and 0.60-1.10 mg kg-1 Zn (mean 0.82 mg kg-1). Similarly, soil microbial population in terms of bacterial count and fungal count varied from 44 to 110 x 103 cfu g-1 soil (mean 62 x 103 soil) and from 12-44 x 103 cfu g-1 soil (mean 62 x 103 cfu g-1), respectively. The microbial biomass nutrients viz., Cmic, Nmic and Pmic showed a variation of 111.4-168.3 mg kg-1(mean 132.4 mg kg-1), 21.3-39.7 mg kg-1(mean 29.6 mg kg-1) and 16.2-23.8 mg kg-1 (mean 18.4 mg kg-1), respectively. Three major soil enzymes viz., urease, alkaline phosphatase and dehydrogenase varied from 1.88-4.07 µg NH3 liberated hr-1 g-1 (mean 2.14 µg NH3 liberated hr-1 g-1), 0.128-0.286 units hr-1 g-1 (mean 0.163 units hr-1 g-1) and 0.182-0.321 units hr-1 g-1 (mean 0.201 units hr-1 g-1), respectively, with peroxidase activity as nil.

The fruit yield was significantly correlated with KMnO4-N ($r = 0.782$, $p = 0.01$), Olsen-P($r = 0.636$, $p = 0.01$), NH4OAc-K ($r = 0.418$, $p = 0.05$), DTPA-Fe($r = 522$, $p = 0.05$), DTPA-Zn ($r = 0.716$, $p = 0.01$), suggesting the definite role of available supply of nutrients in soil in dictating the variation in fruit yield. Using soil microbial biomass as bacterial count and fungal count, the degree of corelationship between these two fractions of soil microbial biomass and fruit yield, was significantly higher ($r = 0.812$, $p = 0.01$ and $r = 829$, $p = 0.01$), warranting the superiority of soil microbial biomass as better index of soil fertility evaluation than available index of nutrients in soil. While soil microbial biomass nutrients as Cmic,, Nmic, and Pmic proved still better index of soil fertility evaluation compared to soil microbial biomass, evident from the highest degree of correlation between fruit yield and all the three fractions of soil microbial biomass nutrients (Fruit yield versus Cmic as $r = 0.846$, $p = 0.01$; fruit yield versus Nmic as $r = 0.906$, $p = 0.01$ and fruit yield versus Pmic as $r = 0.844$, $p = 0.01$). The optimum values of these alternative soil fertility indices have been suggested through multiple regression analyses.

Keywords：*soil fertility , soil microbial biomass , soil microbial biomass nutrients, soil enzymes , citrus*

P4-301

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil Quality under Organic and Conventional Farming Systems in Java, Indonesia

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A comparative study of organic and conventional farming systems both in paddy and vegetable fields was conducted to determine the effect of management practices on soil chemical and biological properties as soil quality indicator. Seven samples from each organic and neighbouring conventional sites in West and Central Java, Indonesia were obtained and analyzed for soil chemical and biological properties. Soil organic C (SOC), total N, nutrient availability (potential and available P_2O_5 and K_2O, plant available macronutrients and micronutrients), the activity of dehydrogenase, β-glucosidase, β-glucosaminidase, microbial biomass C (MBC) and microbial community composition by phospholipid fatty acid analysis were measured in this study. Moreover, the negative impact of inorganic fertilizer application on soil pH was observed. Result showed all enzyme activities, MBC and PLFA correlated with SOC and total N in paddy fields, while correlation of β-glucosidase and β-glucosaminidase activity with MBC and PLFA were observed in vegetable fields. SOC and total N combining with β-glucosidase activity, MBC and PLFA appears to be particularly suited indicators to determine management practices impact on soil quality in paddy fields, while in vegetable fields, suitable indicators are SOC, total N, dehydrogenase, β-glucosaminidase activity and MBC. Higher soil organic matter, soil pH, nutrient availability, microbial activity, microbial biomass and microbial community composition were also detected in organic farming compared to conventional farming systems both in paddy and vegetable fields. In conclusion, organic farming might have higher soil quality than conventional farming systems.

Keywords：*Soil quality, organic farming, soil enzymes activity, microbial biomass C, PLFA*

P4-302

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Simulation of Soil Water and Heat Flow in Mulched Ridges and Furrows Wheat Field of Loess Plateau, China

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A widespread measures for soil water storage in the semi-arid region of China is the ridge-furrow planting system combined with mulching. However, it is not well understood, how and to which extent the water and heat flow regime in this manmade field is hereby modified. The objective of this study was to investigate soil water distribution and heat transport in the cross-sectional ridge-furrow system, through laboratory experiments and numerical simulations. Four experimental treatments consisted of conventional fertilization (CK), recommended fertilization (JN), recommended fertilization + straw mulching (JN+S), and recommended fertilization + plastic film mulching on soil ridges and straw mulching in furrows (JN+PFM+S). The two-dimensional process-based model HYDRUS-2D was calibrated and experimentally validated to simulate the effects of different treatments on winter wheat yield, soil water storage, soil water and heat coupling processes and water use efficiency in the dryland of loess plateau. The root mean square error (RMSE) and coefficient of determination (R2) provide a satisfactory quantitative comparison of the goodness-of-fit between observed and simulated soil water and heat regimes. This demonstrated HYDRUS-2D as a reliable tool for accurately simulating coupled soil water and heat fluxes, so as to it can be used for analyzing soil water and heat processes in the plastic mulched ridge cultivation system. The results showed that there are significantly different in soil moisture contents among all the treatments, and soil water content of different soil layers fluctuated with rainfall and was influenced by different covering cultivation modes . JN+PFM+S treatment had the highest water storage and therefore the highest water use efficiency. Compared with the CK treatment, the wheat yield was increased by 5.25% and water use efficiency was increased by 18.85% in the JN+PFM+S treatment. Soil daily mean temperature was very similar among all the treatments, but the intraday temperature changes were significantly different with the strong warming effects by the plastic mulching coverage. That is, the plastic mulched ridge cultivation system improved water resource use through reducing evaporation and elevated temperature in the dryland agriculture. Therefore, we recommend the application of perforated and biodegradable plastic mulch in the Loess Plateau regions of China to improve crop production.

Keywords：*Winter wheat; Yield; water use efficiency; HYDRUS-2D model*

P4-303

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil Surface Nitrogen Balance of Field Crop System of China's Agro-Ecological Zones

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In the past 30 years, China's agriculture has made remarkable achievements, partly due to the extensive use of chemical fertilizers. Appropriate nutrient surplus is beneficial to soil fertility, but excessive nutrients surplus causes negative impacts on environment. The soil surface nutrients balance, a powerful indicator to measure the nutrients inputs/outputs, surplus or deficit at regional scale, has been widely used in China and around the world. This paper analyzes soil surface nitrogen (N) balance of field crop system in 2005 for 8 agro-ecological zones and 21 sub-zones of China by summarizing agriculture statistics of more than two thousands counties. This study is concerned in the field crops, nitrogen nutrient consumed by fruits and vegetables had been deducted in calculation. The average national N surplus level for the field crops is 127 kg ha^{-1}. Chemical fertilizer and manure were the major N input sources, accounts for 56.51% and 22.32% of total N input respectively. The N surplus level, 142 kg ha^{-1} in 9 major grain-producing regions, was significantly higher than that of 101kg ha^{-1} in 22 non-major grain-producing regions. The variations of N surplus between sub-regions are significantly smaller in major grain-producing regions than that in non-major grain-producing regions. Both the highest and lowest N surplus appeared in non-major grain-producing regions. Compared with other researches on N balance conducted around 2005, the result of N surplus from this study was significantly lower. By subtracting N consumption of vegetables and fruits, the N surplus of the field crop system was not as high as the results obtained from other researches. In fact, high fertilization applied to cash crop such as vegetables and fruit trees increased N surplus level in the entire farmland ecosystem. The N surplus level in all regions except Northwest China and Qinghai-Tibet Plateau was higher than that of the EU-15 average. The N surplus level of Southeastern Fujian reaches up to 326 kg ha^{-1}, which was the highest in all sub-regions, greater than that of the Netherlands in 1997. High N surplus not only caused waste of resources, but also brought about a big pressure to the environment. Therefore, for areas with high-level N surplus, the inputs of N should be under control, while for areas with low level of N surplus or in N deficiency state, more nitrogen should be applied.

Keywords：*soil surface nutrients balance, nitrogen, agro-ecological zone, China*

P4-304

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Changes in Soil Properties After 15 Years of Different N Fertilization

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After establishment of the experimental field (1996) with different nitrogen fertilization practices for arable crops, we have analyzed influence of different treatments on selected soil properties. Included treatments are 1. Control, without any fertilization, 2. N0PK, 3. N100PK, 4. N150PK, 5. N200PK, 6. N250PK and 7. N300PK. Fertilization with phosphorus and potassium was equal for all trial treatments in the same year of investigation, excluding check treatment. Research was conducted on experimental field located within drained cropland in Western Pannonian subregion of Croatia (45°33´N, 16°31´E). The soil type of trial site is drained distric Stagnosols. Terrain is flat with average altitude 97.2 m. Groundwater occurs under 175 cm below soil surface. Besides soil physical properties that favor water stagnation in upper layers, and low soil organic matter content, the main factor that limits crop yield is low soil pH value. We have recorded changes in soil pH, and in soil content of plant available P2O5 and K2O, total C content, total N content in soil. In order to get good spatial distribution, during summer 2010 we have used new way of soil sampling with increased volume of sampled soil, and with high density of sampling. Semi-automatic circular tractor soil probe prototype (PCT-HR2011-000021) was tested after winter wheat harvest (20th July, 2010). Sampling was performed with grid sampling in a grid of 15 x 15 m, at grid intersections. In soil samples pH was determined in 1:2.5 (w/v) in (1 M KCl) soil suspension (modified ISO 10390). For soil P2O5 and K2O content determination we have used AL method (soil extraction by ammonium-lactate solution) which is the most common method for this type of analyses in Croatia. Total carbon and nitrogen content were determined by dry combustion method (elemental analysis) with the Vario Macro CHNS analyzer (Elementar).
Different mineral nitrogen fertilization was found to be the key factor that influenced soil pH 15 years later, with decreasing values corresponding with the increased N levels. Changes in P2O5 and K2O were significant, after 15 years of continuous fertilization, compared to the original state at the time of the beginning of experiment.
We have recorded higher average total nitrogen content in soil at the treatments with higher nitrogen fertilization rates. We have also concluded that nitrogen fertilization has influenced the increase in total soil carbon content.

Keywords：*N fertilization treatments, soil pH, P205 and K20, total N, total C*

P4-305

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Cumulative Nutrient Uptake by Roots as Simulated by Fixed and Moving Boundary Models. Corrections and Improvements

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This work examines the relevance of physical models used to study the flux and uptake of nutrient by roots and the efficiency of the used numerical methods. The physical models studied are the fixed boundary model of Cushman-Barber and an improved version of our moving boundary model (Reginato et al., 2000). Previous to solve the moving boundary model, the domain of the problem is immobilized in dimensionless variables and then solved by the finite elements method. To compute the cumulative nutrient uptake a correct and verified formula is used for both models. Moreover, we prove that previous Claassen-Barber and Cushman formulas of cumulative nutrient uptake do not verify, in general, a mass balance condition. The Claassen-Barber formula only verifies this condition when the influx is constant and root grows linearly. The Cushman formula verifies the mass balance when the influx is constant regardless of the law of root growth and our formula (Reginato and Tarzia, 2002) and its simplified version always verify the mass balance whatever be the representative functions for the influx and the law of root growth. Moreover, in the case of low concentrations we show that it is not convenient to use the influx as a parameter to evaluate if a prediction of cumulative nutrient uptake is good o poor. For simulations of nutrient uptake four date sets extracted from literature were used. First, we compute the cumulative K and P uptake by pine seedling for high soil concentrations (Kelly et al., 1992). Second, we compute the cumulative N uptake by rice, wheat and rape for high soil concentrations (Xia Jiang et al., 1991). Third, we compute the P uptake for peanut for low, intermediate and high soil concentrations (Singh et al., 2003) and finally we compute the K uptake by maize, wheat and sugar beet for low K soil and soil with K addition (Samal et al., 2010). The results obtained show that both models produce similar results with small errors for ions without limitations of availability, low variation of density of roots and low Peclet numbers. For low concentrations, large variations of density of roots and low numbers of Peclet the moving boundary produces better predictions particularly for K. For P the moving boundary produces better predictions only at low concentrations. Obtained improvements are mainly due to three factors: a) the use of a correct formula for the cumulative nutrient uptake, b) the influxes obtained by the moving boundary model and the cumulative uptake, which is obtained through integration in a variable domain are represented by the same dynamic, while for the fixed boundary model influxes are obtained in a fixed domain and the cumulative uptake by integration on a variable domain, c) the use of a numeric method (finite elements) that ensures the balance of mass between the absorbed ions and the remaining ions in soil while the finite differences method does not satisfy it. Finally, and in the light of these findings, conclusions drawn by previous papers (Hinsinger, 2011) could be reinterpreted.

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Keywords：*Nutrient uptake, fixed and moving boundary models*

P4-306

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil Fertility Capability Classification for Rice Soils in the Mekong Delta, Vietnam

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Intensive rice cultivation in the Mekong delta, Vietnam is rapidly development. These developments need better soil information to enable good planning, accurate interpretation of data, and the extension of results to new area. Besides, improving the production and efficiency of rice cultivation demands an understanding of the Delta's soil resources. Currently, farmers and agricultural extension officers have little information about soils on which to rely, since a soil fertility capability classification and evaluation system for intensive rice soils in the Mekong delta (FCC-mkdt) has the dual aims of providing a system for people who deal with soils at more comprehensive information for the experienced soil scientist.

The classification relies mostly on the topsoil properties that affect rice production and some properties at subsoil which related to topsoil properties, and is conceptually built on the soil series approach. The classification allows nonspecialists to classify the soil on which they are standing, in the field, even without the aid of a laboratory. Importantly, the system is not designed to replace more formal soil taxonomic classification but to complement them. An avenue for correlation to international classification has been incoporated through the fourth component of the system, the Fertility Capability Classification-FCC (Sanchez et al, 2003). The key to the success of the system will be its usefulness to agriculturalist or soil scientist working in the field.

The classification system based on FCC system of Sanchez et al (2003), a quantitative assessment of the soil fertility constraints and provides guidelines for management, with some modification and addition, consists of 4 categories : Type, Substrata Type, Subsoil Type, and Modifiers, and based on only three diagnostic layers of the soils. The upper layer coincides with the top 20cm of the soils, as topsoil or Type (C for clay and L for Loamy). The soil below the upper layer from 20 to 50cm is referred to as the Substrata Type (C for clay and L for Loamy), and from 50 to 100 is referred to Subsoil Type (C for clay, L for Loamy, and S for sandy). The condition Modifiers, directly relevant to plant growth, including19 modifiers which directly affected to intensive rice cultivation in the Mekong delta, including a, a- c, c-, d, e, f, f-, g, g+, i, i-, i+, n-, s, s-, o, p, v. Most of class limits are borrowed from Soil taxonomy (Soil Survey Staff, 1994) or the FAO/Unesco soil classification system (FAO, 1974). However, some modification and addition for classification of intensively rice cultivation are suggested, in which new modifiers of p (low P available), o (low organic carbon), c, c- (actual acid sulfate), f, f- (potential acid sulfate) are added, while modifiers of a, i, n, s, are suggested with some modification from Sanchez et al (2003). Besides, the classes within each categories and assigned modifiers for each soil type are difference from Sanchez et al (1982, 2003) and Smith (1989), which each type, or substrata type, or subsoil type is followed by each modifier that presented.

The system is used to classify intensive rice soil in the Mekong delta, showing that major soil fertility constraints for intensive rice cultivation in the Mekong delta including Gley (g), High P fixation and potential Fe toxicity (i+), Potential salinity (s-), Low available P (p), and acid and Al toxicity (a), respectively. However, constraints of actual acid sulfate (c, c-), potential acid sulfate (f, f-), and low organic carbon status (o), are also major constraints for intensive rice cultivation in the Mekong delta.

The same as the 3rd FCC (Sanchez et al, 2003), if a soil cannot be adequately classified, then it is possible to create a new phase or modifier, because the system has been left "open ended" to accommodate such modifications in the future, which can classified the soil for better management and get more crop production.

Keywords：*Type, Substrata, Subsoil, Modifier, soil constraints, intensive rice cultivation*

P4-307

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Influence of Different Forms of Fertilizers and Approaches of Nutrient Recommendations on Hybrid Maize Yield and Nutrient Use Efficiency

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A field experiment was conducted during Kharif 2012-13 at Zonal Agricultural Research Station, University of Agricultural Sciences, Bangalore to study the influence of different approaches, forms of fertilizers on maize yield and nutrient use efficiency of hybrid maize in red sandy loam soil. The experiment was laid out in Randomized Complete Block Design with three replications which consist of ten treatments viz; T1: Absolute control, T2: 100% of RDF through conventional fertilizers, T3: 100 % of RDF through soluble fertilizers, T4: 50% of RDF through soluble fertilizers, T5: 100% of LMH approach through conventional fertilizers, T6: 100% of LMH approach through soluble fertilizers, T7: 50% of LMH approach through soluble fertilizers, T8: 100% of STCR approach through conventional fertilizers, T9: 100% of STCR approach through soluble fertilizers, T10: 50% of STCR approach through soluble fertilizers. The treatments were replicated three times in 4.8m X 3.0 m plots. For all the treatments except control 10 tones of FYM and 10 kg ZnSO4 per hectare was applied. The three different approaches of nutrient recommendation were adopted in this study namely blanket recommendation i.e. recommended dose of fertilizer (RDF), LMH (Low Medium High concept) approach and STCR (Soil Test Crop Response) approach. Similarly two forms of fertilizers namely conventional and soluble fertilizers were used in the experiment, where Urea, Single Super Phosphate and Muriate of Potash were used as conventional fertilizers and 12:61:0, 28:28:00, 00:00:50 grades of NPK and calcium nitrate (15.5 % of N) were used as 100 per cent water soluble fertilizers. The amount of fertilizers required as per the different approaches were calculated using scientific methods.

During the harvest of the crop, the observations on growth and yield parameters were recorded from each plot. The grain and straw samples of each plot were drawn, dried, powdered and analyzed for various nutrient elements and nutrient uptake was computed. The soil samples collected before and after harvest of the crop were processed and analyzed for macro and micro nutrients by adopting standard procedures.

The investigation revealed that significantly highest grains per cob and grain weight per cob were (554.87 and 188.00 g respectively) found in 100 per cent of STCR approach applied through soluble fertilizers. 100 and 50 per cent of STCR approach applied through soluble fertilizers recorded significantly higher grain yield (94.74 and 84.56 q ha-1 respectively), compared to 100 % of RDF applied through conventional fertilizers (73.72 q ha-1). However, it was on par with 100 % of LMH approach through soluble fertilizers (92.43 q ha-1) and 100 per cent of RDF through soluble fertilizers applied plot (87.96 q ha-1). Similar to that of grain yield, highest stover yield (104.22 q ha-1) was found where 100 per cent of STCR approach was applied through soluble fertilizers. However, it was on par with 100 per cent of LMH approach applied through soluble fertilizers (100.42 q ha-1). The significantly lowest stover yield (64.72 q ha-1) was found in control plot. Significantly higher total uptake of nitrogen, phosphorus and potassium (232.95 kg N, 56.07 kg P and 116.55 kg K ha-1 respectively) by maize crop was found where 100 per cent of STCR approach applied through soluble fertilizers. Similarly, higher uptake of micro nutrients in grain and straw was

recorded where 100 per cent of STCR approach was applied through soluble fertilizers. The highest apparent recovery of nitrogen, phosphorus and potassium (0.64, 1.52 and 0.76 kg kg-1 respectively) was recorded in 50 per cent of STCR approach applied through soluble fertilizers. Highest value cost ratio (VCR) of 8.48 was recorded in the treatment where 100 per cent of LMH approach applied through conventional fertilizers. Available N status of the post harvest soil was significantly highest (224.42 kg N ha-1) where 100 per cent of STCR approach was applied through soluble fertilizers as compared to control (169.60 kg N ha-1). Significantly highest available phosphorus and potassium (79.68 kg P2O5 and 173.63 kg K2O ha-1 respectively) values were found in 100 per cent of STCR approach applied through conventional fertilizers. It was concluded that the application of soluble fertilizers through STCR approach was found to be superior in getting higher maize grain and stover yield compared to conventional fertilizers and other approaches.

Keywords：*Maize, Conventional fertilizers, Soluble fertilizers, STCR and Nutrient recommendation.*

P4-308

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Salinity Management With Potassium in Horticultural Crops in Irrigated Areas of Argentina

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Saline soils affect several thousand hectares of productive soils in Argentina, located in arid or in humid environments, and irrigated or not. However, irrigation management in most of the arid or semiarid areas, typically used for intensive crop production, often results in development of halomorphic conditions.
Apart of the saline conditions, low potassium (K) supply is other frequent fertility constraint in soils of the irrigated areas. In these igh salinity soils, sometimes associated with low quality water for irrigation, the delivery of nutrients to crops may face difficulties in choosing the right source without negative effects on soil or plants. It means the election of low salt index fertilizer sources where accompanying nutrients are useful for crop nutrition. In this sense, either potassium nitrate (NOP) or sulfate (SOP) are preferred over chloride (MOP) as K source.
The objective of this work is the evaluation of typical K sources on the effect of yield and quality of harvestable vegetable products and on soil salinity after cropping.
Several field trials had been conducted with onions, tomatoes and cantaloupes/melons, all for fresh markets, in three saline prone environments in Argentina (Rio Negro, San Juan-Mendoza, Santiago del Estero) during four growing seasons (2010/11-2013/4). Not all site-years had all crops, being onions only in Rio Negro (2 seasons); trials with melons were in six site-years (Santiago and San Juan-Mendoza) and tomatoes were on four site-years in Rio Negro and San Juan-Mendoza.
All the experiences had seven treatments in a factorial arrangement of three K sources (NOP, SOP and MOP) time's two rates of K (75 and 150 kg of K2O ha-1) and a check without applied K. The seven treatments were allocated in a randomized block design of four replications with varying plot sizes. All treatments, except NOP, were applied more nitrogen (N) to compensate for the N carried in the MOP.
Crops were conducted under the high standards of management for a commercial production with the available technology, especially with enough N and P supply. In all cases, furrow irrigation was the used system, except in one site-year where drip lines was employed. Fertilizer sources were hand applied split in two or three fractions synchronizing with irrigation timing.
Yields of fruit/bulbs were recorded at harvest and classified by size and other commercial traits. Also as a quality indicator, Brix degrees were measured in melon/cantaloupes and tomatoes.
Composite soil samples were collected from each site-year before planting to characterize soil fertility. After harvest, soil of the plots was sampled to measure EC as affected by the fertilizer treatments.
Results indicated positive responses to K sources that varied in magnitude for yield of marketable fruits/bulbs depending on the crop, the site and the season. The K has clearly affected the yields of marketable onions, cantaloupes /melons and tomatoes by significant increases over the non fertilized. However the source of the potassium fertilizer affected yields less clearly: SOP was sometimes higher or lower than the NOP. Similarly MOP as a source was sometimes superior, or no differences between sources were found.
Source and rates of the potassium fertilizers affected soil salinity after harvest. MOP show the highest values of EC, but no difference was found between NOP and SOP.

Keywords：*Soil EC, fruit quality, tomatoes, melons, furrow irrigation*

P4-309

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Improving Yield and Nitrogen Use Efficiency of Maize in China

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Achieving both high grain yield and high nutrient use efficiency (NUE) simultaneously has become a major challenge with increased global demand for food, depletion of natural resources, and deterioration of environment. However, as the greatest consumers of nitrogen (N) fertilizer in the world, N has often been overused by Chinese farmers. In this paper, we briefly review the current N management status in China and then suggest improvements to N management strategies by clarifying N requirements as related to the potential yield for the specific varieties, environment and management combination. Finally, we define an integrated soil crop system management (ISSM) to evaluate the potential of this approach to simultaneously improve crop productivity and NUE.

1 Crop N uptake requirement. Poor synchrony has existed between crop N demand and N supply attributable to a limited understanding of the N uptake-yield relationship. Therefore we evaluated the total and pre- and post-anthesis N requirement for different yield ranges for both maize and wheat in China.

N requirement per 1 Mg grain yield (Nreq.), with optimized N treatment, was 17.4 kg on average for maize, and 24.3 kg for wheat. These values were considerably lower than previous observations in China and other areas. More importantly, Nreq. initially deceased with grain yield improvement and then stagnated. This declining and then stagnation trend in Nreq. with increasing grain yield, is mainly because of increasing harvest index (HI) and declining N concentrations in grain, and it suggests that the N physiological efficiency has improved within a high-yielding system in some extent.

The percentage of dry matter and N accumulation in the middle-late growing season (i.e. the post-anthesis stage for maize and from stem elongation to the anthesis stage for wheat) increased significantly with grain yield increasing. These observations highlight the importance of N management in the middle-late growing season.

2 Increasing grain yield and NUE simultaneously: integrated soil crop system management. Based on the understanding of N demand and dry matter accumulation by high-yielding crops, together with best crop management, an integrated soil crop system management (ISSM) strategy is advocated here to achieve high yields with minimum N inputs and to simultaneously reduce environmental risks.

Field results from multi-sites/year on-farm experimental plots showed that maize yield under the ISSM approach averaged 13 Mg ha-1, nearly twice the yield from current farm practices. More importantly, the N fertilizer rate in the ISSM (237 kg ha-1) was similar to current farm practices (257 Mg ha-1). Thus, the partial use efficiency from the applied N (PFPN, grain yield divided by N rate) in the ISSM was 55 kg kg-1, significantly higher compared with farm practices. For wheat, field results from 110 agricultural counties from 2008 to 2009 in China showed that grain yield increased by 9.9-12.6% when PFPN was improved by 12.8-18.5%.

In summary, re-understanding N uptake requirement, together with best crop management, ISSM strategy has great potential for simultaneously increasing both the grain yield and NUE.

Keywords：*Maize, yield, nitrogen*

P4-310

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Improving Soil and Crops Productivity through Resource Conservation Technologies in Warmer Area

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Rice-wheat (RW) cropping systems are critical to food security of increasing population in Bangladesh. However, the sustainability of RW systems is threatened by productivity decline and environmental sustainability. Crop production on permanent raised beds (PRB) with residue retention is expanding worldwide as a way to improve soil and crops productivity, diversify cropping and reduce cost of crop establishment. When coupled with raised beds with residue retention can improve soil moisture retention, soil health, crop productivity and sustainability. A 9 years field study was conducted at the Regional Wheat Research Centre, BARI, Rajshahi, Bangladesh as a warmer area (average annual rainfall 865 mm with temperature range 3.3 to 45.20C), to compare the effects of five N fertilizer levels (0, 40, 80, 100 and 120% N of recommended dose) and four straw retention(SR)/tillage treatments (30% SR of all crops+ Permanent raised beds(PRB), 0% SR +PRB, 30% SR+ Conventional tillage practice (CTP) and 0% SR+ CTP in a intensified RW systems by adding a third pre-rice crop of mungbean(Pulse crop). Permanent beds with residue retention produced the higher productivity for all three crops in the sequence. Within each N rate the total system (rice-wheat-mungbean) productivity was maximum with 30% SR on PRB and least in CTP with zero straw retention. At 100% of recommended fertilizer N rate, mean annual system crops productivity was 12.5 t/ha for PRB with 30% SR, 11.2 t/ha with PRB without SR and 10.3 t/ha with CTP without straw. These benefits from residue retention with PRB were established within or after 4-5 years cycle. System crops productivity in N unfertilized plots increased when straw was retained due to increased supply and uptake of N. The results suggest that 20 % N fertilizer rates can be reduced when 30% straw is retained after nine years. Water use efficiencies improved 25, 23 and 29% in wheat, rice, and mungbean crops, respectively when 30% SR with PRB system. By sowing crops on raised bed, irrigation water moves laterally from the furrow to the top and middle of the bed by capillary flow. Soil organic matter in surface soil layers of the PRB had increased by 0.72% after 9 years (9 rice-wheat-mungbean crop cycles) with 30% straw retention. PRB with residue retention avoidance of puddling which adversely affects on soil physical properties and saves on the use of machinery, labor, water and also help from soil cracks. Residue retention is an important component of soil and crop sustainability and may have long term positive impacts on soil quality and fertility. Straw retention influenced the soil moisture in wheat crops. In the 0-30 cm soil layer the maximum soil moisture 22.4% was in 30% SR with PRB. Resource conserving technology required 54 litre/ha/year fuels per year compared to conventional wheat method 96 litre/ha/year. 42 litre/ha/year fuels saved with 44% less CO2 emission in the atmosphere by resource conserving technology in rice-wheat-mungbean system. The combination of PRB with residues retained appears to be a very promising technology for sustainable intensification of RW systems as well as improve soil heath and productivity in warmer area of Bangladesh.

Keywords：*Soil Productivity, Sustainability, Intensification, Conservation Agriculture and Global Warming*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Remediation of Andisol In Managing And Improving the Soil Charateristics and its Sustainable Productivity in the Agricultural Area

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Andisol is considered as a fertile soil due to the excellent soil physical characteristics, and high basic nutrients content. However, the high P retention and low available P in high variable charge of Andisol made it tend to be impoverished if not be managed as their natural behaviours. Phosphorus fertilization is not the solution because the P fertilizer will be quickly retained by the soil colloid and only ten percent will be available for plants. Remediation these soils with high negative charge materials like silicate and organic matter can be done to block the positive charge of Andisol which can release the P-retention, increase the available P, the CEC, the available of the basic cations and keep maintain the distinction soil physical characteristics. This is the effort to stave them off from the impoverished, and manage them as their natural characteristics. The research was done in field of Research Centre of Vegetable Crop in Lembang, West Java Indonesia, where the Andisol derived from Mt. Tangkuban Parahu. The research run within two periodes. In the first periode, the soils were remediated with steel slag (as silicate) and bokashi of husk (as organic matter) for four months, and be investigated the soil chemical characteristics like pH, P-retention, available P, available basic cations and CEC. Some soil physical characteristics were also be investigated like bulk density and porosity. In the second periode, the remediated soils were planted with corn and broccoli till their vegetative periode to have the crop responses after remediation. The weight of yield were accounted as the parameters. The treatments were arranged in Randomized Block Designed in factorial pattern, consisted of two factors. The first factor was steel slag, and the second factor was bokashi of husk, each consisted of four level : 0, 2.5, 5.0 and 7.5 % of soil weight percentage respectively. The treatments were repeated twice, bring a combination of 4 x 4 x 2 treatments. Two series of treatments with polybags were arranged for corn and brocoli, make the whole treatments series of 4 x 4 x 2 x 2 = 64 polybags. Every polybag contained 10 kg of Andisol, considered the water content and bulk density. The soils with each remediated treatments materials were mixed thoroughly, be filled into the polybags, watered until the field capacity, and closed tightly to avoid the evaporation. They were incubated for four months, then be sampled from every polybags for chemical and physical analyses. The fertilization was given as the recommendation dosages, and be planted with corn and broccoli till the end of generative periode. The parameters were the the yield of corn and broccoli. The statistical analyses indicated that steel slag and bokashi of husk had the significant effect in increasing pH (0.42 point), decreasing P-retention (6.67%), increasing available P (55.05 mg kg-1), but no significant effect in available basic cations and CEC. The statistical analyses indicated that steel slag and bokashi of husk had the significant effect in decreasing bulk density (0.41 g cm-3), and porosity (15 %). The treatments also significantly increased the yield of corn (360 g polybag-1) and broccoli (210 g polybag-1). Steel slag and bokashi of husk are the promising materials in managing and improving soil characteristics of Andisol and its sustainable productivity in the agricultural area.

Keywords：*Andisols, steel slag, bokashi of husk, P-retention, available P*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Prospects of Crop Rotation for Improving Soil Quality and Rice Yield in the Mekong Delta, Vietnam

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Continuous intensive monocultures of rice can lead to increased soil compaction, reduced soil quality and decline of rice yield. The objectives of this study were to evaluate the effect of rotations of rice with upland crops on soil quality of an alluvial clay, and on yield and yield components of rice in a long-term experiment in the Mekong Delta. A field experiment was established in 2002 for 10 years at Cai Lay district - Tien Giang province using a randomized complete block design with four treatments and four replications: (1) rice-rice-rice (control - conventional system as farmers' practice), (2) rice-maize-rice, (3) rice-mung bean-rice, and (4) rice-mung bean-maize. Prior to our experiments, the experimental site was cultivated for over 30 years under a conventional system. The soil samples were collected at three depths 0-10, 10-20 and 20-30 cm. Results showed that the rotation of rice crop alternated with upland crops contributed to a significant increase in soil organic matter, soil labile carbon, soil available nitrogen and improved soil bulk density, soil porosity, soil aggregate stability index and soil strength in comparison with traditional rice mono cropping practice. As a consequence, rice plant height, total tillers, panicle, filled grain percentage and yield was improved when rotating rice with upland crops in comparison with the conventional rice monoculture practice: rice yield increased compared with the control with 32 to 36%. Our study demonstrated that rotating rice with upland crops is recommended to improve soil quality, rice productivity and farmer's income hence contribute immensely to sustainable agriculture. Therefore, we recommend large scale implementation of these rotations on alluvial clay soils and possibly on other soils in Mekong Delta.

Keywords：*clay soil, crop rotation, soil quality, paddy, rice yield, farmer's income*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Accumulated Nitrogen Recovery and its Application in Wheat-Maize Cropping Systems

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Recovery efficiency of nitrogen (N) fertilizers (NRE) applied to soils, which is defined as the ratio of total N uptake by aboveground plant to amount of N applied) has always been an important issue for food security and environmental pollution, but it has been studied in details, although it is very useful for N fertilizers recommendation. In the present study, apparent accumulated N recovery (NREac) were determined by long-term (15 years) experiments in wheat (Triticum aestivum L.) and maize (Zea mays L.) rotations various soils and climate characteristics in China. The long-term experiments in China were set up in 1990 at five field sites in different areas including Urumqi in Xinjiang, Changping in Beijing, Zhengzhou in Henan, Yangling in Shaanxi and Qiyang in Hunan. The values of NREac (%) were calculated by total N uptake by crops (grain and straw) divided by total N fertilizer input in the period of cultivation. The results showed that NREac varied from 14 to 85%. NREac from balanced fertilization were always higher than that from unbalanced fertilization. Also, NREac was decreased with N application rates. The NREac at optimal application rates of N fertilizers and balanced fertilization was found to be from 77% to 85%, 81% on average. Meanwhile, the value of optimal NREac was validated by the fertilizer experiments in literature. Based on the optimal NREac of 81%, the optimal N application rates could be estimated only based on crop yields in wheat-maize cropping system in China. The equation is as follows: optimal N amount = (wheat yield (kg/ha) × 2.7% + maize yield (kg/ha) × 2.2%)/81%, where 2.7% and 2.2% were corresponding N concentration in the aboveground biomass and 81% is optimal NREac. Also, the application of optimal NREac for N fertilizer recommendation for N-rich or N-deficient soils were discussed in details. For example, based on the fact of accumulation of NO3-N in soil profile being serious and prevalent in wheat-maize cropping system in china, it suggested that NO3-N could be utilized by subsequent crops calculated by the equation (1.23 × (NO3-N - 87). Another more simple and feasible method was that the N recommendation rates were adjusted based on the soil fertility. For example, when a basic yield without fertilization exceeds 81.7% and 77.8% of the optimal yield for wheat and maize, respectively, the N recommendation rates should be decreased and could be calculated based on basic yield. In conclusion, yield-based N fertilizer recommendation based on optimal NREac is found to be a simple and less-cost method for wheat-maize rotation systems, maybe as well as other crop rotation systems in China.

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Direct and Residual Effects of Boron and Zinc Application on Rice and Subsequent Wheat Crop

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Rice and wheat are the two most important cereal crops and the largest cropping system in the world because it is the major staple food of the global populace. These both crops are very important in food security and the economy of the many countries, their productivity must increase in order to meet food demand of growing population. Soil nutrient removal is higher in rice-wheat cropping systems so in these regions wide spread boron (B) and zinc (Zn) deficiencies take place. These both micronutrients had multitude effects on plant growth and their insufficiency are causing low-grade crop quality and production. Keeping in view the significance of B and Zn for cereal crops a long term field experiment was conducted to study their direct and residual effects on growth and yield of rice and wheat respectively. Field experiments were conducted at B and Zn deficient, silty clay, slightly saline and alkaline farmer's field in the main rice growing area of Sindh-Pakistan during 2011-2012 (GPS location: 28013'03.28 N, 68047'36.09 E). Each plot received either B or Zn at the per hectare rates, T1 control (0 kg B), 1 kg B (T2), 2 kg B (T3), 3 kg B (T4), 4 kg B (T5) , 5 kg Zn (T6), 10 kg Zn (T7), 15 kg Zn (T8), 20 kg Zn (T9), 1 kg B and 5 kg Zn (T10), 2 kg B and 10 kg Zn ha-1 (T11). These fertilizers were applied in first season by surface application at the time of hybrid coarse rice seedlings transplanting. The experiment layout was kept undisturbed for observing the residual effect of B and Zn. The second season wheat crop was planted in the same plots after the 30 days of rice harvesting and during this time gap soil was fallow. Wheat variety TD1 was sown. All the agronomic observations and chemical analysis of both crops were recorded. The data were analyzed using Statistical Analysis System (SAS) software package version 8.2.

The direct application of B and Zn has shown positive effects on all the agronomic parameters of the first season rice crop. The number of tillers, height of plant, the number of grains per panicle, weight of the 1000 grains, B and Zn content of grain significantly increased and the number of empty grains in a panicle decreased. The positive improvement in agronomic growth increased the per hectare rice production. The highest yield was recorded at 3 kg B ha-1, 15 & 20 kg Zn ha-1 and 2 Kg B, 10 Kg Zn ha-1 rate in compare to control and other treatments. The yield increase was 23% over the control at above B and Zn levels. This study had shown that when B and Zn applied individually than B upto 3 kg and Zn application upto 20 kg ha-1 is adequate for higher yields and if these both micronutrients are applied together than 2 Kg B and 10 Kg Zn ha-1 is sufficient. Boron application above the level of 3 kg ha-1 had not shown growth in the agronomic parameters and yield of rice crop.

The positive residual effectiveness of B and Zn on subsequent wheat crop was observed. The residual effect of these micronutrients increased the plant height, tillers per plant, grains per spikelet, weight of 1000 grains, Zn and B content of grain. Wheat crop harvested from last season fertilizer applied plots produced significantly higher yields at the rates of 3 and 4 kg B ha-1, 20 kg Zn ha-1 and 2 Kg B, 10 Kg Zn ha-1 than the other treatments. At these rates the yield was 13% higher than the control. The residual effect of lower levels of B and Zn was not significant. This field study showed that one B and Zn fertilizer application can improve crop yields for at least two consecutive seasons because soil chemical analysis had shown that very small quantities of these nutrients were consumed by first season crop and remaining amount was still present in soil which was sufficient enough for second season crop for healthy growth. Therefore, there is no need to apply these micronutrients to the following crop when it is applied on the previous one.

Keywords：*Residual Boron, Zinc, Rice, Wheat*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Different Sources of Silicon on Growth and Yield of Maize in Southern India

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The influence of different sources of silicon on growth and yield of maize (Zea mays L. cv. NAH-2049) was investigated at ZARS, Mandya, Karnataka, South India, using calcium silicate, foliar silicic acid. Since foliar silicic acid contains 0.8 per cent boron as boric acid, treatments with boric acid as foliar spray was also considered in the present investigation. Field experiment was conducted using RCBD as a design with 15 treatments repeated three times. Different treatments were used among which, one was recommended dose of fertilizers, two treatments with different levels of calcium silicate @ 1 and 2 t ha-1, two treatments with application of foliar silicic acid @ 2 and 4 ml L-1, four treatments with application of calcium silicate (2 and 4 t ha-1) in combination with foliar silicic acid (2 and 4 ml L-1), two treatments with application of boric acid @ 2 and 4 ml L-1, four treatments with application of boric acid in combination with calcium silicate @ 2 and 4 ml L-1. Land was leveled using harrow, field was divided into different plots with spacing of 60×30 cm. Recommended dose of fertilizers (150 kg N, 75 kg P2O5 and 40 kg K2O ha-1) along with 10 t ha-1 FYM was applied. Calcium silicate was applied as one of the silicon sources two weeks before sowing. Nitrogen was applied in three splits i.e. one third at basal dose, one third at knee-high stage and remaining one third at tasseling stage, while phosphorus and potassium were applied as basal dose. Silicic acid and boric acid were used for two sprays at an interval of 30 days. First spray of silicic acid and boric acid was given after 30 days after sowing. Five plants were selected at random and at harvest these plants were taken for observations. The observations from 5 cobs were recorded and converted to per hectare. Plant samples were dried, powdered and digested for the estimation of Si, N, P, K, Ca, Mg, S. Post harvest soil analyzed for different chemical properties and available nutrients. The results revealed that application of calcium silicate @ 2 tha-1 has higher growth and yield. Application of foliar silicic acid @ 4 ml L-1 in combination with calcium silicate @ 2 t ha-1 recorded even higher grain and straw yield. However, combined application of calcium silicate @ 2 t ha-1 in combination with foliar silicic acid @ 4 ml L-1 recorded highest grain yield of 7700 kg ha-1 and stover yield of 8536 kg ha-1. The application of 0.8 % boric acid @ 4 ml L-1 in combination with calcium silicate @ 2 t ha-1 recorded higher grain and stover yield compared to control. Calcium silicate application recorded highest concentration and uptake of silicon in grain and stover over other treatments. Application of calcium silicate @ 2 t ha-1 along with foliar silicic acid @ 4 ml L-1 recorded highest content of plant nitrogen (1.15 %), phosphorus (0.16 %), potassium (1.06 %), calcium (0.51 %), magnesium (0.40), sulphur (0.21 %) and silicon (1.67%) whereas the uptake of nitrogen (93.06 kg ha-1), phosphorus (12.65 kg ha-1), potassium (88.84 kg ha-1), calcium (42.17 kg ha-1), magnesium (32.89 kg ha-1) and sulphur (16.59 kg ha-1) was highest when calcium silicate was applied @ 2 t ha-1. Silicon uptake (128.29 kg ha-1) was higher when calcium silicate and foliar silicic acid was applied together. Available nitrogen (335.48 kg ha-1), exchangeable calcium (8.25 c mol kg-1) and available sulphur (9.03 ppm) in soil were high when calcium silicate was applied @ 2 t ha-1. Application of calcium silicate @ 2 t ha-1 along with foliar silicic acid @ 4 ml L-1 recorded highest content of available phosphorus (96.10 kg ha-1), available potassium (251.46 kg ha-1), exchangeable magnesium (5.09 c mol kg-1) and available silicon (155.63 kg ha-1). Higher silicon content was recorded in stover compared to grain, sheath and rind of maize crop. Silicon content in rind, grain, sheath and stover ranged from 0.13 to 0.23 %, 0.07 to 0.17 %, 0.48 to 0.85 % and 0.90 to 1.67 % respectively. Application of calcium silicate and or foliar silicon was found very effective in achieving higher yields.

Keywords：*Calcium silicate, silicic acid, boric acid, foliar spray, maize,*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Humic Liquid Fertilizer on Six Genotype of Bread Wheat in the End of Drought Conditions

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Wheat is one of the most valuable plants on the earth which is occupied near one-eighth of the overall surface and also it is clearly important to human nutrition, source of animal feed and forage. In Iran bread wheat is one of the most important crops and drought stress in many areas at different growth stages has sharp reduction effect in wheat grain yield. In order to investigate the effect of humic liquid fertilizer (potassium humat) on quantitative and qualitative traits of six genotype of bread wheat (Gaskozhen, Sabalan, 4057, Roozi -84, Quboostan and Saratoosskaya-29) an experiment in terminal drought condition by factorial split plot method has been done based on randomized complete block design in three replications in the research station of Ardabil islamic azad university, Iran. Results showed the number of grains per spike, grain weight per spike, grain yield and protein content was meaningful for each variety. Genotype 4057 with 2.98 tons per hectare had the highest grain yield. The most grain protein with an average 14.80 belonged to Saratoosskaya-29 variety and grain yield was increased about 31.36 percentage. So humic liquid fertilizer (Potassium humat) as miraculous natural substance can be used for increasing the quantity and quality of organic bread wheat cultivation.

Keywords：*Bread wheat, terminal drought, potassium humat*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Modeling of Rice Yield Response to Biochar Application in Vietnam

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Biochar is currently being considered as an important agricultural resource in countries where its application to soils can alleviate the decline of soil fertility due to agricultural intensification while improving crop productivity, soil performance, and greenhouse gas balance. Recent field experiments in Vietnam indicated noticeable increases of rice yields likely associated with improved water hold capacity when biochar was applied along with chemical fertilizers. In order to investigate such relationship between water holding capacity enhanced by biochar application and corresponding rice yields, we utilized a process-based model for cropping systems - Decision Support System for Agrotechnology Transfer (DSSAT) model coupled with an automatic calibration algorithm ? Shuffled Complex Evolution method. We first calibrated the model's parameters related to soil initial conditions and rice cultivars using yield records during the period of 2010 to 2013 under farming practices with or without NPK fertilization. Then we calibrated and validated the model's coefficient controlling water holding capacity of residue added to soils using yield records under biochar application. This type of work will permit DSSAT model to predict rice yield response to various biochar application rates in Vietnam that can further link to policy and econometric models.

Keywords：*Biochar, process-based model, rice yield, and water holding capacity*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Criteria for Asssessment of Acid Sulfate Soil Environments for Rice Cultivation in the Mekong Delta, Vietnam

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The aim of the studies to: (i) Identify the major environment factors (soil, hydrology, climate and biology) which affects to growth and yield of rice on acid sulphate soils (ii) Recommend some criteria for classification of land capability. The study conducted in Go Quao, Tri Ton; Tam Nong. The results show that the limit environmental factors for rice yields on acid sulfate soil based on field surveys and soil analysis including 19 factors. In which soil fertility has 8 factors including of: acidity (A), soil salinity (E), the occurrence depth of sulfuric horizon (G), the occurrence depth of sulfidic material (F), low of total nitrogen (N), low of phosphorus (P), low of mineral (K), low of organic matter (O), structure (C); Hydrology factor consists of: less active irrigating (k), less active drainage (d), depth of inundation (n), waterlogged (g), acid sulfate water (p) and saline water (w). Climate factors consists of: drought duration (h), rainfall duration (m), temperature (t). Biological factors consists of: rice varieties (i) and occurence of pest (z). Besides, the study has developed the criteria applying for rice field classification as the basis for land resourses management and rice yield improvement.

Keywords：*Resources, classification, soil environment, acid sulphate soil*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Integrated Nutrient Management and Crop Rotation for Sustainable Crop Production and Soil Fertility Maintenance in Alfisol under Dryland Condition

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The Alfisol of Eastern Dry Zone (Zone 5) of Karnataka State in India is characterised by low organic matter, higher infiltration rate, low water holding capacity, poor to medium fertility and surface soil crusting leading to low seedling emergence. Addition of organic manure is essential for sustainable crop production and to maintain soil physical, chemical and biological properties in dryland condition.

A field experiment was conducted from 1992 to 2011 in permanent plot during Kharif season at the All India Coordinated Research Project for Dryland Agriculture, GKVK, Bangalore under rainfed situation on deep, yellowish red, sandy loam soils to study the long term effect of organic manure with fertilizers and crop rotation with finger millet-groundnut cropping system on soil fertility and sustainable yield of finger millet.

The initial soil pH was 5.0, EC - 0.2 dSm-1, organic carbon - 0.40 per cent, available nitrogen- 159 kg ha-1, available phosphorus - 24 kg ha-1 and available potash - 160 kg ha-1. The nutrient status of farm yard manure (FYM) used for the experiment is 0.54, 0.35 and 0.63 % N, P and K, respectively. The experiment was laid out in a randomized block design with five treatments (T1- Control; T2- FYM @ 10 t/ha; T3- FYM @ 10 t/ha + 50% NPK; T4- FYM @ 10 t/ha + 100% NPK; T5- 100% NPK (50: 50: 25 kg/ha) and replicated twice with a gross plot size of 13.0 × 3.3 m2 and net plot size of 12.8 m × 2.4 m.

Farm yard manure @ 10 t/ha was incorporated into soil 15 days before sowing. Fifty per cent of N and entire dose of P2O5 and K2O was applied at the time of sowing in the form of urea, di-ammonium phosphate and muriate of potash, respectively based on the treatment combinations. The remaining 50 % N was top dressed at 30 days after sowing in the form of urea. The finger millet cv. 'GPU-28' was sown with a spacing of 30×10 cm. All agronomic practices were carried out as per the schedule.

The results of the study from 1993 to 2011, from ten crop cycles indicated that mean grain yield of finger millet when rotated with groundnut every alternate year was higher (3,884 kg/ha) with farm yard manure @ 10t/ha + recommended NPK (50:50:25 kg/ha) when compared to application of only NPK (2,517 kg/ha). Similarly, under mono-cropping system, mean grain yield of finger millet was higher (3,205 kg/ha) with FYM @ 10t/ha + recommended NPK when compared to recommended NPK only (1,817 kg/ha). The finger millet grain yield has increased by 17.48 per cent with farm yard manure @ 10t/ha + recommended NPK under crop rotation with groundnut as compared to mono-cropping. The INM treatment with crop rotation (10 crop cycles) recorded higher Sustainability Yield Index (SYI) (0.68) when compared to mono-cropping (0.63). Application of only NPK has shown SYI of 0.33 under rotation and 0.20 under mono-cropping which is considered as not sustainable. Highest B: C ratio of 2.55 was obtained with the application of farm yard manure @ 10t/ha + recommended NPK under crop rotation as against 2.25 due to the application of recommended NPK alone. In monocropping of finger millet, higher B: C ratio of 2.26 was obtained with the application of farm yard manure @ 10t/ha + recommended NPK as against 1.92 with the application of recommended NPK alone. The soil pH was found to decrease significantly in control and NPK alone as compared to either FYM alone or INM treatments. The EC increased significantly higher in FYM or INM plots as compared to control and NPK alone. The available NPK (207.20, 147.97 and 136.50 kg/ha, respectively) in farm yard manure @ 10t/ha + recommended NPK were higher when compared to recommended NPK (128.80, 90.57 and 87.84 kg/ha, respectively). Build up of organic carbon was observed from initial 0.40 to 0.56 per cent in INM treatments. The availability of secondary nutrients (Ca, Mg and S) was observed to be higher with FYM application or INM treatments.

Thus, supply of both organics and fertilizers along with crop rotation is a sustainable practice in finger millet crop production in an Alfisol of Eastern Dry Zone of Karnataka under rainfed conditions.

Keywords：*Integrated Nutrient Management, LTFE, Fingermillet, Organics*

P4-320

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Dry Matter Partitioning, Nitrogen Uptake and Use Efficiency by Cucumber (cucumis Sativa L) on a Sandy-Loam Alfisol Amended with Organic-Based Fertilizers

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Application of Organic Fertilizer (OF), with or without Mineral Fertilizers (MF), is a good soil nitrogen (N) management practice, which improves dry matter accumulation and crop quality. However, increased costs and environmental concerns often compel growers to re-evaluate application rates so as to optimize the utilization of applied fertilizer, maximize crop yield and minimize N-losses. Screen house and field trials were conducted in 2012 at the University of Ibadan in Nigeria, to determine the optimum N-fertilizer rate and evaluate the effects of N-fertilizer sources on Dry Matter Yield (DMY), Nitrogen Uptake (NU) and Nitrogen Use Efficiency (NUE = DMY/native+applied N) by cucumber (Cucumis sativa L.). Urea was applied at 0, 30, 60, 90 and 120 kg N ha-1 to cucumber (variety 'Marketmore') grown in 4kg soil and replicated three times in a Completely Randomized Design (CRD). Effects of five N-treatments (Control, NPK-15:15:15 as MF, OF and OF+MF in two ratios, 1:1 and 2:1) on DMY and NU of cucumber (variety 'Ashley' and 'Marketmore') were evaluated using split-plot arrangement in CRD (screen house) and RCBD (field). Data collected on vegetative traits (stem girth, number of leaves, leaf area and vine length) as well as yield (dry whole biomass) of cucumber plants were subjected to ANOVA and means separated by DMRT ($p \leq 0.05$). Using polynomial ($y = a + b1X + b2X2$) regression analysis, optimum N-rate was estimated to be 60 kg N ha-1 that resulted in maximum DMY (11.64 g/pot; 79% over Control), NU (323 mg/pot) and NUE (3.1g/g) by cucumber plants. Further application at 90 and 120 kg N ha-1 led to 18 and 28% reduction in DMY. There was initial increase in NUE with increase in N-rate; 60 kg Nha-1 increasing it by 72% over Control but 90 and 120 kg N ha-1 reduced it by 14% and 24%, respectively. 'Marketmore'-treated with OF had the highest stem girth and number of leaves but OF+MF [2:1] resulted in the highest leaf area and vine length compared to plants treated with the other N-fertilizer sources. NUE was highest with the application of OF+MF [1:1] for Ashley (2.9g/g) and marketmore (3.2g/g). Marketmore supplied with OF+MF [2:1] enhanced higher dry matter fruit production compared to the Ashley variety, while the order of the magnitude of dry matter partitioning was: fruit > leaves > stem > root across the various N-fertilizer sources. For maximum DM accumulation into fruits, application of OF+MF [2:1] should be preferred. Use of OF+MF [2:1] at 60 kg N ha-1 also guarantees maximum dry matter accumulation in cucumber production on the sandy-loam alfisol.

Keywords：*Alfisol, Organic Fertilizer, Cucumber, Dry Matter Partitioning, Nutrient Use Efficiency*

P4-321

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Coupling Soil Properties, Weather, Management and Nitrogen Transformations to Optimize In-Season Nitrogen Application Rates for Maize Production

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Optimizing fertilizer nitrogen (N) application rates for maize has been, and continues to be, one of the most researched topics in the USA. Nitrogen fertilizer applications are critical for optimum yield and profitability. Too little N results in suboptimal yield while excessive N fertilizer applications result in significant N losses and negative environmental consequences. The year to year variability in optimum fertilizer N rate for maize grown on the same field clearly indicates that weather drives soil and fertilizer N transformations and crop N availability. To better predict in-season optimum N rates in the field, we developed a weather-driven N model that couples soil moisture, soil surface and subsurface N mineralization algorithms and soil and fertilizer N transformation and loss processes to predict crop N uptake. Currently, processes considered in the model include soil N mineralization, ammonia volatilization, nitrification, denitrification and nitrate leaching; and the model is driven by air temperature, soil moisture and pH, and a crop growth model. Readily available data including soil texture, pH and organic matter, daily air temperature and precipitation/irrigation, fertilizer N source, placement and timing, and crop planting/emergence date are used as model inputs. Through simple regression analyses from 16 existing N response studies we found that yearly plant N uptake simulated with this model was highly correlated to yield data under field conditions ($R2 > 0.95$ for any site year, $R2 > 0.80$ for combined site years). Thus, we believe that this model has the potential to improve the prediction of optimum in-season fertilizer N rates compared to traditional fertilizer N recommendation strategies. We are currently evaluating the model's performance on approximately 25 more site years of experimental data, and we are also modifying net precipitation by incorporating terrain attributes with digital soil map data to account for within-field yield variability measured in farmer fields with combine yield monitors. We will discuss these results and how the model can be used in a predictive mode by farmers and the agricultural professionals that work with them.

Keywords：*Nitrogen, Management, Nitrogen Rate, Yield, Model,*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Nutrient Uptake and Use of Image Analysis to Detect Nutrient Deficiencies in Maize Subjected to the Omission of NPK and Mn

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Maize is a nutrient demanding crop. Thus, in order to attain the productive potential, the nutritional requirements should be fully met. The use of image analysis in agriculture has been common in the recent years. It is a technology capable of providing information extracted from leaves, which can contribute to the nutrition management aiming at high yields. The aim of this study was to evaluate the effect of omitting Mn and NPK on uptake nutrients and yield of maize, adding the study of image analysis to detect symptoms of nutrient deficiency. The work was conducted at the University of São Paulo in Pirassununga - São Paulo, in low fertility soil (pH in CaCl2 = 5.2, P = 5.0 resin and S = 3.0 mg dm-3 in; K = 0.6, Ca = 10, Mg = 9.0, Al = 1, H + Al = 18, Sum of bases = 20 and CTC = 38 in mmolc dm-3, organic matter = 23 g kg-1; base saturation (V%) = 52%. The experimental design was randomized block design with 5 treatments and 5 replicates, totaling 25 experimental plots. The treatments were composed by the individual omission of nitrogen (N), phosphorus (P), potassium (K) and manganese (Mn), plus the control treatment with all nutrients. The area of each plot was 76.8 m2. Liming was made to elevate the V% to 70, with a period of notice of 50 days before planting, and the doses of NPK were respectively 170, 100 and 160 kg ha-1 and 1 L ha-1 Mn applied via leaf. The maize leaves sampling for image analysis and analytical determinations of nutrients were performed at R1. To obtain the images, the middle third of leaves were scanned at 1200 DPI and processed in the Matlab software. In this step were extracted blocks of 80x80 pixels, separating 100 blocks of images per treatment. From the images were extracted features of texture and color, using the fractal technique of Gabor Wavelets in color images. The statistical classification was carried out using the support of vector machines, where were obtained the global error probability (PAG) and the correctness confidence (Kappa). At the end of the crop cycle was assessed the production (kg ha-1). The results obtained for nutrients content in leaves and yield were statistically analyzed and means were compared by the Tukey test at 5 % probability. The omission of N compromised significantly the development of maize plants having low foliar N content on the plant (27 g kg-1) compared to treatment with all nutrients (36 g kg-1), resulting in visual symptoms characteristic of N deficiency, such as low-growing plants, tip chlorosis of older leaves, progressing to tissue necrosis and early senescence. The lack of N, compared to the control, also caused significant reduction ($p < 0.01$) in P contents from 2.9 to 2.3 g kg-1. The omission of K, therefore caused a significant reduction in the K content (18 g kg-1) compared with the control (21 g kg-1), increased the calcium and magnesium contents. P omission significantly increased the levels of Zn 40-48 mg kg-1. And the treatment which had manganese omission did not differ significantly from the other treatments. Nitrogen and potassium were the most limiting nutrients in maize yields, causing significant reduction of approximately 50 (3770 kg ha-1) and 35% (4900 kg ha-1), respectively in grain production compared to control (7480 kg ha-1). For the study of image analysis, the results revealed overall error probability of 72% and the reliable Kappa index (0.69) in which 95% of the images had N deficiency, i.e. correctly classified by the system, followed by treatments with omission of Mn (87% accuracy), P (82% accuracy), K (81% accuracy) and control (77% accuracy). The treatments affected the maize nutrition for N, P and K, with lower productivity for N and K. The study of image analysis for nutritional diagnosis showed promising for identifying deficiencies, with better results for N, followed by Mn, P and K.

Keywords：*Zea mays, plant nutrition, processing image, nutrient omission*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Fixed Nitrogen by Green Manure Plants and their Effects on Melon Productivity in Northeast Brazil

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Incorporation of green manure is a common practice to add organic matter and nitrogen and to protect the soil, which may, in the mid run, increase yields of the main crops. The objective of this work was to estimate biomass and nitrogen incorporation by green manure plants and their effects on the melon productivity, as a subsequent crop in a semiarid region in Northeast Brazil.

Three green manure systems (two mixtures of planted species and a third system in which spontaneous plants were left to grow) and two incorporation systems (biomass left on the soil surface and revolved into the top soil layer) were tested, before cultivating yellow melon. The green manure species belonged to two plant categories: 1) the legume species Canavalia ensiformis, Vigna unguiculata, and Crotalaria spectabilis; and 2) the grass species Zea mays, Pennisetum glaucum and Sorghum bicolor, plus sunflower (Helianthus annuus). The species were arranged in two seed mixture groups: group 1 had 75% of the total seed weight composed of legume seeds and 25% of grasses + sunflower; group 2 had 25% of the total seed weight composed of legume seeds and 75% of grasses + sunflower.

The two green manure mixtures accumulated 2.5 to 3 times more biomass (8.6 and 10.3 x 3.3 Mg ha-1) and nitrogen (176 and 185 x 58 kg ha-1) than the spontaneous plants. The contributions of each species varied and did not reflect their proportion in the seed mixtures.

As expected, all legume species fixed atmospheric N, corresponding to 38 to 56% of their total N content. Since they were not inoculated, they established efficient symbiosis with native rhizobia, as has been reported in other areas of the same region. V. unguiculata had the highest fixed N proporion (50.6%) among the legume species but its contribution to the fixed amount was low due to its low biomass production. The highest contribution came from C. spectabilis, 27 kg ha-1.

The grass species also had low 15N concentrations, indicating atmospheric fixation, especially that of S. bicolor with a δ15N of 0.34 ‰ and 92% of its N derived from symbiotic fixation. Recent research using isotopic techniques has demonstrated fixation in grass species, but no information was found related to sorghum. The isotopic signals of the legume species higher than those of the grasses indicate that the fixed N of the grasses did not come from transference from the legumes. The spontaneous plants, mostly native grasses, and the sunflower plants had high δ15N signals, indicating no fixation.

The melon plants produced 1.7 Mg ha-1 of dried leaves and stems and 21.230 fruits per hectare, corresponding to 36.7 Mg ha-1 of fruits. The green manure mixtures and the incorporation systems had no significant effects on the melon production or on the leaves and stem production.

The amounts of N in the melon fruits were 43 and 44 kg ha-1 in the two green manure mixtures, while the amounts of fixed N were 47 and 56 kg ha-1; therefore, considering that the melon leaves and stem are left in the field, the N balances were positive. The spontaneous vegetation added no or very little N to the system and resulted in a negative N balance of 43 kg ha-1.

Keywords : N-15, natural abundance, Cucumis melo, biological nitrogen fixation, cover crops, isotope

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Integrated Crop-Livestock Farming Systems

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Population growth, urbanization and income growth in developing countries are fuelling a substantial global increase in the demand for food of animal sources, while also aggravating the competition between crops and livestock (increasing cropping areas and reducing rangelands). This term summarizes a complex series of interrelated processes and outcomes in livestock consumption, production and economic growth. The revolution could provide income growth opportunities for many poor rural people involved in the livestock sector .The livestock revolution is stretching the capacity of existing production, but it is also exacerbating environmental problems. Therefore, while it is necessary to satisfy consumer demand, improve nutrition and direct income growth opportunities to those who need them most, it is also necessary to alleviate environmental stress. Conventional agriculture is known to cause soil and pasture degradation because it involves intensive tillage, in particular if practised in areas of marginal productivity. Technologies and management schemes that can enhance productivity need to be developed. At the same time, ways need to be found to preserve the natural resource base. Within this framework, an integrated crop-livestock farming system represents a key solution for enhancing livestock production and safeguarding the environment through prudent and efficient resource use. The increasing pressure on land and the growing demand for livestock products makes it more and more important to ensure the effective use of feed resources, including crop residues. An integrated farming system consists of a range of resource-saving practices that aim to achieve acceptable profits and high and sustained production levels, while minimizing the negative effects of intensive farming and preserving the environment.

Keywords：*Crop-livestock*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Reconsidering Integrated Crop-Livestock Systems in India

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Integrated crop–livestock systems have been employed globally for millennia. In the past century, farmers in india have tended toward increased specialization. There is renewed interest in reintegrating crops and livestock because of concerns about natural resource degradation, the profitability of farm income, long-term sustainability and increasing regulation of concentrated animal feeding operations. Integrated crop–livestock systems could foster diverse cropping systems, including the use of legume forages. Integrated systems inherently would utilize animal manure, which enhances soil fertility. Integration of crops and livestock could occur within a farm or among farms. Both scales of integration rely on farmers' knowledge, motivation and resources. Despite the numerous benefits that could accrue if farms moved toward on-farm or among-farm integration of crops and livestock, The complexity of such systems could constrain adoption. However, farmers should expect that adoption of integrated crop livestock systems would enhance both profitability and environmental sustainability of their farms and communities. The combination of system complexity and potential for public benefit justify the establishment of a new national or international research initiative to overcome constraints toward greater profitability and sustainability.

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

A Potential Method for Synchronous Improvement of Soil Fertility, Biological Function and Productivity in Red Soil Region of Subtropical China

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There is about 218×10^4 km^2 of red soil region in subtropical China. It occupied about 28% of total cultivated area in China. Besides acidic and clayish, soil quality are relatively lower in this region. It is an urgent problem to increase the organic retention and improve the biological function in red soil. Meanwhile crop straw is commonly discarded or burned in this region—an obvious resource waste and a severe environmental problem. Therefore the aim of present study was to (1) promote the quality of straw compost by chemical additives, (2) analyze changes of soil fertility and biological function in red soil after applying the compost and (3) investigate the effect of chemical additive-promoted straw compost on crop growth and yield.

Effect of chemical additives on quality of peanut and rice straw composts was studied by decomposition experiment. Ten treatments, such as no additive control (CK), 5% alkali slag (A5), 10% alkali slag (A10), 15% alkali slag (A15), 1% $FeSO_4$ (F1), 3% $FeSO_4$ (F3), 5% $FeSO_4$ (F5), 5% alkali slag combined 3% $FeSO_4$ (A5F3), 10% alkali slag combined 3% $FeSO_4$ (A10F3), 15% alkali slag combined 3% $FeSO_4$ (A15F3), were conducted for each type of straw. The results of peanut straw experiment indicated the available nutrients in A5 were higher than in other treatments. Higher humic substances (HS) was measured in A5 and F1. The highest value of humic acid (HA, 37.22 g kg^{-1}), ratio of humic to fulvic acid (HA/FA, 0.62) and lowest ratio of HA absorption value at 465 nm to that at 665 nm (E4/E6, 5.35) were detected in F5. However germination indexes (GI) in F1 and F5 were below 80%. The results of rice straw experiment showed the nutrient contents in A15 were higher. The HS and HA were more than 80 g kg^{-1} and 48 g kg^{-1} in A5 and A15 respectively. But GI in A5, F3 and A5F3 exceeded 80%. By overall consideration 5% alkali slag, 3% $FeSO_4$ and 5% alkali slag combined 3% $FeSO_4$ were selected for subsequent experiments.

Incubation experiment was performed to clarify the effect of compost on soil chemical and biological properties. Five treatments, such as soil mixed without fertilizer (CK), with no chemical additive-promoted straw compost (NC), with 5% alkali slag-promoted straw compost (AC), with 3% $FeSO_4$-promoted straw compost (FC), with 5% alkali slag combined 3% $FeSO_4$-promoted straw compost (AFC), were set up. Peanut straw compost incubation experiment indicated soil available nutrients in AC were higher at 90 day. The urease, invertase activities and microbial biomass in AC were 30%, 13% and 85% higher than in NC. BIOLOG analysis showed that microbial C utilization ability and McIntosh evenness were highest in AFC at 90 day. But Shannon-Weaver index was highest in AC and 0.4%-11.6% higher than in other treatments at 30 day. Principal component analysis indicated that microbial community structures were also influenced by different compost. Results of rice straw compost application indicated that soil nutrients were increased by FC significantly. Soil enzymatic activities, microbial biomass and microbial functional diversity were increased by AC.

Peanut pot experiment was carried out with following treatments-no fertilizer control (CK), NPK fertilizer (NPK), NPK with NC (NPK+NC), NPK with AC (NPK+AC), NPK with FC (NPK+FC), NPK with AFC (NPK+AFC). The results of peanut straw compost showed enzymatic activities in NPK+AC were higher than in NPK. Soil microbial biomass carbon and nitrogen were also highest in NPK+AC. The plant biomass of peanut in NPK+AC was 26.0% higher than in NPK. Pot experiment with rice straw compost also showed NPK+AC could enhance soil urease activity and microbial biomass. Therefore 5% alkali slag-promoted straw compost was employed for filed trial.

Influence of compost on soil properties and peanut yield were studied by field experiment. Four treatments, such as no fertilizer control (CK), NPK fertilizer (NPK), NPK with 5% alkali slag-promoted peanut straw compost (NPK+PC) and NPK with 5% alkali slag-promoted rice straw compost (NPK+RC), were established. Compost amendments increased soil available nutrients effectively. Enzymatic activities in NPK+RC were higher than in NPK. Soil microbial biomass and functional diversity were also improved by compost application. The peanut yield was increased by 2.55% through increasing the Berry weight in NPK+PC.

Keywords：*chemical additives, compost, soil fertility, soil productivity, red soil region of subtropical China*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Legume Residue Incorporation and N Uptake by Crop: A Synchronization Study between Nitrogen Release and Rice Demand in Bangladesh Soil

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An in-situ field study was conducted with three different types of legume residues: lentil, mungbeam and soybean, to determine the effectiveness of legume nitrogen (N) release and rice crop demand under Tista Meander Floodplain soils of Bangladesh during 2011-12. The release of N from incorporated legume residue was measured throughout the growing season of succeeding rice growing season using Nylon mesh bag techniques. The N uptake by rice was also measured to determine if legume N could meet the uptake demand. Among the different residues, soybean residue decomposed rapidly, releasing about half of their N within 4 week after burial while the minimum portion of N was released (33.7%) from mungbean residue. Over 14 weeks of incubation, the highest amount of net N released was noticed at 8 weeks of incubation and soybean showed the maximum results (35.7 kg N ha-1) and it decreased as 26.7 kg N ha-1 at 14 weeks. The rate of net N release showed a similar trend with the release of available N and among the tested legume residues, the maximum rate of net N release was observed at 6 weeks of incubation from soybean residue at 2.4 kg N ha-1day-1. Considering the total N uptake by rice, the maximum uptake of 56.8 kg N ha-1 was found in soybean residue treated plot which showed 34.3% higher over control (no residue added). From the study it was revealed that by the addition of legume residue in rice field before transplanting, it indicates a good synchrony between the pattern of N released in soil and N uptake by rice. Through decomposition of different legume residues, especially soybean residue released a considerable amount of N in soil for rice production. Hence, soybean residue can be an effective N source for succeeding rice in Tista meander Floodplain soils of Bangladesh.

Keywords：*Legume residue, N release, N uptake, rice*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Mineralization of Bioslurry and its Integrated Use with Fertilizers in the Rice Based Cropping Systems

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Bioslurry is an anaerobic decomposition product that comes out of the biogas digester after extraction of biogas, chiefly CH4. The present study aimed at examining the mineralization pattern of C, N, P and S from bioslurry and evaluating the integrated use of bioslurry with fertilizers in the rice-based cropping systems. Mineralization study involved incubation of cowdung, cowdung slurry, poultry manure, poultry manure slurry and city compost mixed with soil in pots at 25°C ± 2°C temperature under aerobic (field capacity) and anaerobic (continuous submergence) conditions for 16 weeks. The pots received an application of manure @ 1.5, 2.5, 5.0 and 10.0 g kg-1 soil. Aerobic incubation showed greater mineralization of C, N and S compared to anaerobic incubation. In contrary, anaerobic condition mineralized P greater than aerobic condition. Carbon mineralization reached its peak after 2 weeks of aerobic incubation while the peak under anaerobic condition reached after 4 weeks. The magnitude of nutrient release decreased exponentially with the increasing rates of manure incorporation to soil. Mineralization of C and N fitted very strongly to the first order kinetic model, whereas P and S fitted to the model moderately to strongly. Compared to the original manure, bioslurry showed higher potential mineralization but lower rate constant for N, P and S. The field experiment involved two chemical fertilizer treatments (without manures), five treatments based on integrated plant nutrition system (IPNS) with 5 t ha–1 cowdung, cowdung slurry and city compost and 3 t ha–1 poultry manure and poultry manure slurry, and a control (no fertilizer). The treatments were tested in rice (Boro) – rice (T. Aman), wheat-rice (T. Aman) and potato-rice (T. Aman) cropping systems for two consecutive years. The Boro/rabi crops received manure or slurry application, as per treatments, and their residual effect was evaluated on the succeeding T. Aman crop. Contribution of slurry compared to original manure appeared greater in case of IPNS, particularly, for P application. Cowdung slurry supplied at least 40, 52 and 48% of the total P dose for Boro, wheat and potato, respectively. The contribution of poultry manure slurry as a source of P was 50% for Boro rice and 100% for wheat and potato, respectively. Application of cowdung, poultry manure and their slurry and city waste increased grain yields in rice and wheat and tuber yield in potato. Residual effect of the manures was also recognized in the succeeding T. Aman crop. Among the tested manures, poultry manure produced greater yield than cowdung and city waste. Bioslurry and original manure gave no significant difference in rice, wheat or potato yields. The application of IPNS considerably increased the OM, N, P and S contents of soil after 2-crop cycles. This study demonstrated that both the bioslurry and the original manure, for a given source, had no difference in nutrient values in terms of crop yields and soil nutrient amendment. However, in IPNS, cowdung or poultry manure slurry contributed greater amount of nutrients. In conclusion, cowdung slurry (5 t ha–1) may be recommended as a substitute of 18 – 32% N, 40 - 100% P and 13 - 34% K and poultry manure slurry (3 t ha–1) may be recommended as a substitute of 15 – 21% N, 50 – 100% P and 8 - 18% K for the chemical fertilizers in the rice-based cropping systems. Thus, large scale use of bioslurry would save huge amount of N, P and K fertilizers.

Keywords：*Bioslurry, mineralization, IPNS, cropping systems*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Soil Phosphorus and Phosphorus Sources on Phosphorus Nutrition and Yield of Wetland Rice

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Field experiments were conducted in dry and wet season rice (Oryza sativa L.) in six different soil P levels, i.e. 2.5, 2.8, 3.5, 3.8, 4.2 and 8.3 mg kg-1 which were adjusted with three P sources i.e. cowdung (CD), poultry manure (PM) and triple super phosphate (TSP) for obtaining higher grain yield and P nutrition of wetland rice. Increased soil P levels have enhanced the maturity of rice around 7 to 15 days and increased the yield of rice in both dry and wet seasons and decreased the need of P from outside sources. The P concentration and P uptake in plant tissue showed significant interaction. The agronomic efficiency; nutrient use efficiency and physiological efficiency were also influenced significantly in different soil P levels and P sources. Poultry manure and cowdung are proved good sources of phosphorus for supplement TSP fertilizer in wetland rice culture.

Keywords：*Soil P, P source, P nutrition, Rice yield*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil Test Based Fertilizer Prescription Through IPNS for Rainfed Maize on an Inceptisol

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The global rainfed croplands were estimated at 1.132 billion hectares (Birdar et al., 2009) where rainfed areas in India contribute 84 - 87 per cent of coarse cereals (Srinivasa Rao, 2011). Maize (Zea mays L.), the "Queen of Cereals" and one of the most versatile crops that grown over diverse environmental conditions. In India, maize is cultivated in 8.11 million hectares with a production of 19.77 million tonnes with an average yield of 2.4 t ha-1 (DMR, 2008). Integrated nutrient application of organic manures and fertilizers always found effective in increasing yield of crops and maintaining soil fertility. Among the various methods of formulating fertilizer recommendations, yield targeting (Truog, 1960 and Ramamoorthy et al., 1967) is unique which not only indicates soil test based fertilizer dose but also the level of yield the farmer can hope to achieve, if good cultivation package is followed in raising the crop (Velayutham, 1979). Hence, the existing fertilizer prescription equations for irrigated hybrid maize (Coumaravel, 2012) has been refined for rainfed conditions.

A field experiment was conducted with TNAU maize Hybrid CO6 at Maize Research Station, Vagarai, Dindigul District under rainfed conditions to develop fertiliser prescription equations (FPEs) for rainfed maize. The experimental soil was red sandy loam (Typic Ustropept), non-calcareous with a pH of 6.97 and EC of 0.39 dS m-1 and available N, P and K were 176.0, 12.3 and 276 kg ha-1 respectively. The design of experiment was RBD with three replications and nine treatments viz., STCR-NPK alone-4, 5 and 6 t ha-1, STCR-IPNS-4,5 and 6 t ha-1, Farm Yard Manure (FYM) @ 6.25 and 12.5 t ha-1 alone and absolute control. Pre-sowing soil samples were collected plotwise (27 plots) and analysed for available N, P and K. For STCR treatments, based on the pre-sowing soil test values of each plot, fertilizer N, P2O5 and K2O doses were computed using the already available FPEs for irrigated maize. For STCR-IPNS treatments, the recommended dose of FYM @ 12.5 t ha-1 was applied and fertilizer N, P2O5 and K2O doses were adjusted accordingly. At harvest plot wise grain and straw yields were recorded; grain and straw samples were collected, processed and analysed for their N, P and K contents. The grain yield of rainfed maize ranged from 2316 to 5590 kg ha-1 with a mean value of 4136 kg ha-1. Over all, N, P and K uptake varied from 36 to 103.6, 4.8 to 18.2, 33.8 to 48.2 kg ha-1 with a mean of 67.7, 12.5 and 43.7 kg ha-1, respectively. The results emanated from the present investigation revealed that rainfed maize requires 16.2 kg N, 6.9 kg P2O5 and 13.1 kg K2O for producing one ton of grain yield. The per cent contribution of N, P2O5 and K2O from soil was 20.93, 39.52 and 13.26 and from fertiliser was 50.20, 45.61 and 76.04 per cent respectively. The per cent contribution of nutrients from FYM was 26.24, 18.78 and 30.12 per cent N, P2O5 and K2O respectively. Using the pre-sowing soil available N, P and K, fertilizer doses applied, grain yield and total N,P and K uptake, the basic parameters viz., Nutrient requirement (NR), contribution of nutrients from soil (Cs), contribution of nutrients from fertiliser (Cf) and contribution of nutrients from organic manure (Co) were computed and FPEs for rainfed maize were developed. The fertilizer prescription equations developed under IPNS are FN = 0.323 T - 0.42 SN - 0.52 ON ; FP2O5 = 0.151 T - 1.98 SP - 0.94 OP ; FK2O = 0.173 T - 0.21 SK - 0.48 OK ; Where, FN, FP2O5 and FK2O are fertilizer N, P2O5 and K2O in kg ha-1 respectively; T is the yield target in t ha-1 ; SN, SP and SK respectively are alkaline KMnO4-N, Olsen-P and NH4OAc-K in kg ha-1 and ON, OP and OK are the quantities of N, P and K supplied through FYM in kg ha-1.The results showed that with the application of FYM @ 12.5 t ha-1 (with 32 % moisture, 0.50 %, 0.21 % and 0.49 % NPK respectively), there was a saving of 22, 17 and 20 kg of fertilizer N, P2O5 and K2O respectively.

Keywords：*STCR, IPNS, rainfed maize, inceptisol*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Response of Chickpea (cicer Ariteinum L.) to Identified Micronutrients Constraints under Vertisol in Karnataka, India

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A survey was undertaken in A village under Malaprabha command area of Karnataka, India with an objective of identifying micronutrients constraints by GIS technique and to study the response of chickpea (Cicer ariteinum L.) to identified micronutrients constraints.

Surface soil samples at 20" (second) grid interval were collected from the study area for the assessment of micronutrients constraints. The sampling location was recorded by using GPS. After processing, the samples were analyzed for pH, EC, CaCO3, OC, N, P, K, S, Zn, Fe, Cu, Mn and B. Soil fertility maps were prepared for each of the nutrients by GIS technique using Arc GIS 10.0 software. Major portion of the study area was deficient in N, P and S with higher level of available potassium. Mapping of nutrients by GIS techniques revealed that major portion of the study area was deficient in available N, P, S, Zn, Fe and B.

After identifying micronutrients constraints, a field experiment was conducted during the in the farmer's field. Various treatments imposed were recommended dose of fertilizer (RDF) for chickpea, application of deficient micronutrients at two levels (FesO4, ZnSO4 and borax; 10 and 25, 10 and 25, 2.5 and 5.0 kg ha-1, respectively) and their combination. Sulphur was applied through gypsum to know the response of crop to sulphur. Chickpea (variety ICCV-2) was the test crop. The soil of the experimental site was clay in texture alkaline and calcareous. Based on the observations made at harvest, following conclusions were drawn.

Application of FeSO4 @ 25 kg ha-1 + ZnSO4 @ 25 kg ha-1 + Borax @ 5 kg ha-1 along with RDF recorded the highest plant height, number of branches at all the growth stages followed by FeSO4 @ 10 kg ha-1 + ZnSO4 @ 10 kg ha-1 + Borax @ 2.5 kg ha-1 along with RDF. The lowest was recorded in the treatment receiving only RDF (25:50:00 kg N:P2O5:K2O ha-1).

The dry matter production was increased in all the treatments from early stage to harvest. Highest dry matter was recorded in the treatment which received FeSO4 @ 25 kg ha-1 + ZnSO4 @ 25 kg ha-1 + Borax @ 5 kg ha-1 along with RDF, which was on par with RDF + FeSO4 @ 10 kg ha-1 + ZnSO4 @ 10 kg ha-1 + Borax @ 2.5 kg ha-1.

The yield components viz., number of pods per plant and test weight were highest with the application of FeSO4 @ 25 kg ha-1 + ZnSO4 @ 25 kg ha-1 + Borax @ 5 kg ha-1 along with RDF followed by FeSO4 @ 10 kg ha-1 + ZnSO4 @ 10 kg ha-1 + Borax @ 2.5 kg ha-1 along with RDF .

The quality was increased in all the treatments. The Highest crude protein content was recorded in the treatment which received FeSO4 @ 25 kg ha-1 + ZnSO4 @ 25 kg ha-1 + Borax @ 5 kg ha-1 along with RDF, which was on par with RDF + FeSO4 @ 10 kg ha-1 + ZnSO4 @ 10 kg ha-1 + Borax @ 2.5 kg ha-1.

Application of FeSO4 @ 25 kg ha-1 + ZnSO4 @ 25 kg ha-1 + Borax @ 5 kg ha-1 along with RDF recorded significantly higher total uptake of N, P, K, S, Zn, Fe and B by chickpea at harvest, which was on far with RDF + FeSO4 @ 10 kg ha-1 + ZnSO4 @ 10 kg ha-1 + Borax @ 2.5 kg ha-1. The lowest uptake of nutrients was recorded in the RDF (25:50:00 kg N:P2O5:K2O ha-1).

The available S, Zn, Fe and B in post harvest soil were higher in the treatment RDF + FeSO4 @ 25 kg ha-1 + ZnSO4 @ 25 kg ha-1 + Borax @ 5 kg ha-1 followed by RDF + FeSO4 @ 10 kg ha1 + ZnSO4 @ 10 kg ha-1 + Borax @ 2.5 kg ha1 . The cost benefit analysis of chickpea cultivation showed that, the treatment FeSO4 @25 kg ha-1 + ZnSO4 @25 kg ha-1 + Borax @ 5 kg ha-1 recorded the highest benefit followed by FeSO4 @10 kg ha1 + ZnSO4 @10 kg ha-1 + Borax @ 2.5 kg ha1.

Keywords：*Micronutrients' constraints, GIS, Chickpea*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Rationalized Fertilizer Prescription for Rice Rice Sequence under System of Rice Intensification (sri)

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Rice is a global foodgrain and staple food for more than half of the world population. India needs to produce about 135 million tones of rice by the year 2025 which is about 25 per cent higher than the current production. System of Rice Intensification found to increase the productivity besides reducing the cost of cultivation and agricultural inputs and it is gaining momentum among the Tamil Nadu farmers. Use of fertilizers by the farmers without information on soil fertility status and nutrient requirement by the crop result in adverse effect on soil and crop either by nutrient toxicity or deficiency (Ray et al., 2000). This can be eliminated by adopting the Inductive cum targeted yield methodology developed by Ramamoorthy et al (1967) which provides a scientific basis for balanced fertilization not only between fertilizer nutrients but also with the soil available nutrients and nutrients absorbed by the plant. Following this model, soil test based fertilizer prescriptions for various crops have been developed and documented (Santhi et al., 2010). Keeping the above points in view, an investigation has been carried out in the wetlands farm of TNAU with rice on Noyyal series (Typic Haplustalf). during 2010-11 to establish significant relationship between soil test values and crop response for developing Fertilizer Prescription Equations for desired yield target of rice under SRI.

Gradient experiment was conducted with rice variety ADT 43 in order to create fertility gradient in one and the same field. The soil was low in KMnO4 - N (245 kg ha-1), medium in Olsen-P (20 kg ha-1) and high in NH4OAc-K (558 kg ha-1). The field was divided into three strips and graded dose of fertilizers were applied viz., N0P0K0 (strip I), N1P1K1 (strip II) and N2P2K2 (strip III) and was grown. N1 (150 kg ha-1) is the nitrogen dose equivalent to blanket recommendation for rice and P1 (229 kg ha-1) and K1 (121 kg ha-1) were the P and K fixing capacities of the soil. The results of pre-sowing and post-harvest soil analysis of gradient experiment elucidated the significant variations in the status of available nutrients in all the strips as compared to initial level. The progressive increase in grain yield from 3850 kg ha-1 in strip I to 6900 kg ha-1 in strip III and NPK uptake also confirmed the variations of fertility gradients among the strips.

After confirming the creation of soil fertility gradients , test crop experiment was conducted with CO (R) 49 during rabi season in Fractional Factorial Randomized block design. .Each strip was divided in to 24 sub plots and pre-sowing soil samples (72 nos) were collected. Twenty four treatment combinations were super imposed consisting of four levels of N, four levels of P2O5 and four levels of K2O. Across the strips, NPK alone, FYM @ 6.25 t ha-1 and 12.5 t ha-1 were imposed to study the effect of IPNS components. In NPK treated plots, maximum grain yield of 7440 kg ha-1 was recorded in strip III with N3P3K3 treatment (225: 75:75 kg ha-1) along with the application of .FYM @ 12.5 t ha-1 whereas minimum yield of 3750 kg ha-1 was recorded in strip I, with N1P1K1 treatment (75:25:25 kg ha-1). Using the data on grain yield, uptake of NPK, initial soil test values and the doses of N, P2O5 and K2O applied the basic parameters were calculated viz., Nutrient Requirement in kg per ton of rice (NR), per cent contribution from soil available nutrients (Cs), fertilizer nutrients (Cf) and FYM (Cfym). Making use of basic parameters, Fertilizer prescription equations under Integrated Plant Nutrition System were developed. FN = 0.420 T- 0.45 SN - 0.68 ON; FP2O5 = 0.205 T - 2.65 SP - 0.66 OP FK2O = 0.285 T- 0.29 SK - 0.59 OK where, FN, FP2O5 and FK2O respectively are fertilizer N, P2O5 and K2O in kg ha-1 ; T is the yield target in t ha-1 and SN, SP and SK respectively are alkaline KMnO4-N, Olsen-P and NH4OAc-K in kg ha-1. Using the above FPEs the fertilizer N, P2O5 and K2O doses were calculated for desired yield target which will pave the way for getting higher yield and response ratio along with sustenance of soil fertility.

Keywords：*SRI, STCR IPNS, Fertiliser Prescription Equation*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluating the Productivity of Selected Soils in Nsukka, Southeastern Nigeria, Using Riquier's Index Model

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Quantitative evaluation of soil productivity is growing in importance because of its relevance in developing new and integrated management strategies for improving the capacity of existing agricultural lands to produce more food for a rapidly growing global population without polluting the environment. The objective of this study was to evaluate the actual productivity (productivity) and potential productivity (potentiality) of two soils in Nsukka, derived savanna agro-ecological zone of Nigeria, using Riquier's index method. This research was carried out in 2012 at the University of Nigeria, Nsukka Teaching and Research Farm (UNN) (06051' N; 07025' E; 447 m above sea level) and at Ekwegbe (06042' N; 07025' E; 520 m above sea level), both in Nsukka agricultural zone. The soil/site parameters used in computing the Riquier's model (RI) were moisture duration, drainage, effective soil depth, texture, pH (H2O), organic matter, cation exchange capacity (CEC) of clay, and mineral reserve. Groundnut (Arachis hypogaea) was used as a test crop. Application of 10 t ha-1 of poultry manure 2 weeks before planting and tillage were used as a soil management measure to obtain improved soil characteristics for the computation of potentiality index. Data were collected on plant height and leaf area index (LAI) at 6, 10, and 14 weeks after planting (WAP). Pod yield was measured at maturity and reported on dry mass basis. The ratio of the potentiality index to the productivity index, known as coefficient of improvement, was used to assess the extent to which productivity can be improved following the introduced management practices. The results from this study showed that at UNN, RI had significant ($p < 0.05$) positive correlations with plant height at 10 WAP ($r = 0.75$*), LAI at 14 WAP ($r = 0.76$*) and pod yield ($r = 0.72$*). At UNN, the RI accounted for 57%, 58%, and 52% of the variations in plant height at 10 WAP, in LAI at 14 WAP and in pod yield, thus validating the effectiveness of the index model at the location. In contrast, the RI was less useful at Ekwegbe as it showed non-significant relationships with all the measured crop parameters. The soils at UNN and Ekwegbe had productivity index ratings of 15% and 8%, respectively, indicating that they belonged to the productivity class IV (poor productivity). The RI was higher at UNN (where the soil is sandy clay loam) than at Ekwegbe (where the soil is sandy loam). Similarly, plant height and LAI were higher at UNN (13.24 cm and 23.70 × 10-4, respectively) than at Ekwegbe (10.30 cm and 15.30 × 10-4, respectively). The soil at UNN also had higher pH (5.2 versus 4.5) and organic matter (2.01% versus 1.87%). Following the application of poultry manure and tillage, the soils recorded potentiality index ratings of 22% and 13%, respectively, raising the potentiality class of the UNN sandy clay loam to III (average potentiality), while the Ekwegbe sandy loam soil still belonged to class IV (poor potentiality). The computed coefficients of improvement (Ci) were respectively 1.5 and 1.6 for the soils at UNN and Ekwegbe. The findings indicate that although the current productivity levels of the soils are poor, there is room for improvement, given appropriate management practices, especially at the UNN site.

Keywords: soil productivity, Riquier's index, southeastern Nigeria, soil/site properties

Keywords：*Soil productivity, Riquier's index, southeastern Nigeria, soil/site properties*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Future Agriculture - Sustainable Intensification of Crop Production by New Management of Soils

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Global food demand is estimated to be increased by 60-70% between 2010 and 2050 (FAO 2012a). However, arable land is a limited global resource (FAO 2012b). Food production can be increased through intensification on existing land and/or expansion of arable land converting natural ecosystems to crop or livestock production. The drawbacks of land use change have been clearly identified - increasing emissions of greenhouse gases and loss of biodiversity (Green et al., 2005). Thus, sustainable intensification enhancing soil productivity remains as the most realistic solution for yield increase. Although the term 'intensification' often refers to more input of e.g. fertilizers to produce higher yields, we want to point towards other, new efforts.

Amelioration of subsoil conditions: Subsoil conditions are a major limiting factor in crop production in many parts of the world. Crop yields can theoretically be increased if a larger soil volume can be exploited by roots. Recently, deep incorporation of organic material into subsoil layers upon mechanical loosening were found to improve yields, which could be explained by an increase in plant available water and nutrients from the subsoil (Gill et al. 2008). We propose that incorporation of wastes not normally applied in agriculture such as paper mill wastes, biochars, hydrothermal carbonized straw, composted wood bark etc. can be promising measures for long-term improvement of subsoil conditions. Agricultural management technologies enabling long-term amelioration of subsoil needs to be developed.

Root adapted fertilizer placement: To make best use of fertilizers is essential as inefficient crop utilization leads to pollution. As soil moisture is often higher deeper in the soil profile, deeper placement of potassium and phosphorus, whose movement is mainly limited by diffusion, can increase yield, especially when soil moisture becomes limiting during crop growth. Concerning N-fertilizer, formation and losses of nitrous oxide through nitrification and denitrification can be higher when surface applied. However, only few studies testing these hypotheses have been performed and no tentative results can so far be found in the literature. Still, there is evidence that optimal fertilizer placement in relation to root morphology offers a great possibility to advance nutrient utilization.

Production of inorganic fertilizers from recycled wastes: Use of renewable phosphorus fertilizers is likely to be one of the great future challenges due to predicted global phosphorus scarcity (Cordell et al. 2011). Methods enabling recycling of P in wastes as fertilizer are developed, for example, ash from burned sewage sludge can be processed to completely water-soluble mono- or di-ammonium phosphate with a low metal content (Cohen et al. 2011). Fossil fuel is used for ammonia production but may be

substituted by renewable energy in the future. Biomass-based production of N-fertilizer has been investigated from a life-cycle perspective (Ahlgren et al. 2009) showing that 1 kg of N-fertilizer can be produced from 2.6 kg wood chips or 2.7 kg straw.

In conclusion, we hypothesize that the world's challenge to produce much more food than today with less environmental footprints by recycling resources (Kirchmann and Thorvaldsson 2000) is compatible with a shift towards sustainable bio-based production. Future agriculture will comprise of adaption to limited arable land ('peak soil'), advances in resource efficiency, and climate-friendly solutions.

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Keywords：*Sustainable yield, subsoil improvement, 'green fertilizer'*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Insights of the Nitrogen Use Effciency in Volcanic Soils of Southern Chile

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Nitrogen (N) is fundamental for pasture production in southern Chile, so that over the last decade the amounts of N added as inorganic fertilizer to grasslands has increased by 35%, on average. Previous studies showed that N losses to water and air are low, so that N use efficiency by plants is considered to be >60%. Nevertheless N soil budgets calculated for these productive systems are increasingly positive, suggesting an accumulation of this nutrient in soils and an association of this accumulation and soil organic matter (SOM) concentration. Thus, the objective of this study was to calculate N use efficiency in three volcanic ash soils relevant for pasture production of different SOM characteristics.

For this, monolith lysimeters (60 cm depth; 0.36 m internal diameter) were collected in 2010 from three soils series: Osorno series, Typic Hapludand,18% SOM (40°31' S 73°03' W), Cudico series, Typic Hapludult, 14% SOM (40°39' S 73°21'W) and Chonchi series, Acrudoxic Durudand, 23% SOM (40°15' S 73°39' O) from grassland sites with no grazing over the previous year. Lysimeters were moved to an experimental site at INIA Remehue (40º 35' S 73º 12' W) and adapted for the determination of N plant uptake and N losses to the environment over a two years period (2010-2012). Lysimeters were maintained under natural climatic conditions, to determine N dynamics under typical temperature and rainfall patterns. Treated lysimeters received the equivalent to 200 kg N ha-1 yr-1 as enriched ammonium sulphate (10% 15N). A control treatment with no N addition was also considered.

Dry matter yield was measured by harvesting plants when they reached 20 cm height and drying them at 60°C by 24-48 h. Plant uptake was calculated using yield results and N concentration in plants (Kjeldhal N and labelled N). Labelled and non-labelled results were used to calculate N use efficiency (NUE) in the three soils. Nitrogen lost by leaching was determined in leachates samples collected three times per week during autumn and winter and analysed for available and labelled N. Nitrogen losses by partial denitrification (N2O) were measured after N fertilizer application during the second year of experiment (non-labelled). This information was used to calculate the overall 15N budget.

Once the experiment was finished, lysimeters were destroyed and further 15N determinations were carried out at 0-10, 10-30 and 30-60 cm depth.

Treatments were organized on a randomized block design (n=4), and results analysed by ANOVA using the Genstat 12.0 software.

Nitrogen use efficiency by the pasture varied among 35-45% of N added, and it was c. 50% of the apparent N use.

NUE was 42.1±0.89%, on average, for the Osorno and Cudico soils, while it was only 35.8±1.98% ($P<0.05$) in the Chonchi soil this. This was related to the greater N plant uptake registered in the Cudico and Osorno soils (8.6±0.17 and 8.3±0.15 kg 15N ha-1, respectively), in relation to the Chonchi soil (7.2±0.16 kg 15N ha-1; $P<0.05$). No relationship was found between SOM and NUE ($P>0.05$) and results indicate that differences were related to a lower pasture yield in the Chonchi soil. Of all 15N plant uptake, 73% was recovered during the first year of evaluation, and roots contribution was neglible, suggesting a rapid N translocation by plants once N is taken up.

Labelled N lost by leaching was nil for all three soils and both years of evaluation. Nitrogen lost by partial denitrification was <0.2±0.005 kg N ha-1, so that 15N budget was 11, 12 and 13 kg 15N ha-1.

Further soil 15N analyses indicated that 15N was mostly absorbed as part of the labile organic matter and microbial biomass in the 0-10 cm depths. This contributes to explain the low N losses to the wider environment once the N has entered to the soil.Thus, from N fertilizer added to pastures on volcanic soils of southern Chile, only plants take up a small fraction within two years of application. Thus, most of the N applied is retained by the soil through chemical and biological interactions.

Results suggest that N fertilizer application strategies in these ecosystems should be reconsidered to reduce future environmental impacts.

This research was funded by Fondecyt Regular n°1100300.

Keywords：*nitrogen, N losses, volcanic soils*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Organic Farming on Fruit Yield of Tomato and Soil Fertility in Rainfed Alfisols of Southern Transition Zone of Karnataka, India

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A field experiment was conducted to study the effect of organic farming on fruit yield of tomato (hybrid Arka samrat) and soil fertility during 2011-12 at organic farming research center,Zonal Agricultural and Horticultural Research Station ,University of agricultural and Horticultural Sciences, Shimoga. Karanataka,India. The experiment was laid out in factorial RCBD with three replication. The treatments consists of three organic manures(OM1-100 % N through FYM (basal),OM2-OM1+ 50%N through neem cake manure (as top dress after 35 of transplanting of seedlings),OM3- OM1+ 50 % N through press mud (as top dress after 35 of transplanting of seedlings); Two method of placement(MOP) of organic manures:MOP1-Broad casting, MOP2-Deep placemen(Furrow) placement and two levels of mulching(M1- mulching glyricidia green lopping @ 1.5 kg/m2, M2-without mulching. The soil belong to sandy clay loam texture, low in available nitrogen (<175 kg/ha), high in phosphorous (120 kg/ha) and medium in available potassium (136 kg/ha) and low in available sulphur(<10 ppm). The soil is acidic in soil reaction(pH 5.5),low CEC (7.3 cmol(p+) kg-1,low water holding capacity (33 per cent).The organic manures used for the study were FYM(N-1.1 %, P-0.50 % , K-0.67 %), press mud(N-1.89 %, P-0.67%, K-0.75%) and neem cake(N-5.6 %, P-0.69%,K- 0.75 %). Glyricidia green loppings@20kg/plot was used as mulch at 35 days after transplanting. The results indicated that, among the organic farming practices studied, fruit yield of tomato was significantly higher in mulching (Glyricidia green loppings(@ 1.5 kg/ m2), method of organic manures placement and sources of organic manures. Significantly higher fruit yield (34.16 t/ha) of tomato was recorded in the treatment receiving deep application(furrow) of 100 per cent N through FYM + 50 per cent additional N through press mud as top dress 35 days after transplanting of seedlings + mulching with Glyricidia green loppings . The soil chemical results of the surface samples revealed that the treatment receiving 100 per cent N through FYM + 50% recommended N through press mud as top dress with mulching of glyricidia fresh lopping recorded significantly and higher organic carbon(0.63%),soil available N(195 kg/ha),available P205(191.16 kg/ha),available K20(319.5 kg/ha),soil available S(47.02 kg/ha) as well as higher bacteria(168 cfug-1),fungi(32 cfug-1), actinomycetes (7 cfug-1),phosphorous solubalising bacteria(75 cfug-1) and Nitrogen fixers (51 cfug-1) populations were found where plots receiving 100 per cent N through FYM + 50 per cent additional N through press mud as top dress + mulching with Glyricidia green loppings.

Keywords：*Fruit yield, method of placement, mulching,organic farming, soil fertility,top dressing*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Restoring Crop Productivity of Irrigated Cotton-Wheat Aridisols by Integrated Nutrient Management and Crop Residue Recycling

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The 3 million ha irrigated cotton (Gossypium hirsutum L.)-wheat (Triticum aestivum L.) cropping system in alluvial Aridisols of Pakistan is of prime importance for the national economy and food security. These calcareous soils are low in organic matter (0.5–0.9%) and the whole crop produce (including cotton stalks and wheat straw) is removed from the field for use as fuel of fodder. The prevalent fertlizer use is imbalanced, highly biased in favour of N; organic manure use is minimal. Thus, both the crops suffer with deficiency of nitrogen (N), phosphorus (P), boron (B) and zinc (Zn). Despite increasing use of N fertilizer, the soil resource base and crop production appear to be non-sustainable. Therefore, a farmer-friendly nutrient management strategy was developed to restore soil health and fertlility for sustaining crop productivity.

A 5-year permanent layout field experiment was conducted at Multan, Pakistan (30° 11□′ N, 71° 28□′ E) on two predominant soil series under irrigated cotton-wheat system (i.e., Awagat (coarse loamy mixed, hyperthermic Fluventic Camborthid; SOM, 0.60%; bulk density, 1.40 Mg m-3; AB-DTPA P, 2.2 mg kg-1; HCl B, 0.28 mg kg-1; AB-DTPA Zn, 0.48 mg kg-1), and Shahpur (fine silty mixed, hyperthermic Fluventic Camborthid; SOM, 0.85%; bulk density, 1.35 Mg m-3; AB-DTPA Zn, 0.72 mg kg-1; HCl B, 0.40 mg kg-1; AB-DTPA P, 3.5 mg kg-1). The nutrient management treatments were: (i) farmers' fertilizer use (FFU; i.e., cotton, 110 kg N ha-1; wheat, 80 kg N + 26 kg P ha-1); (ii) soil test-based recommended fertilizer use (RFU, i.e., cotton, 170 kg N + 26 kg P + 1 kg B + 5 kg Zn ha-1; wheat, 140 kg N + 44 kg P ha-1); and (iii) integrated nutrient management [INM, i.e., same as RFU, except that 75% N was applied as fertilizer and 25% as farmyard manure (FYM)]. These treatments were compared with and without crop residue (i.e., cotton stalks and combine harvester-left over wheat straw) recycling, on flat bed and raised beds sown cotton systems. Experiemtnal data included soil organic matter, soil physical properties, soil nutrient availablity indices, crop yields and apparent soil nutrient balances.

The improved nutrient managements, i.e., RFU and INM, enhanced SOM over FFU in both soils ($P<0.05$); beneficial impact was more pronounced in coarse loamy soil with lesser native SOM. Soil OM improvement was enhanced with residue recycling ($P<0.05$). This led to decreased soil bulk density, enhanced macro- and meso-porosity, stable aggregates and higher Infiltration rates ($P<0.05$).

Minimum crop yields (Mg ha-1), obtained with FFU in flat bed sown cotton sites during year-1, were: coarse loamy soil – cotton, 2.04; wheat, 3.09; fine silty soil – cotton, 2.51; wheat, 3.77. With FFU, yields remained stable or declined slightly over the years, irrespective of crop residue treatment or cotton sowing method. With RFU, yield increases were substantial ($P< 0.05$): coarse loamy soil – cotton, 24%; wheat, 37%; fine silty soil – cotton, 18%; wheat, 24%. Maximum crop yields were attained with INM,

which were slightly higher than with RFU. Crop residue recycling increased yields further, by 3−10%. Also, raised beds cotton yields were 9–10% greater than on flat bed. Crop productivity potential of the fine silty soil was greater than that of coarse loamy soil. Contrarily, magnitudes of crop yield increases with improved nutrient managements and residue recycling were lesser in fine-textured soil.

With FFU, without residue recycling, apparent soil N and K balances were negative; i.e., -22 to -118 kg N ha-1 and -755 to -1063 kg K ha-1 over the 5-year period. However, apparent soil P, B and Zn balances were positive. Despite positive soil P, B and Zn balances with FFU, prevalence of their deficiency may be attributed to high fixation in calcareous soils. Despite much greater nutrient uptakes with RFU and INM, soil N, P, B, Zn and K availability status was also enhanced with improved nutrient management treatments and residue recycling ($P<0.05$). Positive impacts were progressive over the years; thus, were more pronounced during year 4–5.

Thus, the use of recommended dosage of the deficient major and micro-nutrients, along with crop residue recycling, is essential for harnessing high-level profitable crop yields and sustaining soil-crop productivity.

Keywords：*Cotton-wheat system, Aridisols, nutrient management, residue recycling, crop productivity, sustainab*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Determination of Heavy Metals in Soil And Plants that Received Steel Industrial Residue Application.

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Steel industrial residue used in agriculture, such as steel slag, brings benefits to soil chemical properties, such as increased pH, base saturation and phosphorus, besides it is a source of micronutrients and silicon aspects that help to increase crop productivity. However, the presence of heavy metals in its composition is a concern when use this residue is used in agriculture. If the residue has high levels of heavy metals, it can become toxic and its use in agriculture must be limited. Although studies have not reported contamination from steel slag application, the quantification of heavy metals is important. The steel industrial residue has highly variable chemical composition and it is unknown the effects that these residues could have on the availability of heavy metals in the soil and on the uptake by plants in the long term. This study investigated the availability of heavy metal in the soil and in plants of bean, oats and soybean due to steel slag application as soil acidity correctives. The experiment was carried out at the São Paulo State University - UNESP in Botucatu, Brazil, from December 2010 to April 2013. The treatments consisted of two forms of application (incorporated and surface) of seven soil acidity correctives: steel slag (SS), blast furnace slag (BFS), saucepan furnace slag (SFS), stainless steel slag (SSS), wollastonite (W), lime (L) and calcined dolomite lime (CDL), and one control treatment without corrective application. Each material dose was calculated to raise the soil base saturation to 70%. Soil samples were collected at 0-20 cm at 2, 12 and 23 months after the application of soil acidity correctives . It was used DTPA as extractant and the ICP/AES to determination of heavy metals. The available contents of Cd, Cr, Ni, Pb and Hg in the soil and in the crops were low. The results showed that there was no contamination of heavy metals by steel slag. In the soil, only the contents of Ni (2 months) and Pb (12 months) were significantly affected by treatments that were reflected in the plants. Soil Ni content decreased with CD application, for the others materials there were no difference between the treatments or the control. There was reduction in the content of Pb due to the soil acidity correction. The levels of Cr and Hg in the soil were very low showing in all treatments contents <0.004 mg dm-3 for Cr and <0.003 mg dm-3 for Hg in all evaluations. The levels of heavy metals were constant during the evaluations; however, Ni, Cd and Pb showed some variations. It was observed increases for Cd and Pb contents from the first evaluation to the last two evaluations, and for Ni, the reverse occurred; however this increase or decrease also occurred in the control, which can be attributed to variations in the process of extraction and quantification. Studies also showed no contamination problems with steel slag application, which is explained by the increase in the soil CEC that allows greater adsorption of cationic heavy metals by soil, and covalent binding to colloids. In weathered soils, the CEC increase is associated with pH increase due to the larger amount of negative charges associated to the pH characterized by the higher presence of 1:1 minerals and hydrated oxides of Fe and Al. Only Ni varied in all crops and Pb in the oats/2011 with the treatments, the corrective application decreased the content of these elements. The results showed that the dose of steel slag applied to correct soil acidity does not represent a risk of excessive accumulation of heavy metals.

Keywords：*steel slag, heavy metals contamination.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Organo Mineral Fertilizer on Soil Nutrients in an Ultisols of Nigeria

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Field experiment was conducted in Ambrose Alli Teaching and Research farm, Ekpoma, in both early and late season to determine the effects of organo-mineral fertilizer and its residual effects on soil properties. The treatments consisted of seven levels of organo-mineral fertilizer (0, 2, 4, 6, 8, 10 and 12 ton OMF/ha) which were fitted into a randomized complete block design and replicated three times. Surface soil samples before and after the field experiments were analysed for its physic-chemical properties. Results showed that plant height, number of leaves and leaf area were significantly increased at 3, 6 and 9 WAP, by the application of 6, 8, 10 and 12 ton OMF/ha and their residual effects in the late planting season. Application of 4, 6, 8, 10 and 12 t OMF/ha increased grain yield significantly when compared to the control in the early planting season. Optimum grain yield of 4.45 ton /ha was obtained with the application of 8 ton OMF/ha and 2.42 ton /ha was obtained from residual 8 t OMF/ha. Available phosphorus, calcium and magnesium contents of the soil were enhanced significantly with the application of 10, 12 and 6 t/ha OMF in the early season, while in the late planting season, the residual effects of 4, and 12 t/ha OMF significantly increased phosphorus, calcium and ECEC contents of the soils respectively. Organo-mineral fertilizer application improves plant nutrients in soils, especially its residual contribution.

Keywords：*grain yield, maize, organo-mineral fertilizer, residual,soil properties.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Interactive Effects of CO2 Fertilization and Nitrogen on Biomass and Elements Concentrations of Cucumber Seedlings

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An open-top chamber experiment was designed to estimate the effects of CO2 and nitrogen interactions on cucumber biomass and elements concentrations in different organs. Cucumbers were grown in modified Yamazaki nutrient solution with five N levels in open-top chambers fertilized with three different CO2 concentrations. CO2 fertilization and N level both had significant effects on dry weight of cucumber seedling, and their interaction effects were more obvious after 62 days of treatment than that after 18 days of treatment. However, the interactive effects on root/shoot ratio were not statistically significant. N concentrations in cucumber tissues increased with increasing N level in nutrient solution, whereas CO2 fertilization reduced N concentration in leaves. For P, K, Ca and Mg concentrations, effects of CO2 fertilization and N level were distinctly different, which indicated that dilution was not the only explanation account for the decrease of the element concentrations.

Keywords：*CO2 fertilization, dry weight, element distribution, N levels*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Effect of Silicate to the Releasing Pattern of Native Inorganic Phosphorus of Andisol Lembang with Successive Resin Extraction

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Andisol is soil order which covers wide area in lembang, West Java. Lembang is a horticultural crops area with intensive phosphorus (P) fertlization for years. It is supposed that P in Lembang is already highly accumulated. The efforts to mine P in Andisol Lembang is necessary to increase the efficiency of P fertilization and to decrease P enrichment in water bodies. The objective of this research was to evaluate the effect of silicate to the releasing pattern of native P from Andisol Lembang. Soil sample was collected from Indonesian Vegetables Research Institute, Lembang West Java. The amount of 0, 1, 2.5 and 5 % CaSiO3 (calcium silicate) in the form of Na2SiO3 (sodium silicate) was added to the 300 g (oven-dry weight) soil and incubated for one month. A completely randomized design in three replications was set up. After one month incubation, ten times successive resin extraction and P fractionation were conducted. Data of successive resin extraction were simulated with first order kinetic equation. The amounts of soil P in different fractions were determined by : (i) resin strip in bicarbonate form in 30 mL distilled water followed by extraction with 0.5 mol L-1 HCl (resin-P inorganic (Pi) that is readily available to plant), (ii) 0.5 mol L-1 NaHCO3 extracting Pi (P which is strongly related to P uptake by plants and microbes and bound to mineral surface or precipitated Ca-P and Mg forms), (iii) 0.1 mol L-1 NaOH extracting Pi (P which is more strongly held by chemisorption to Fe and Al components of soil surface) and (iv) 1 mol L-1 HCl extracting Pi (Ca-P of low solubility). Prior to experiment, initial soil analyses were conducted.

Initial data analyses showed that Andisol Lembang contained very high Bray 1 P and total P. The values of Bray 1 P and total P were 80.8 mg kg-1 and 4783 mg kg-1 respectively. It confirmed that P in Andisol Lembang was already highly accumulated. The results showed that P releasing patterns were very well simulated by first order kinetic equation (R2 = 0.99). The application of silicate increased maximum P released. The application of 5 % calcium silicate in the form of sodium silicate resulted in the highest maximum P released. While the application 0, 1 and 2.5 % resulted in the maximum P released 275, 479, and 744 mg P kg-1 respectively. However the application of silicate decreased the rate constant of P released. The changes of P fractions after successive resin extraction showed that NaHCO3-Pi, NaOH-Pi (Al-P dan Fe-P) dan HCl- Pi (Ca-P) were P fractions contributed to P released. Among them, NaOH-Pi and HCl-Pi were fractions which contributed to the P released. NaHCO3-Pi contribution to P released ranged from 15.6 to 33.3 % while NaOH-Pi and HCl-Pi contribution to P released ranged from 40.7 to 45.6 % and 33.7 to 46.9 % respectively. The results suggested that silicate could be used to mine P from Andisol Lembang.

Keywords：*Andisol Lembang, Phosphorus release, Successive Resin Extraction*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Responses of Soil Physico-Chemical Properties, Ryegrass Growth And Uptake of Nutrients and Heavy Metals to Dairy Manure Amendment in a Mudflat Soil

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The fast pace of cropland loss in China is causing alarm with food security and China's ability to remain self-reliant in crop production. Mudflats after organic amendment can be an important alternative cropland in China. Land application of dairy manure has become a popular approach to mitigate its pressure on environment and to amend croplands in many countries. Nevertheless, the land application of dairy manure to mudflats has received little attention. Therefore, the objective of the present work was to investigate the impact of dairy manure amendment (DMA) at 0, 30, 75, 150, and 300 t ha-1 rates on soil physicochemical properties, ryegrass (Lolium perenne L.) growth, and heavy metal accumulation in a mudflat soil.

The results showed that the application of dairy manure decreased soil bulk density in comparison to unamended soil, with the decrements of 8.58%, 9.57%, 18.17% and 21.76% at 30, 75, 150 and 300 t ha-1 DMA rates, respectively. The OM content in mudflat soil increased with increasing DMA rates. The salinity of mudflat soil decreased with increasing DMA rates, and the salinity at 30, 75, 150 and 300 t ha-1 DMA rates corresponded to decreases of 26.1%, 35.8%, 37.8% and 45.4%, compared to 8.63 g kg-1 in unamended soil. The pH of mudflat soil showed minor decreases with increasing DMA rates, with no significant changes between DMA rates. Electric conductivity (EC) of mudflat soil decreased with increasing DMA rate, while CEC increased duo to DMA. The contents of total N, total P, alkaline N, and available P in mudflat soil increased with increasing DMA rates. The DMA increased total Zn at 150 and 300 t ha-1 rates ($P<0.05$), whereas there were either no changes ($P>0.05$) or decreases ($P<0.05$) in total Mn, Cu, Cr, Ni, and Cd concentrations in the dairy manure amended soils compared to unamended soil. The available metal concentrations increased with DMA in most cases except for Cu and Ni, which did not show apparent change in response to DMA ($P>0.05$). There were sharp increases in soil available Zn and Cr with increasing DMA rates, whereas the available Mn and Cd showed only minor increases with increasing DMA rates.

Ryegrass biomass at 60 and 150 days-after-sowing (DAS) was significantly higher at DMA soils than that in unamended soil. The increment of green herbage yield of ryegrass at 210 DAS at 30, 75, 150, and 300 t ha-1 DMA rates were 87.3%, 111.4%, 169.7%, and 223.0%, compared to unamended soil ($P<0.05$). Plant heights of ryegrass at 60 and 150 DAS were significantly higher at all DMA rates than those in unamended soil ($P<0.05$). Ryegrass tiller number per plant increased with increasing DMA rates, but was significantly higher at 300 t ha-1 DMA rate than that in unamended soil at 60 DAS, and higher (not significantly) at 150 and 300 t ha-1 DMA rates than that in unamended soil at 150 DAS. The data showed that root length, root surface area, root average diameter and root volume of ryegrass at 60 and 150 DAS increased with increasing DMA rates. The DMA increased concentration of N and P in ryegrass at 60, 150 and 210 DAS. At 60 DAS, N and P concentration in ryegrass at more than 30 and 75 t ha-1 DMA rate were significantly higher than that in unamended soil ($P<0.05$). At 150 DAS, N and P concentration in ryegrass at more than 75 and 150 t ha-1 DMA rate were significantly higher than that in unamended soil ($P<0.05$). The concentration of N and P in ryegrass at 210 DAS was significantly higher at 150 and 300 t ha-1 than that in unamended soil.

Fe, Mn, Cu, Zn, Ni, Cr and Pb concentrations in aboveground and root parts of ryegrass did not change significantly at all DMA rates. In summary, land application of dairy manure could be an effective and safe way to amend mudflat soil, due to the rapid development of soil fertility, enhancement of plant growth and nutrient uptake and low risk in accumulation of heavy metals in plant body.

Keywords：*mudflat soil, dairy manure, ryegrass, biomass, heavy metal.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Prevention of Soil Degradation for Oil Palm Sustainability

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The oil palm (Elaeis guineensis) which grows well on acidic soils in the tropics has been planted mainly in South East Asia, Africa and South and Central America and is regarded as an important economic crop to developing countries in these regions. As the oil palm requires substantial amount of nutrients for high productivity, fertilizer applications are necessary in view of the low soil inherent nutrients of most tropical soils where the oil palm is planted. Without the use of synthetic fertilizers, oil palm yields would be economically unsustainable. Nevertheless, continued usage of most synthetic fertilizers have been known to decrease soil pH which if not augmented can lead to soil degradation and can affect oil palm sustainability despite the high tolerance of oil palm to soil acidity. An effective way to mitigate and prevent soil degradation would be to cultivate leguminous plants as a cover crop in oil palm fields when the oil palm is replanted or renewed after its economic life span. In field experiments where leguminous cover crops (LCC) of Mucuna bracteata and Pueraria javanica were planted with the oil palm, investigation on the soil properties in terms of pH and organic carbon suggest that cultivation of these LCC were able to prevent soil degradation when accompanied by proper synthetic fertilizer usage. The LCC were also able to fix atmospheric nitrogen by as much as 250 kg N ha^{-1}, reduce runoff and soil sediment losses significantly during the replanting process and also capture available nutrients being released by the decaying old palm biomass at replanting (17 to 37% of available N, P, K and Mg) resulting in lower usage of synthetic fertilizers and minimizing soil degradation and water pollution. Applications of phosphate rock to the LCC not only improved LCC growth but recycling of P to the oil palm was noted resulting in lower P inputs required to the latter by as much as 50% in the initial years. In addition, the applications of three different sources of phosphates (phosphate rocks and water soluble phosphates) to the oil palm resulted in significantly higher soil total and available P (Bray-2 and Olsen-P) when compared with the control. This demonstrates that the use of phosphate rocks is a viable option in sustaining soil P status whilst supplying adequate P to the growing oil palm in order to achieve maximum yields. The replanting or renewing process of the oil palm can potentially result in huge losses of organic matter, soil degradation and environmental pollution if proper good agricultural practices are not in place. With correct guidance and procedures, establishing good LCC which forms part of a good agricultural practice can both be carried out by large plantation companies as well as smallholdings. Nutrients required for high oil palm productivity should not solely come from usage of synthetic fertilizers but instead incorporate the use of LCC to nourish the soils, improve soil organic matter and soil health and ultimately prevent soil degradation in order to ensure sustainability. Another major field practice to prevent soil degradation is to recycle available palm biomass including reusing of palm empty fruit bunches (EFB). Field EFB applications typically in the range of 20 to 40 tons ha^{-1} (fresh weight) have been shown to significantly improve soil physical and chemical properties by reducing soil erosion on sloping lands as well as improving soil aggregate stability and aggregation in view of the high content of organic matter and humic substances in EFB. Significantly higher soil microbial biomass by as much as 28.6 times was measured for plots applied with EFB compared with standard practice using only synthetic fertilizers. Applications of EFB and cultivation of LCC could contribute more than 7 and 8 tons C ha^{-1} respectively. With good agricultural practices including establishing good LCC and recycling of palm biomass, continued high oil palm productivity can be realisable even on the same site in order to achieve highest profitability and at the same time minimizing its impact on the environment whilst providing job opportunities to communities in developing countries.

Keywords：*Oil palm sustainability, prevention of soil degradation, legumes and recycling palm biomass*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil Health Indicators Measure Multifunctional Benefits of Farm Yard Manure Application

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Soil health is the key factor in crops production and with the new emphasis on sustainable agriculture comes a reawaking interest in soil health. Soil health is regarded as the integration and optimization of the physical, chemical and biological aspects of soil for improved productivity in an economic and sustainable manner. The objective of this study was to apply a standard set of soil health indicators to measure the effects of manure application to Pakistan soils. Samples were collected from a five year old experiment with four levels of farm manure (FM) application: 0 15, 30 and 45 Mg ha-1 annually. Maize (Zea mays L.)-wheat (Triticum Aestivum L.) rotation was followed. Samples collected from the research trial were analyzed for four physical (macroporosity, soil bulk density (BD), available water capacity (AWC), and wet aggregate stability (WSA), nine chemical (CEC, NO3-N, P, K, Ca/pH, Mg, S, Zn contents) and three biological indicators (active C content (Act C), potentially mineralizable N (PMN), and organic matter content (OM). Manure application resulted in positive and linear increases in most of the soil quality indices. ActC, OM and PMN were increased by 51.2, 54, and 88% for the 45 over the 0 Mg ha-1 application level. WAS and macro-porosity were increased by 46.5 and 22.2 % and bulk density decreased by 12 %, respectively. P, K, NO3-N and Zn were increased by 40, 74, 39.48 and 47.91 %, respectively. This study demonstrated the benefits of manure application in terms of physical, biological, and chemical aspects of a Pakistan soil, and the utility of a holistic soil test in evaluating the multi-functional aspects of soils in this environment.

Keywords：*Manure, Soil Quality, AWC, WAS, PMN, Active C, Zn, S*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Cow Urine (gomutra) as a Source of Nitrogen on Wheat (Triticum Aestivum)

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The decline in crop productivity and response of crops to added fertilizers are the major problem of present day agriculture. The problem has possibly resulted from deterioration in soil health due to heavy use of chemicals. Therefore, it is very much essential to develop a strong workable and compatible package of nutrient management through organic sources based on scientific facts, local conditions and viability. Among organic sources, cow urine (locally known as Gomutra) may be a source of nitrogen. Cow urine (Gomutra) is used for several centuries in different ways in many parts of the world. Cow urine contains nitrogen constituents in different amounts and may be used as nitrogen source for plant nutrition. In view of above facts, the present study was undertaken. Accordingly, a field experiment was conducted in a soil having pH 7.8, EC 0.51dS/m, organic carbon 0.36%, available N 185, P 16, K 210 and S 10 kg /ha. The experiment consisted of six treatments comprising T0 = control (recommended dose of P and K @ 60 kg /ha), T1=N @ 150 kg /ha through urea, T2= cow urine @ 300 ml /plot, T3= cow urine @ 450 ml /plot, T4= N @ 100 kg/ ha through urea + cow urine @ 300 ml /plot and T5= N @ 100 kg /ha through urea + cow urine @ 200 ml /plot. Treatments were replicated thrice adopting randomized block design having plot size of 3x2 m. Cow urine procured from same cow was applied weekly up to panicle initiation stage from the date of first irrigation (CRI stage). Initially cow urine was applied one day before sowing of wheat. Recommended doses of phosphorus and potassium were applied uniformly in all the plots. The results revealed that wheat crop favourably responded to different levels of nitrogen through fertilizer and cow urine. Plant growth (plant height and number of tiller) and yield (grain and straw) significantly increased as compared to control by the application of nitrogen. Application of treatment T4 registered maximum dry matter production. Application of nitrogen at 150 kg /ha through urea recorded highest level of available nitrogen in post harvest soil. Nitrogen content in plant (grain and straw) and uptake were found maximum when nitrogen was applied at 100 kg /ha through urea + cow urine @ 300 ml /plot.

Keywords：*Cow urine, nitrogen, urea and wheat.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil and Fertilizer

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Uganda is blessed with a wide diversity of natural resources: soil, climate, water and vegetation, enabling it to grow a large number of adapted crops. However, most soils in Uganda are older than 500 millions years and are in their final stage of weathering. The predominant minerals in the soils are quartz and kaolinite that don't directly supply nutrients to soils. The soils are acidic and infertile with low cation exchange capacity (CEC). Nutrients such as phosphorus occur in inorganic and organic forms that are not readily available to crops. Phosphorus is fixed by oxides of iron and aluminum. Nitrogen that is low in most mineral soils can only be naturally supplied to the soil from the atmosphere by symbiotic biological fixation and slowly from organic matter. Potassium another essential element, is also limiting in these soils because there are no primary minerals that can supply it. Also, due to the low CEC, inorganic cations are easily leached out of the root-zone of most crops.

Over the years, food production has been characterized by subsistence farming. A subsistence production system usually focuses on a maximizing short-term profit, consuming natural stocks of plant nutrients. Such a farming system has resulted in soil fertility degradation through nutrient mining. In the past, when Uganda's population was still low, lost soil fertility was restored through long periods of fallows. With an average land holding of about 2 ha per household, fallows are no longer practical or the periods greatly shortened. Research has clearly demonstrated that fertilizer inputs and appropriate land management practices are important components of technology required to increase crop yields in Uganda.

Soil science is the study of soil as a natural resource on the surface of the earth including soil formation, classification and mapping; physical, chemical, biological, and fertility properties of soils; and these properties in relation to the use and management of soils.

Sometimes terms which refer to branches of soil science, such as pedology (formation, chemistry, morphology and classification of soil) and edaphology (influence of soil on organisms, especially plants), are used as if synonymous with soil science. The diversity of names associated with this discipline is related to the various associations concerned. Indeed, engineers, agronomists, chemists, geologists, physical geographers, ecologists, biologists, microbiologists, sylviculturists, sanitarians, archaeologists, and specialists in regional planning, all contribute to further knowledge of soils and the advancement of the soil sciences.

Soil scientists in Uganda has raised concerns about how to preserve soil with a growing population, possible future water crisis, increasing per capita food consumption, and land degradation.

In Uganda Science fair projects on soil and fertilizer are common due to their accessibility and low cost. These projects are a very useful way to teach practitioner and students the relationship between plant growth and nutrients for the purpose of helping them learn in an interactive way.

Comparison of Fertilizers is one of the simple science projects on soil and fertilizer which is mainly to compare different brands of fertilizer to see which one works best. There are three basic components of fertilizer: nitrogen, phosphorous and potassium. But

each fertilizer brand has different percentage of these ingredients. Therefore, the packaging of soil and fertilizer needs to Take four pots and fill them equally with soil.

Fertilizer efficiency was not of great economic importance, and environmental concerns were not a high priority. More effort was devoted to high yield research. The period when more soil samples are analyzed by commercial laboratories than university laboratories and commercial laboratories began making fertilizer recommendations.

In Uganda Commercial soil testing laboratories didn't conduct further research into field verification of recommendations and generally did not emphasize soil testing.

Therefore, fertilization depends on many factors in Uganda. One of the most important is the farm manager's objectives for that field. Many ideas have been proposed to put fertilization in the context of a general management principle yet most various ideas commonly discussed on the issue of crop fertilization only

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Impact of Crop Land Agroforestry on Soil Properties in Bangladesh

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A four years field experiment was conduct at the Agroforestry research field of Hajee Mohammad Danesh Science and Technology University to evaluate the impact of crop land Agroforestry practices on soil properties in floodplain ecosystem of Bangladesh using three multipurpose tree species like mango (Mangifera indica), ipil-ipil (Leucaena leucocephala) and gora neem (Melia azedarach). The tree species used in this crop land agroforestry systems were prunes frequently and the pruned materials were added to the soil immediately after each pruning. Wheat, tomato and rice were grown in the alleys of mango, ipil-ipil and gora neem during the eight growing seasons starting from winter of 2008-2009 to winter 2011-2012. The crops were grown in the alleys consisted of the tree species under the recommended dose of fertilizer of the respective crops. Crops were also grown in open fields (without trees) for comparing the crop yield and changes of soil property from the crop land agroforestry practices. Therefore, four different crop production systems regarding the tree crop combination were prevailed like mango +annual crops based cropland agroforestry system (M+A), ipil-ipil+annual crops based cropland agroforestry system (I+A), gora neem+annual crops based cropland agroforestry system and sole cropping system.

The experimental result revealed that soil properties in the agroforestry plots had changed in positive directions due to incorporation of pruned materials of different tree species. But soil properties changing pattern differed depending upon the variation of tree species and also their presence. Soil properties such as organic C, total N, available P, exchangeable K and Ca, CEC and S were 22.00, 30.25, 14.69, 42.26, 34.87, 14.35 and 16.75 percents higher in crop land agroforestry plots over their initial values. More favorable soil pH was found in the plots where no tree was present (i.e. in sole cropping). But soil organic carbon was increased in agroforestry plots. Among the tree species, added pruned materials of L leucocephala contribute more organic carbon than those of the other two species did. Higher N level was also noted in the plots where pruned materials L leucocephala were incorporated. Application of pruned materials irrespective of tree species had increased available P in the soil. Among the tree species, relatively higher available P level was recorded in the M. azadirachta and L leucocephala plots. Like P more exchangeable K was recorded in the same plots. Practicing of crop land agroforestry could not bring any remarkable change in exchangeable Ca, and Mg content in the soil. The incorporation of pruned materials irrespective of tree species had increased Ca levels but decreased Mg level. Sulfur level had increased slightly at cropland agroforestry practices as compared to sole cropping. CEC improved due to practicing agroforestry systems. Finally, the results revealed that L leucocephala and M azedarach performed better in building up of soil fertility than that of M indica. The better performence fo L leucocephala in building up of soil fertility could be attributed due to higher nutrient content and faster decomposition rate of its pruned materials.

Keywords：*agroforestry, crop land, mango, ipil-ipil, gora neem, soil properties, Bangladesh*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Study of the Cumulative Effects of the Application of Urban Sewage Sludge on an Eroded Soil Cultivated in the Algerian Steppe

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Since the seventies, desertification is one of the major problems faced by the Mediterranean climate regions. These problems are inherent in the soil and climate characteristics of these regions, but their magnitude and acuity depend mainly on human activities. The process of desertification that affects more and more land is more pronounced as soil degradation, which accelerates constantly reduced resources farmland and pasture. Especially in areas bordering the Sahara, as the Algerian steppe, a real belt between the Sahara and the Algerian tell

As part of the study of the cumulative effect of the application of urban sewage sludge on sandy soil and culture that is a cereal (barley), we had results that enabled us to identify some precepts,.The short-term effects studied in this experiment indicate that the amendment of the sewage sludge had a beneficial effect on the fertilizing qualities of the soil and therefore the performance of barley.

To observations of Culture (barley), indicate that the best grain yield was obtained with D3 (28.76 quintals / ha) and D2 (33.91 quintals / ha). This is due to the effect of the sludge by the addition of required nutrients crop production. The lowest yield (24.11 quintals / ha) being obtained for the control (D0). It is the same for straw yield, with 47.5 quintals / ha in D2. The D3 treatment (30 t / ha) has previously presented the best results, but after 3 years we noticed that the best yields are obtained with D2 (10 t / ha).

Except the pH and the rate of limestone that are related to changes in the characteristics of the site, there was an improvement in some physical and chemical properties of the soil. The contributions of sewage sludge amended greater quality soil biology D2 (number and effective species collected).

Increasing the organic matter content (1.45%) and electrical conductivity (0.18 microseconds / cm) in the soil is only significant for the highest dose (30t/ha), although a tendency to enrichment in proportion to the dose appears clearly (except for nitrogen with a maximum of 0.066% in D3). The content of nitrogen increases less than organic carbon, which results in an increase of the C/N in the processing D2, justifying a biological activity which allows a soil structure, ensuring protection against leaching and challenging creating conditions favorable for crop development.

So opportunities for agricultural use of sewage sludge exist for the rehabilitation of degraded sites (revegetation), while remaining in an application under controlled and regulated. These pathways underused in Algeria may comprise an interesting alternative to overcome the lack of organic matter, and even conserve soil areas subject has often destructive climatic and anthropogenic conditions.

Keywords：*Sewage sludge, application, doses, soil erosion, rehabilitation*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Food Waste Compost on the Available Nutrient Content of Sandy Soil and Nutrient Uptake of Plant in a Two-Year Greenhouse Experiment

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In a greenhouse pot experiment the effects of food waste compost were investigated in the year and after a year of its application on available element contents of humic sandy soil and on the growth and element uptake of carrot and ryegrass. A randomized complete block design were used with five compost treatments (10t/ha, 20t/ha, 30tha, 50t/ha, 50%compost:50% soil), mineral fertilizer and control treatments. All treatments were set up with four replications. Throughout the experiment all plots were watered with ion exchange water to maintain soil moisture at 60% of water holding capacity. In the first year of the compost application the testplant was carrot and in the second year was ryegrass. Soil samples were taken for analysis after harvest in both experimental years. The objective of our study were to determine the food waste compost effects on the 0.01 M CaCl2 soluble nitrogen forms (NO3-N, NH4-N, organic-N,total-N) and AL-P2O5, AL-K2O contents of sandy soil for two years, and to evaluate the compost effects on carrot and ryegrass growth and nutrient uptake of these species. Compost, up to 30t/ha dose, linearly increased the weight, length and width of carrot in the first year of the compost application. Higher compost doses (50t/ha and 50%compost:50%soil) decreased the sizes and weights of carrot. Significantly higher values of AL-P2O5, AL-K2O and 0,01M CaCl2 soluble nitrogen forms of soil were observed in 50t/ha and 50%compost-50%soil treatments in the first year compared to control measured after harvest. In the second season of compost application food waste compost enhanced the growth of ryegrass up to 50t/ha dose, but the highest dose (50% compost:50% soil) decreased the yield. The greatest P and K uptake of grass were observed in 50t/ha compost application. The soil available P, K and the 0,01M CaCl2 soluble nitrogen forms were significantly higher in the 50%compost:50%soil treatment compared to other treatment in the second year of the study as well. Results of our study proved that food waste compost provided nutrients for crop grow in both experimental years. The effects were depended on the compost doses, plant species and on the time of compost application. The optimal compost dose might be influenced by soil type as well. In order to determine optimal dose further, more extensive studies are needed.

Keywords：*food waste compost, nitrogen, phosphorus, potassium, sandy soil*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Frond Piling on Manganese Dynamics in the Soil at an Oil Palm Plantation

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Introduction

Oil palm is widely cultivated in tropical countries such as Malaysia and Indonesia. In oil palm plantation, due to highly weathered tropical soil, mineral fertilizers are applied at canopy circle of palm trees to sustain high fresh fruit bunch yields. Meanwhile, oil palm fronds which were pruned during harvesting of fresh fruit bunches are stacked between the oil palm trees (frond pile) to reduce soil erosion and nutrient losses through surface runoff. Although it has been supposed that nutrients contained in the fronds could be released into the soil through decomposition and recycled by the palm trees, few detailed studies have been conducted so far on this process, especially about micronutrients. Manganese (Mn) is one of the essential micronutrients and Mn containing proteins play important roles on photosynthesis and various redox reactions in plants.

With the aim at contributing to efficient fertilizer management, the purpose of this study was to investigate the distribution and forms of the manganese in the soil with special reference to frond piling practice. In this study, we hypothesized that Mn contained in the fronds will be incorporated into underlying soil through decomposition and result in a high accumulation of Mn in the topsoil.

Materials and Methods

This study was conducted at an 18-year old commercial oil palm plantation in Tun Razak Agricultural Services Centre located in Pahang, Malaysia. Surface (0-5 cm) and subsurface (5-10 and 30-40 cm) soils were collected from the weeded circle under the canopy of an oil palm tree (WC), the frond pile (FP) and the harvesting path without frond piling (HP).Total and DTPA-extractable (available) Mn, Fe, Cu, and Zn as well as soil general properties were analyzed. Sequential extraction method was applied for evaluating the amounts of Mn in different chemical forms and soil Mn were fractionated into exchangeable (Ex-), acid soluble (Aci-), Mn oxide-occluded (MnO-), organically bound (OM-), Fe oxide-occluded (FeO-), and residual (Res-) fractions, respectively.

After measuring total amounts (kg m^{-2}) of a FP, frond samples were collected from the newest and oldest layers of stacked fronds. Each sample was cut into three parts along the petiole and rachis. About 5-10 cm length of mid-section of each part were selected and separated into petiole, rachis, and lamina. Fresh fronds were also collected from palm trees and prepared by the same procedure. The concentrations of macro and micro nutrients were analyzed and the average concentration in the frond and these amounts in FP were estimated.

Results and discussions

The order of the micronutrient concentrations in frond was in the order of Mn >Fe > Zn >Cu. In the freshly cut frond, Mn concentration of lamina was 717 mg kg^{-1}, which was more than 6 times higher than the Fe concentration. The Mn concentration was higher in the lamina than in the petiole and rachis. Based on the Mn concentration in the fronds taken from the FP, it was estimated that about 400 mg m^{-2} of Mn can be incorporated in the underlying soil when stacked fronds were completely decomposed.

Soil general properties and Mn status at the WC showed large standard variations probably due to fertilization. To examine the influence of frond piling, the results at FP and HP were compared in the following discussion. In the 0-5cm soil, total Mn were significantly higher at FP (114 mg kg^{-1}) than at HP (37 mg kg^{-1}), while total Fe, Cu, and Zn did not differ between FP and HP. On the other hand, the availability of all micronutrients in 0-5 cm soils at FP was higher than that at HP. Soil Mn in the Aci-, MnO- and OM-fractions in 0-5 cm soil layer at FP were significantly higher than those at HP. The Mn accumulation in the topsoil under stacked fronds can be attributed to the incorporation of Mn through the decomposition of pruned fronds into these soil chemical fractions. In addition, decomposition of pruned fronds can influence the soil general physico-chemical properties and the types and amounts of organic substances in the soil, which may affect the chemical forms and distribution of Mn in the soil.

Keywords：*Manganese dynamics, Oil palm plantation , Frond pile, Harvesting path*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil N Retention and Recovery of Fertilizer N by Maize Grown with Nutriseed Pack by Using 15n Tracer

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In a cropped land plant and soil utilizes nitrogen (N) mainly from fertilizer. Deep placement of fertilizer N enhances added N use efficiency. Nutriseed Pack technique is a way of deep placing fertilizer in the root zone simultaneously when sowing the seed. A Green house experiment with 15N tracer technique was conducted during 2009 at open premises of green house in the Department of Soil Science and Agricultural Chemistry, TNAU, Coimbatore to evaluate the effect of application of fertilizers in maize by surface broadcast and Nutriseed Pack. Each Nutriseed Pack was assembled by stacking of seed, manure and fertilizer pellets and then wound in newspaper as a roll. The treatments consisted of placement in vertical/horizontal position having with or without Neem and Furadan. On placement in soil, supply of nutrients is expected from Nutriseed pack throughout the crop period. Nitrogen tracer (15N) technique is an accurate tool to assess the N use efficiency and retention of added N in soil under different N management practices. Assaying on 15N tracer added as labelled urea made in the present study in different plant parts of maize, brought out the superiority of particular treatments based on the derivation of fertilizer N from soil and its accumulation in plant parts, total N and retention of labelled N in soil layers and per cent recovery of labelled N in plant parts and N use efficiency.

In the study 15N recovery from the added labelled 15N urea was estimated by mass spectrometry in different parts of plants. Among the treatments, horizontal placement of Nutriseed Pack registered the highest total N (6350 mg) in 0-15 cm layer, whereas the other Nutriseed Pack treatments recorded relatively high total N ranging from 6044 to 6350 mg. Surface broadcast of fertilizers resulted in low status of total N (6118 mg). With respect to retention of applied labelled N, the highest value was found in horizontal placement of Nutriseed Pack registering 326 in the 0-15 cm soil layer surface layer (0-15 cm), from 4.9 to 10.8 per cent in sub-surface layer (15-30 cm), and from 2.8 to 6.0 per cent the underlying lower layer (30-45cm). In case of surface application of fertilizers, N retained was 5.5 per cent in surface layer (0-15 cm), 3.2 per cent in sub-surface layer (15-30 cm) and 11.1 per cent in lower layer (30-45cm).

The placement of Nutriseed Pack as well as surface broadcast showed very low recovery of labeled N in root ranging from 0.03 to 0.06 per cent. High recovery of labeled N measuring 7.70 and 6.69 per cent in leaf occurred due to surface broadcast of fertilizers and Nutriseed Pack with Furadan respectively. The recovery noted was meagre for all treatments ranging from 0.36 to 0.85 per cent for tassel development and from 0.99 to 1.76 per cent in pith. Nutriseed Pack with Furadan and surface broadcast influenced high support for the development of Ear leaf with recovery of labeled N of 4.64 and 4.22 per cent respectively. Horizontal placement of Nutriseed pack showed very high recovery of labeled N in grain (17.15 %). Overall the total recovery (NUE) was highest for horizontal placement of Nutriseed Pack (36.17%) followed by vertical placement of Nutriseed Pack with Furadan with 33.62 per cent. The performance of Nutriseed Pack plain, Nutriseed Pack with Neem and surface broadcast are similar with NUE ranging from 30.17 to 30.45 per cent.

The true efficiency of added N fertilizer measured as total % 15N recovery (NUE) ranged from 30.17 to 36.17 per cent. Placement of Nutriseed Pack horizontally registered the highest N use efficiency (36.17%), followed by vertical placement (30.17%). Close placement of nutrients in the pellets of Nutriseed Pack near the surface where roots proliferate caused very high mgNdff that has been reflected in 15N recovery under horizontal placement, followed by vertical placement. Greater increase in NUE has resulted in these treatments particularly due to translocation of fertilizer N accumulated in stover to grain. Even though surface broadcast caused higher recovery of fertilizer N in leaves and stem, it was not translocated to grain as that of Nutriseed Pack and hence only 30.45 per cent NUE was achieved. As expected, due to added N interaction more utilization of soil N by stover might have been favoured at every time of urea application under surface broadcast.

Keywords：*N Retention and Recovery , maize, Nutriseed pack, 15N Tracer*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

A Novel Method to Optimize Nitrogen Requirements of Drip Fertigated Sugarcane

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Sugarcane is one of the most important cash crops which play a pivotal role in Indian agricultural economy. Sugarcane is cultivated in an area of 42.45 lakh hectares with total sugar production of 192.67 lakh tonnes. India is one of the largest producers of sugar and has a neck to neck race with Brazil for the first position. India shares about 13.25 per cent of world and 41.11 per cent of Asian sugar production.

Significant amount of nitrogenous fertilizer is necessary for commercial sugarcane production because of the large biomass produced by sugarcane crops. Urea being the high analysis nitrogenous fertilizer and common cheap source considered to be the topic of interest. Continuing to apply the same N rates used in conventional management systems to fertigated sugarcane crops would probably result in lower N- use efficiency and increased losses of N to the environment. Hence, the outcome could be contrary to the desired benefits from adopting fertigation. Hence, this study was conducted to evaluate the fertigation schedule predicted from model by field verification. The schedule was developed by Ravikumar et al. (2011) based on the crop assimilation curve. Field experiment was conducted with sugarcane variety CO 86032 at Irrigation cafeteria of Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore during March 2011 to February 2012.

Initially, incubation study was conducted to find out the reaction rate constant for urea with different concentrations. The values for KHU, (hydrolysis rate constant) observed were 0.014,0.0134, 0.0139, and 0.0140 h-1 for 1.582, 3.71, 37.04, and 55.55 (mg N/cm3), respectively. The KD, (distribution rate coefficient) values observed were 0.0138,0.03465, 0.03386, and 0.0139 h-1 for 1.582, 3.71, 37.04, and 55.55 (mg N/cm3), respectively. KV, volatilization coefficient values observed were 0.0070, 0.0078, , 0.0083 and 0.0071 hr-1 for the urea N concentrations of 1.582, 3.71, 37.04, and 55.55 (mg N/cm3), respectively. And the KN, nitrification rate constant values were 0.0076, 0.0074, 0.0074 and 0.0077 h-1 for 1.582, 3.71, 37.04, and 55.55 (mg N/cm3), of urea doses respectively. The results showed that the amount of volatilized ammonia is higher when the urea concentration is higher. The hydrolysis rate constant of urea increased with the increased urea concentrations. The observed volatilization rate constant increased with increasing urea concentration. The distribution coefficient tends to decrease with the increased urea concentration. The nitrification rate constant found to increase with the increased urea concentration

The distribution of different N fractions before and after fertigation was studied in each fertigation schedule. The results revealed that, the hydrolysis of urea starts immediately after its application into the soil, which was observed in the incubation study confirms with the field verification. The NH4-N concentration after 24 hours of fertigation is higher than its concentration before fertigation. The NH4-N concentration found to distribute upto the 45 cm depth 24 hours after fertigation. The concentration of NO3-N found to decrease in the soil profile than the initial level which may be due to leaching loss, which and had accumulated in the soil profile beyond 45 cm. Since, NH2 –N is highly mobile in soil, its distribution was found all over the profile. The concentration immediately after fertigation was found to be higher and its concentration drastically reduced after 15 days after fertigation, which was similar to the results obtained in the incubation study.

The results of field experiments revealed that the higher cane yield, quality and input use efficiency were under the treatment which received N @ 195.5 kg ha-1. Application of this dose recorded 17 per cent increase in cane yield over the treatment which received N @ 299 kg ha-1. Single cane weight and number of millable canes increased significantly with the treatments which received N @ 195.5 kg ha-1 through fertigation. And this dose enhanced the quality parameters viz., brix, sucrose, commercial cane sugar and purity. Among the different N doses tried, the dose which was predicted to be optimal was excelled in all the quality parameters of sugarcane. Thus, it could be concluded that application of N @ 195.5 kg ha-1 under the suitable fertigation schedule can be recommended for the field level adoption to get higher sugarcane yield in sandy clay loam soil.

Keywords：*N dose, Sugarcane, drip fertigation*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil Fertility and Crop Productivity in Organically Managed Field Bean under Rainfed Alfisols

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A field experiment was conducted on soil fertility and crop productivity in organically managed field bean under rainfed Alfisols during 2012-13 at organic farming research centre, Zonal Agricultural and Horticultural Research Station , University of Agricultural and Horticultural Sciences, Navile, Shimoga, Karnataka, India. The experiment was laid out in RCBD design with nine treatments Viz T1: Rec.FYM +100% N equivalent to FYM ,T2:75% N equivalent to FYM ,T3:100% N equivalent to FYM ,T4: 125% N equivalent to FYM; T5:Rec.FYM+ 100%N equivalent to Vermicomost,T6: 75%N equivalent to vermicompost ,T7:100% N equivalent to vermicompost ,T8: 125% N equivalent to vermicompost ,T9:50% N equivalent to FYM + 50% N equivalent to vermicompost and three replication. The each plot area was 24 mt2. The selected experimental site belong to sandy loam in texture, lower in CEC(7.3 cmol (p+) kg -1), acidic in soil reaction (pH <5.5),low in organic carbon(4.0 -4.5 g/kg), low to medium in available potassium(<333 kg/ha), high in available phosphorous(>56.9 kg/ha) and low in available nitrogen(<280 kg/ha). Field bean variety HA-2 was selected as test crop. As a measure of pest management econeem 50000 ppm spray @ 2 ml /litre and 10:1 water and cow urine dilution were used (3 sprays during crop period). Trichoderma viride @ 2 kg per tonne of FYM was applied. The yield and soil parameters were recorded after harvest. In soil chemical analysis standard methods and procedures were adopted.

Among the different organic manures used in organic farming trials , application of recommended FYM + 100 percent N equivalent to vermicompost recorded significantly higher dry pod yield (14.92 q/ha) and seed yield (10.97 q/ha) and is on par with the application of recommended FYM + 100 percent N equivalent to FYM and 125 % equivalent to vermicompost. The results of the surface (0-15 cm depth) soil collected after harvest of the crop revealed that a significant variation in soil organic carbon, available nitrogen, available phosphorous and potassium due to use of different quantity and proportion of different organic manures. Higher organic carbon (6.0 g/kg) .available K2O (167.8 kg/ha), available P205 (189 kg/ha) and nitrogen (354.3 kg/ha) were recorded in recommended FYM + 100 % N through vermicompost. Highest soil bacteria, fungai, actimycetes ,phosphorous solubilising bacteria and N-fixer population (cfug-1)was found in the treatment receiving recommended FYM+100% N through vermicompost. Lowest microbial population was observed in treatment which receiving only 75% N equivalent to FYM.

Keywords：*Organic farming,soil fertility,yield ,fieldbean*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Sulphur Status of Selected Soil Series of Karnataka and Studies on Direct and Residual Effect of Graded Levels of Sulphur on Crops

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The status and distribution of different forms of sulphur in different soil regions representing black, red, coastal and western ghat soils were evaluated in both surface and depth wise . Relation between forms of sulphur and soil properties and direct effect of graded level s of sulphur on potato and the residual effect added sulphur on finger millet crop. The available sulphur content of soils varied with soil type, the highest mean value was obtained from western ghat soils and lowest mean values was in coastal soils. Majority of samples fell under medium category followed by high and low categories. A relatively higher amount of total sulphur was noticed in black soils compared to other soils. The per cent contribution of different forms of sulphur to total sulphur was mainly in the form of organic plus non sulphate sulphur and very small fraction was in sulphate sulphur form. The profile study revealed that total sulphur and organic and non sulphate sulphur content of soils decreased with depth. Correlation studies revealed that total sulphur content of soil was positively and significantaly correlated with organic plus non sulphate sulphue, CaCO3 and organic carbon content of soil. Sulphate sulphur showed significant and positive correlation with soil reaction, salt content , clay , organic carbon and total sulphur content of soil.

In field experiments, the direct effect of of graded levels of sulphur on potato crop and residual effect on finger millet in terms of yield and nutrient composition. Also changes in the sulphur fractions of soil was monitored before and after the experiment. Four levels of sulphur (0, 15, 30 and 45 kg sulphur per hectare) along with recommended dose of N,P,and K were tried.Suitable control s were included for comparing the treatment effects. In the experiment to study the direct effect of graded levels of sulphur, the tuber yield of potato crop was highest (17552 kg per hectare) at 30 kg sulphur per hectare, followed by 45 kg sulphur per hectare (17492 kg/hectare). But in the residual effect of sulphur, grain yield of finger millet was highest (3512 kg per hectare) at 45 kg sulphur per hectare followed by30 kg sulphur (3304 kgper hectare) . Application of sulphur at 30 kg/ha along with recommended dose of NPK was found to increase the potato tuber yield appreciably. Application of sulphur at45 kg/ha did not showed the significant increase in yield but increase the sulphur content in plant parts. The residual effect of sulphur on finger millet crop yield and uptake was noticed at 45 kg sulphur per hectare. The NPK content and uptake by both potato and finger millet crops were found to increase with increase in sulphur addition upto 30 kg per hectare and then twere was slight decrease. But sulphur content of crops increased linearly.The highest benefit: cost ratio , agronomic efficiency and apparent nutrient recovery noticed at 30 kg sulphur per hectare followed by 45 kg per hectare and 15 kg sulphur per hectare .

Keywords：*sulphur, surface , depth wise, potato and finger millet*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Improving Soil Quality to Increase Yield and Reduce Diseases in Organic Rice Production

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The major challenges in organic rice production include nutrient improvement, weed management, and variety selection. In this study, we tested the effects of two soil amendments on organic production in southcentral USA. The 2011-12 winter cover crops were established successfully with full coverage. The amount of dry biomass were 5257 and 5780 kg/ha for clover and ryegrass, respectively. Plots were cultivated and drill seeded but high weed pressure in the fallow plots resulted in very poor stands. Only results of rice grain yields from clover and ryegrass treatments were presented. Cover crops had a similar effect on rice grain yield, although numerically, rice grain yield under ryegrass treatment was higher than that under clover treatment. Compared to Presidio, Tesanai had significantly higher grain yield. Soil amendments did not have significant effect on rice grain yield. Compared to the control, the 150 lb N/acre and 210 lb N/acre soil amendment rates increased rice grain yields by 11%. There was no difference in rice grain yields between the two N rates, indicating that 150 lb N/acre was sufficient for organic rice production in terms of N supply. Compared to Presidio, Tesanai had greater plant height and appeared to be more competitive with weeds. Aboveground biomass of the rice crop was affected by the rate of soil amendments rather than the type of soil amendments. Rice milling yield was significantly affected by cover crop and rice variety. Severity of narrow brown leaf spot was significantly higher ($P \leq 0.05$) on Presidio than on Tesanai while severity of brown spot was low on both cultivars. Cover crop treatments did not affect narrow brown leaf spot. However, clover cover crop treatment had significantly lower brown spot severity compared to the winter fallow and ryegrass treatments. Application of N at either 150 or 210 lbs/acre was effective in reducing the severity of narrow brown leaf spot and brown spot as compared to the control. Severity of either disease linearly ($R2 \geq 0.56$) decreased with increased N level. In addition, no symptoms of straighthead were observed in any plots. In South Carolina, prior to harvest, evidence of sheath rot (Sarocladium oryzae) and brown spot (Cochliobolus miyabeanus) diseases and rice water weevil (Lissorhoptrus oryzophilus Kuschel) symptoms were noted. Brown spot and sheath rot were most prevalent in the Charleston Gold and the IAC 600 whereas straighthead was more of a problem in the Carolina Gold and Charleston Gold.

Keywords：*Organic rice, soil amendment, cover crop, disease*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Influence of Copper Base Foliar Fertilizer and Controlled Release Foliar Fertilizer on Yields, Fruit Quality, Mineral Nutrition and Leaf Antioxidant Enzyme Activity of Pepper (capsicum Annuum L.)

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A pot culture experiment was conducted to assess the growth, mineral content and physiological response of pepper (Capsicum annuum L.) in relation to copper foliar fertilizer and soil fertilizers. Treatments were: 1-CKW+CCF, 2-CKW+CRF, 3-CBFF+CCF, 4-CBFF+CRF, 5-TBM+CCF, 6-TBM+CRF, 7-UK+CCF, 8-UK+CRF. The results indicated that different interactions of CBFF and CRF had significant effects on yield in the first year（2011）and the second year（2012）. The optimal combination of fertilization for yield was CBFF+CRF. Under this condition, vitamin C and soluble protein content of pepper was significantly higher than the other treatments in 2011, but the soluble protein content is only obviously higher than other treatments in 2012. Moreover, foliar spraying copper fertilizer significantly increased copper concentration in the pepper plant, but the copper concentration was lower than treatment TBM and UK. Meanwhile, the active oxygen that was produced by copper based foliar fertilizers leaded to an increase of superoxide dismutase (SOD), peroxidase (POD) activities. Application of CBFF decreased the catalase (CAT) activity and malondialdehyde (MDA) content in 2011 and 2012. In a word, the research showed that appropriate combined fertilization management can increase proper micronutrients content in peppers and improve the yield and nutrition quality of peppers.

Keywords：*copper-based foliar fertilizers；controlled-release fertilizers；pepper；physiological characteristics；*

P4-357

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects on Plant Nutrient Uptake, yield and Fertilizer Utilization Efficiency of Controlled Release Fertilizers in Cotton

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The study included field trials treated by two controlled release nitrogen fertilizers (CNF) which include sulfur plus resin-coated urea (PSCU) and resin-coated urea (PCU) and an outdoor pot trial treated by controlled release Potassium Chlorate（CKCL）with Guoxin 3(G. hirsutum L.) in 2008 and 2009.The nutrient release curve of two kinds of CNF were measured in water at 25℃,and the result matched the actual nutrient release in field ,The fitted equations of release time of CNF at the same nutrient release rate were established. Nitrogen uptake of cotton was measured in different periods of cotton growth, and find out the relationship between nitrogen uptake of cotton and nutrient release of CNF. In addition , the changes of soil ammonium nitrogen, nitrate nitrogen and available potassium were also measured ,meanwhile statistical analysis was made on fertilizer use efficiency and yield of cotton. The result shows that CNF have an slow release characteristics, which can supply nutrients smoothly that lead to significantly increase yield by 10-15.32% than common urea treatment of cotton in field soil. The release rate between soil and water were in accordance with the linear equation that X2=1.261X1+22.44 of PCU, and X2=-0.0075X22 +1.6957X2-2.7284 of PSCU. Plant growth and nutrient release are directly related and the nutrient release of CNF can satisfied with the uptake of cotton. The maximum of increased dry weight per day of controlled release fertilizer appeared in the period between full-bolling stage and initial boll-opening stage which reached 3.91g/ day. CNF significantly increased the N utilization efficiency, PSCU and PCU were respectively 37.418% and 33.612% which increased 8-11.8% than treatment by common urea. The result of pot trial shows that CKCL can significantly increased the yield of cotton by 12.92% and increased the content of available potassium significantly in later growth of cotton soil than common potassium fertilizer. CKCL can also increased the content of ammonium nitrogen significantly in trefoil stage as well as the K utilization efficiency.

Keywords：*cotton, Plant Nutrient Uptake, Yield ,Fertilizer Utilization Efficiency,Controlled Release Fertilizer*

P4-358

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Change in Farmland Soil Fertility and Nutrient Management Strategy in the Semiarid Regions of North China

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Semi-arid landscapes are vulnerable to cultivation and climate variability. In order to understand characteristics of soil nutrients and propose rational practices for maintaining the fertility in the farmland in semiarid regions, the change and its driver factors of main soil fertilities (organic matter, total nitrogen, available P and available K) was analyzed by using four- times survey data during past five decades in farmlands of Xinfu County, Shanxi Province, and Luancheng County, Hebei Province in North China. The results indicated the average content of soil organic matter for Xinfu County are 8.0, 8.3, 13.5, 15.3g kg-1 in the four-time survey (year 1963, 1979, 2006, 2010), respectively. And a mean increase every year are 0.02, 0.19, 0.45 g kg-1 y-1 for the three Corresponding stages. There is a similar pattern of temporal change for Luangcheng County compare to Xinfu County. The average content of soil organic matter for Luangcheng County are 11.1, 11.2, 17.3, 18.8g kg-1 in the four-times survey (year 1955, 1978, 2001, 2008), respectively. And a mean increase every year are 0.01, 0.24, 0.22 g kg-1 y-1 for the three corresponding stages. Slight increase or equilibrium of organic matter in the fist stage for both the two sites resulted from serious shortage of inputs, which can't compensate the output by harvesting aboveground biomass. The apparent increase in the second stage (1979-2006) for Xinfu County resulted from the increasing chemical fertilizer application, improving irrigation, increasing crop yield and subsequently returning the residues from falling litters and roots. The rapidly increase in the third stage (2006-2009) resulted from dominatingly implementation of retuning straw at this period. The similar rates of organic matter for Luancheng County in the two stages (1978-2001 and 2001-2008) mainly resulted from combined with increasing chemical fertilizer application and returning straw. The pattern of temporal change for total nitrogen, available phosphorus and available potassium content are identical to organic matter during the three stages at both of two sites. To further enhance the soil fertility for Xinfu County, as monoculture area, implementation of combined the application of organic and inorganic fertilizers, increment of incorporated straw into the soil, and improving irrigation should be recommend in future. While for Luancheng County, as multicultural area, implementations of implement practices, including precision fertilizer and conservation tillage are recommend. Therefore, our study suggests that there is apparent increase of soil fertility in the past five decades both at monoculture and multicultural area in the semiarid regions of North China, and there is also potential in future, especially for in monoculture area.

Keywords：*semiarid regions;fertilization; irrigation*

P4-359

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Phosphorus Aggravated Aluminum Toxicity in Wheat: Eliminate the Direct Interaction of Al-P Precipitation in Solution

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To avoid Al and P direct interaction in solution, a split root experiment was carried out in two wheat varieties (Atlas, Al tolerance; Scout, Al sensitive) in a hydroponic system. Parts of wheat roots were exposed to compartment A which contain 1/2 Hoagland nutrition solution with three concentrations of P (0, 25, 250μM) and parts exposed to compartment B which contain –P 1/2 Hoagland nutrition solution. After 2ds, the roots in compartment B were exposed to 25μM Al. Result show that as P concentration increased in compartment A, the root apex Al content (0-10mm) in compartment B was decreased while P content increased. However, root hair was found in root tip from picture. To eliminate the influence of root hair, we compared the Al content of root apex in (0-2mm), we found that in this part of root tip (0-2mm), which Al increased as P increased. We conclude that without Al-P precipitation in solution phosphorus aggravated aluminum toxicity in wheat by eliminate the influence of roots hair.

Keywords：*Phosphorus aluminum split root*

P4-360

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Reducing Nitrate Leaching and Improving Nitrogen Use Efficiency for Wheat Corn Double Cropping Systems in the North China Plain

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The North China Plain (NCP) is the most important wheat and maize production region in China, which produces over 20% of nation's food supply. However, excess fertilizer application and overdraft of aquifers for irrigation have caused contamination and depletion of groundwater in the NCP. Therefore, accurate estimation of nitrate leaching flux in deep vadose zone is essential for the efficient and sustainable groundwater protection in the North China Plain. This study was conducted at the Luancheng Agro-ecosystem Experimental Station (37°53' N, 114°41' E, elevation 50 m) of the Chinese Academy of Sciences. Soil water transportation and nitrate leaching in deep vadose zone were measured in a twelve-meter deepth well. The pressure transducers (Watermark probe, Campbell co., USA) were employed to determine soil matric suction at 8.75 m, 9.25 m, 10.75 m and 11.25 m depth, respectively, for the calculation of the corresponding water potential gradient. Soil water contents and matric suctions were recorded by TDR100 system (Campbell co., USA) automatically every six hour from August 2009 to December 2012. Unsaturated hydraulic conductivity was determined by an evaporation measurement device (HYPROP, HYdraulic PROPerty analyzer, UMS co., Germany) in laboratory. Darcy's law was employed to estimate the water flux in the unsaturated zone. Soil water was collected by a portable vacuum pump from suction cups every 2 weeks, the suction cups were inserted 80cm into the soil from the well wall at 9 and 11 m depth. NO3--N in soil solution was measured by an automated flow IV injection analysis. The results showed that in the North China Plain with a thick vadose zone, consecutive precipitation and irrigation could influence soil water content at 9 m and 11 m depth with a time lag. Water potential gradients were positive value at 9 m and 11 m, which indicated that soil water always moved downward in the measurement period. The vertical water infiltration rate at 9m and 11m were 16.3mm yr-1 and 4.4mm yr-1. The nitrate leaching losses were 5.7kg ha-1 yr-1 and 1.1 kg ha-1 yr-1. The best N managements for improving nitrogen use efficiency and increasing crop yield were proposed.

Keywords：*Nitrate leaching, Nitrogen cycling, Nitrogen use efficiency, North China Plain*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Development of the Diffusive Gradients in Thin-Films (dgt) Technique to Measure Plant-Available Potassium in Soils

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Potassium (K) is one of the most important macronutrients for crop growth and is usually applied to soils as granular muriate of potash (KCl) fertilizer. Therefore, an accurate soil K test before seeding plays an important role in optimizing crop yield by means of guiding fertilizer application. However, the current methods used for soil K testing are based on chemical extraction procedures which have shown to be soil-type dependent and the predictive relationship between soil test value and crop responsiveness to K application across a broad range of soils is generally poor. The diffusive gradients in thin films (DGT) technique, based on diffusion theory, has been extensively used to measure metal elements in environments and successfully applied to measure available phosphorus (P) in soils. It was found to be more accurate in predicting crop P requirements compared to traditional chemical extraction methods. To explore the potential of using the DGT technique for measuring available K in agricultural soils, we modified the resin gel by mixing Amberlite and ferrihydrite which provides an even distribution of Amberlite throughout the resin gel. The elution and uptake efficiencies of the mixed Amberlite and ferrihydrite (MAF) gel for calcium (Ca), K, magnesium (Mg) and P were determined and the diffusion coefficients of Ca and Mg through the diffusive gel were measured. The MAF gel enables the DGT device to measure Ca, K, Mg and P simultaneously. To assess potential cation competitive effects, DGT devices containing the MAF gels were deployed in solutions containing Ca^{2+}, K^{+}, Mg^{2+} and/or NH_4^{+}. At high concentrations of these ions, saturation of the resin gel reduced K diffusion towards the gel, but infinite sink conditions could still be achieved by using shorter deployment times. Lowered but consistent diffusion coefficients of K calculated in solutions containing these cations than solution with K alone were observed. The diffusion coefficient of K in soil testing using the DGT technique was determined to be 1.12×10^{-5} cm^2 s^{-1} at 25 ℃, which was 80% of that in K solution alone. The elution efficiency of K from the MAF gel was 85%, taking into account the presence of the competing cations in soils. In some soils high Ca concentrations will affect the acquisition of K by the DGT device using the MAF gel. However, this problem can be avoided by using a short deployment time as well. A glasshouse trial to examine the responsiveness of wheat growth to different rates of K fertiliser was performed, and the performance of several soil tests to predict responsiveness was evaluated. Available K in soil was measured before seeding using the DGT method and the traditional methods including $CaCl_2$, Colwell and NH_4OAc extraction methods. The correlation of wheat relative yields with soil testing results in control soils showed Colwell (R^2=0.80) and NH_4OAc (R^2=0.72) methods were more accurate than the $CaCl_2$ and the DGT methods. However, the uptake of K by wheat under glasshouse conditions in small volumes of soil is markedly different to uptake under field conditions where root densities are much lower. Using a mechanistic model of K uptake, it can be shown that soil tests which measure the quantity of K in soil (e.g. exchangeable K, Colwell-K) are much more likely to correlate with crop responsiveness at high root density. On the other hand under field conditions with lower root densities, crop responsiveness to K fertilizer is much more likely to be related to measurement of K intensity (i.e. DGT-K and $CaCl_2$-extractable K). This will be subsequently tested in experiments examining the effect of root density on relationships between soil test values of "available K" and crop responsiveness to K fertilizer. The results indicate that caution is needed when examining the utility of soil tests to predict crop responsiveness to K fertilizer under glasshouse conditions.

Keywords：*DGT, potassium, diffusion, soil testing, Amberlite*

P4-362

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Influence of Abattoir Wastewater Irrigation on Soil Fertility and Root Phenotypes of Two Different Plant Species

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Rhizosphere region and the characteristics of roots play a vital role in plant growth and development, through water intake and nutrient uptake. Assessment of above ground changes in plant growth and biomass yields are commonly measured parameters, whereas knowledge on phenotypic characters of the plant in soil is limited. The examination of root characteristics will elucidate the effects of abattoir wastewater irrigation on the plant root phenotype. This paper will focus on plant root phenotype of two different species (Pennisetum purpureum and Medicago sativa) grown on soils irrigated separately with abattoir wastewater and tap water. The overall objective is to measure the proportion of above and below ground changes of plants grown in soils irrigated with wastewater.

The soil used in this study was calcareous and was fertile due to wastewater irrigation; with Total nitrogen (N) concentration at 2080 mg/kg, Total phosphorus (P) concentration up to 489 mg/kg and Potassium (K) concentration was up to 4081 mg/kg. In this study, Pennisetum purpureum and Medicago sativa were tested. The roots of the plants were harvested at the same time of shoot harvest by destructive harvest method, after 120 days of sowing. The plants were grown in a controlled environment and treated with wastewater and tap water. The root images were scanned after soaking the roots in water overnight and washed carefully to achieve zero soil particles on root surface. This is a prime step in root analysis, because the presence of soil particles can cause error in the root analysis. These scanned root images were pre-processed by RGB (Red, Green, and Blue) format to grey conversion and adaptive thresholding; and finally analysed using root image software (Win-Rhizo, Regent Instruments Inc. Canada). In this study, seven root phenotypic characters were identified and measured. Root phenotypic characters include: root length, surface area, average diameter, length per volume, root volume, forks crossings and number of tips.

The overall results show that wastewater irrigation can cause significant changes in the root characters. A considerable variation in root structure has been observed in between treatments and within the species used. In particular, the root length and number of root tips showed considerable differences between wastewater and tap water treated. The root length of Pennisetum purpureum grown in wastewater was 2671 cm plant-^{1}, which was comparatively lower than tap water irrigated plant 3765 cm plant-^{1}. Similarly, the root volume of Medicago sativa with wastewater irrigation was 1936 cm^{3} pot-^{1}; and tap water was 1555 cm^{3} pot-^{1}. Also a considerable change had been recorded in number of forks and crossings. The increased soil nutrient load has shown positive effects on above ground parts by increasing high biomass production but was less active in below ground in wastewater treated plants. Therefore, wastewater irrigation to the plants grown on calcareous soil improved the fertility of soil by adding plant essential nutrients and hence the root structure was not diversified as seen in tap water irrigation. This can be attributed to the readily available nature of the nutrients from the wastewater compared to tap water, where there is a limitation in nutrient supply.

Keywords：*wastewater, nutrients, roots phenotype, 2D and root system architecture*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Foliar Application of Potassium Mitigates Negative Impact of Water Deficit Stress and Improves Physiological Growth of Mungbean (Vignia Radiata)

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Water deficit is one of the most important abiotic stresses affecting crop production throughout the arid and semi-arid regions of the world. Among the various strategies to cope with drought stress, potassium (K) application can have beneficial effects on plant growth. However, certain soil minerals have ability to entrap the soil applied potassium. In order to overcome this problem, foliar application of K may prove a viable strategy to alleviate water deficit stress in plants. Keeping in view this scenario, a pot experiment was conducted to assess the effects of foliar application of K on the growth of mung bean (Vignia radiata) at different soil moisture regimes. Water deficit stress was imposed by applying irrigation after 1, 3 and 5 days interval. Foliar application of K was performed either once or twice after 30 and 40 days of plant establishment. A total number of twelve treatments were replicated thrice and experiment was arranged in a Completely Randomized Design. Moisture stress had a negative effect on all the plant growth parameters. However, it resulted in more allocation of photosynthates to underground plant parts. Nonetheless, foliar application of K improved stomatal conductance and photosynthesis rate. Moreover 27 % increase in shoot dry weight was observed when K was applied under moisture deficit conditions. However, further studies under various soil and climatic conditions are needed to be evaluated.

Keywords：*potassium, moisture deficiency, mungbean*

P4-364

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Changes in Soil Nutrient Supplying Capacity of Organic and Conventional Cultivation

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In our comparative greenhouse experiment we examined the effect of EM- 1 microbial yield enhancing vaccine, an organic cow manure and an NPK fertilizer on the nutrient supplying capacity of the soil. The test plant was onion (Allium cepa L.) and the applied soil was humic sandy soil. During the experiment 4-4 onions were grown in pots containing 2.5 kg soil. 15 pots got (NPK) fertilizer application, another 15 pots treated with organic cow manure (Bio.1.), and again 15 pots with wheat straw and yield enhancing vaccine (EM- 1) (Bio.2.). 15 pots got no treatment (control). The onions were harvested at marketable onion state (green onions). We collected the plant and soil samples.

The dry matter producion and the element content of plant samples were also determined, from which the element uptake was alculated. We also determined the amount of readily available nutrients for the soils of several treatments.

From the soil samples the 0.01M CaCl2 soluble Mg, K, Mn, NO3- -N, NH4+-N, PO43—-P contents and pH were determined. The ammonium lactate soluble soil fractions were also measured .

From the experiment we drew the following coclusions:

• The increasing effect of NPKfertilizer on the yield was greater than that of organic manure and EM - 1 + straw.

• The soil pH reduced in the growing season as an effect of NPK fertilizers, which can cause problems in other cultivations, while he other two treatments did not change or slightly increased the soil pH.

• The 0.01 M CaCl2 soluble Mn concentration of the soils increased in the fertilized treatment by the end of the growing season. This can be explained by the change of soil pH.

• The s 0.01 M CaCl2 soluble Mg concentration of the bio -managed soils hardly changed at the end of the growing season, thus these soils can provide adequate amounts of magnesium for plants in the next growing season as well. The organic fertilizers are ' complex fertilizers' that supply macro-and microelements as well. In case of NPK fertilized soil treatments the 0.01 M CaCl2 soluble Mg content of the soil decreased due to the cultivation, so magnesium must be replaced by long-term cultivation.

• The amount of extracted mineral nitrogen and phosphorus proved the fact that

in case of organic treatments the soil organic matter mineralization becomes faster due to the intensified soil microbial life.

By comparing certain soil parameters we would like provide further data on how the nutrient supplying capacity of the soil changes in different cultivation methods.

Keywords：*biofertilizer, NPK fertilizer, sandy soil, nutrients*

P4-365

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Assessment on the Effects of Nutrient Management Practices on Some Chemical Soil Properties and Macro Nutrient Status Under 3 Successive Years of Baby Corn Production

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In response to increasing consumption of green foods, more Thai farmers gradually change their production practices to organic farming. This study was designed to assess changes in soil properties due to switching nutrient management practices for baby corn production from conventional farming to organic farming. The experiment was performed on an experimental plot of Kasetsart University, Kampaeng Saen Campus. The soil was sandy loam texture and medium fertility. Three crops were planted per year during 3 successive years. Quantity of fertilizer nutrients adding into soil were assigned based on results of soil analysis and according to corn plant requirement. The amount of nitrogen was used to define the treatments. Sources of N were from chemical fertilizer and cattle manure. Rates of N application was 30 kg N/rai for the first year, and being 20 kg N/rai for the second and the third year, respectively, and the two rates are assigned as the 1 N treatment. Experimental layout was completely randomized design with 7 treatments and 4 replications. Treatments were as follow; T1 control, T2 chemical fertilizer 1N, T3 and T4 cattle manure 1N and 2N, respectively, T5, T6, and T7 were; green manure, green manure with 1N from cattle manure, and green manure with 2N from cattle manure, respectively. For treatments 1-4 baby corn was planted 3 crops in a row, and treatments 5-7 green manure crop was planted in the first year followed by 2 successive baby corns. The average contents of N, P2O5, and K2O of cattle manure were 1.60, 1.44, and 1.80 %, respectively, organic matter was found to be 43.05%, EC (1:10) 2.77 dSm-1, pH (1:10) 7.53, and C/N ratio of 16:1. Jack bean Canavalia ensiformis (L.) DC. was planted as green manure. At 50% blooming stage it was plowed into soil. Accumulation of N, P2O5, and K2O in the legume before incorporating were 21.38, 9.58, and 21.73 kg/rai, respectively. Data on growth and yield were collected together with samples of soils from 0-15, and 15-30 layers before and after harvesting of each crop. The results indicated no significant changes in soil properties after the first corn crop. However, changes began to be detected after the following corn crop. It seemed that changes in soil properties were gradually, being more evident and faster response to treatments in top soil than in the subsoil. Continuous cropping decreased soil pH in every treatment. EC values of soil in chemical fertilizer treatment were higher than organic fertilizer treatment especially in 15-30 cm layer. Considering changes in soil organic matter, bioavailable P, and exchangeable K, less change was found in soil of control treatment nevertheless crop production decreased. For soils in fertilized treatments the contents changed according to the amounts received. Group of cattle manure application treatments had higher organic matter, bioavailable P, and exchangeable K than chemical fertilizer treatment and green manure treatment. Even though total N application of cattle manure and chemical fertilizer was equal, it was found that the later caused higher growth and yield. Treatments of green manure plus cattle manure produced higher growth and yield than sole cattle manure. Although cattle manure contained both the fertilizer nutrients and micronutrients and continuously released them to soil but failed to accommodate the amount of N required by corn plants during exponential growth phase. The incompatible nutrient ratio in cattle manure (N:P2O5:K2O=1:0.9:1.1) and plant nutrient accumulation ratio (N:P2O5:K2O=1:0.5:1.5) caused the plant to utilize less amount of P and K released into soil from decomposition process. This might respond to residual of organic matter and such nutrients in top soil. Reduction of cattle manure application may reduce residual nutrients in soil but decrease in crop production has to be considered. The data pointed out that heavy application of N promoted growth with low response on yield. But inadequate supply of N may, in turn, caused reduction on yield. It was concluded that nutrient content ratio in organic fertilizer, rate of decomposition, kind of crop and its nutrient requirements is the crucial information in organic farming practice. Mixed cropping or between row multiple cropping to utilize residual nutrients and accumulate them in form of biomass thus reduce nutrient leaching loss and profit/cost enhancement were recommended.

Keywords：*nutrient management , baby corn, soil properties, organic farming*

P4-366

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Yield Increase Efficiency Caused by Recycled Nutrients and the Contribution of Fertilization Development to Yield Production and their Geographic Differentiation

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The nutrient recycling in agro-ecosystem is the tradition of Chinese agriculture. However, with the application of chemical fertilizers, the nutrient recycling system has been ignored since 1950s in China. In recent years, the importance of the organic manure is increasingly apparent with the rapid development of pollution-free agriculture. However, because of the limitations of experimental approaches, the effects, which are important in both theory and practice, of environmental conditions have not been fully investigated. Because the previous studies mainly investigated the effects of organic manure on crop yield, but the amount of organic manure applied has not been considered based on the internal nutrient recycling. Therefore, the results were not sufficient to explain the yield increase caused by nutrient recycling.

Though fertilization is essential and important in the current agricultural production, many other factors also influence the crop yield, which include agriculture management technology and various natural conditions, such as precipitation. Therefore, it is very difficult to evaluate the effect of fertilization on crop yield without considering other factors.

Field experiment might be an approach to evaluate the contribution of various fertilization approaches to the food production in China precisely. In the experiment, the basic fertilization systems in different periods of China after 1949 have been simulated. The fertilization developments over time were transformed to fertilization approaches in various fields where the fertilization systems can be compared at the same time. Meanwhile, other factors, such as farming approach, crops, and pest control, were maintained relatively constant in experiments. Thus, the geographic variation could be further studied by running the field experiments under the same design at different fields in different regions at the same time.

In this work, based on the results at three different sites, Hailun, Shenyang, and Taoyuan, from the north to the south, the regional variation pattern of crop yield increase by nutrient recycling, as well as the contribution of various fertilization approaches to crop production and its geographic variations, was investigated.

The results showed that the fluctuation of yield caused by the different climate years was significantly decreased by the application of recycled nutrients. The results also indicated that the yield increase caused by recycled nutrients in agro-ecosystems was significantly affected by the application of chemical fertilizer and the thermal condition of climate. In the case of no chemical fertilizer, the average increase of crop yield caused by recycled nutrients with 80% recycling rate ranged from 223 kg hm-1 (average of eighteen years) at Hailun Station (in temperate zone) to 1041 kg hm-1 (average of fifteen years) at Shenyang station (in warmer-temperate zone) and 3063 kg hm-1 (average of eleven years) at Taoyuan station (in subtropical zone) respectively. A11 the results showed that there was a remarkable geographic differentiation of yield-increase efficiency caused by recycled nutrients. The results of long-term field experiments at three stations in different areas of China also indicated that the contribution of fertilization to crop yield was significantly affected by the thermal condition of climate and the fertilization system. In the case of optimum fertilization, the largest contribution rate was 0.32 (average of eighteen years) at Hailun Station, 0.42 (average of fifteen years) at Shenyang Station, and 0.45 (average of eleven years) at Taoyuan Station, which implied that the existence of geographic differentiation was caused by the thermal condition of local climate. Therefore, keep the optimum fertilization systems, the largest contribution rate to crop yield could be estimated from 30% to 50%, depending on the local climate condition and with no change of other technique adopted in farming. The interaction of fertilization and thermal factor between Shenyang and Taoyuan was much bigger than that between Shenyang and Hailun. The interaction between organic manure and thermal condition of local climate was bigger than that between chemical fertilizer and thermal condition of local climate.

Keywords：*Agro-ecosystems, recycled nutrients, Geographic differentiation, Contribution of fertilization*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Fate of Nitrogen from Organic and Inorganic Fertilizers in Irrigated Lowland and Upland Rice Ecosystems

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Issues addressing health and global warming are now the main focus all over the world. In the Philippines, Republic Act No. 10068 also known as the Organic Act of 2010 was enacted to promote, propagate, develop further and implement the practice of organic agriculture. Organic agriculture dramatically reduces external inputs by refraining from the use of inorganic fertilizers, pesticides and pharmaceuticals. Recent field trials on irrigated lowland rice still show that highest grain yield is obtained from plots applied with recommended rates of inorganic fertilizer. Reducing the recommended rate by one-half and applying biofertilizer did not significantly reduce grain yield (Castillo and Mamaril, 2012). This study was conducted to validate the effect organic fertilizers applied alone or in combination with inorganic fertilizers on grain yield and grain quality under irrigated lowland and upland conditions. Moreover, 15N labeled chemical fertilizers were used to monitor the fate of applied nitrogen and to quantify the amount of N contributed by the different sources. The treatments that were evaluated were: T1, no fertilization; T2, recommended rate using inorganic fertilizer; T3, chicken manure (CM) alone; T4, commercial organic fertilizer (COF) alone; T5, ½ CM + ½ inorganic fertilizer; T6 – ½ COF + ½ inorganic fertilizer; and T7, ½ inorganic fertilizer. 15N labeled urea (5.07 atom%) was used under upland conditions while 15N labeled ammonium sulfate (1.2 atom %) was used in irrigated lowland rice. Results of the field trials showed that application of the recommended rate using inorganic fertilizers (T2) produced the highest grain yields both under irrigated lowland and upland conditions. Combined applications of inorganic and organic fertilizers (T5 and T6) produced comparable yields with T2. Application of organic fertilizers alone (T3 and T4) resulted in significantly lower yields which are comparable with the no fertilizer treatment (T1). For grain quality, application of inorganic fertilizers (T2) under lowland conditions resulted in significantly lower percentage head rice. The percentage of immature grains tended to be higher in treatments with inorganic fertilizer (T2 under upland condition. The use of 15N labeled fertilizers showed higher recovery of applied inorganic fertilizer in rice grains. Lower 15N recoveries were obtained from the combined application of inorganic and inorganic fertilizers (T5 and T6) as compared to T7. Higher losses of applied inorganic N were noted under upland conditions as indicated by lower 15N recoveries in grains, straw and soil.

Keywords：*nitrogen, lowland rice, upland rice, organic, inorganic*

P4-368

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Lanthanum and Cerium on Root and Shoot Growth of Cucumber (Cucumis Sativus)

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The most studied rare earth elements (REEs) are Lanthanum (La) and Cerium (Ce). While conflicting results obtained from different studies led to difficulties in establishing the role of REEs in plants, researchers agreed that different plants have different responses to inclusion of REEs. One of the most studied crops is cucumber (Cucumis sativus), but not for REEs. REEs have been found to promote germination of seeds, stimulate root growth, increase chlorophyll and enhance resistance of crops. Role of REEs on cucumber growth have yet to be identified. This study was conducted to elucidate the role of REEs, particularly La and Ce on root and shoot growth of cucumber. A pot experiment using different concentrations (0.1 ppm, 0.5 ppm and 2.5 ppm) of La and Ce was conducted in the screen house of the Institute of Biological Sciences, University of the Philippines Los Baños (UPLB) in 2012 to study the effects of La and Ce on the growth of cucumber. Results showed that both La and Ce can increase plant height and root length of cucumber. Application of 0.1 ppm La increased height and root length, significantly. However, significant increase in height and root length was only attained after the application of higher concentrations (0.5 ppm to 2.5 ppm) of Ce. Between La and Ce, La had more significant influence on the root and shoot growth of cucumber.

Keywords：*Cerium, Lanthanum, cucumber, rare earth elements*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil Test Crop Response Correlation Studies Under Integrated Plant Nutrition System for Cotton through Drip Fertigation on Inceptisol

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Nutrient management is a major component in intensive high yielding cropping system because of the increasing energy cost and economic pressure. With increasing demand for the cultivation of commercial crops like cotton, it is essential to adopt Soil Test Crop Response based Integrated Plant Nutrition System (STCR-IPNS) under drip fertigation in order to increase the productivity with sustained soil fertility and to mitigate the problem of water shortage. Therefore, this investigation elucidates the relationship between soil test values and crop response to added fertilisers, formulates fertiliser prescriptions under IPNS by targeted yield model, evaluates the extent of fertiliser input saving under IPNS, and validates the fertiliser prescription and post- harvest soil test values prediction equations for cotton.

The gradient and test crop experiments were conducted during 2011-2012 and test verification trial during 2012-2013 in the Eastern Block of TNAU Farm, Coimbatore on Periyanaickenpalayam soil series (Vertic Ustropept). Following the Inductive methodology, variations in soil fertility were created in the gradient experiment with fodder maize. The test crop experiment was conducted with transgenic cotton (RCH 530 BG II) under drip fertigation. The treatments consisted of four levels of N (0, 60, 120 and 180 kg ha-1), four levels of P2O5 (0, 30, 60 and 90 kg ha-1), four levels of K2O (0, 40, 80 and 120 kg ha-1) and three levels of FYM (0, 6.25 and 12.5 t ha-1). There were 21 fertiliser treatments along with three controls, randomized in each strip such that, all the treatments occurred in both directions following the Fractional Factorial design.

Irrespective of the fertility strips, there was a progressive increase in response with increase in the levels of fertilizer N, P2O5 and K2O and FYM; initial soil fertility and IPNS also had profound influence on the yield and uptake by cotton. Using the experimental data, the basic parameters viz., NR, Cs, Cf and Cfym to total uptake of nutrients by cotton were computed and Fertilizer Prescription Equations (FPEs) under NPK alone and IPNS were developed as furnished below:

NPK alone NPK+ FYM (IPNS)

FN = 8.51 T - 0.47 SN FN = 8.51 T - 0.47 SN-0.73 ON FP2O5 = 4.41 T – 2.25 SP FP2O5 = 4.41 T – 2.25 SP -0.75 OP

FK2O = 6.59 T - 0.18 SK FK2O = 6.59 T - 0.18 SK – 0.66 OK

where, FN, FP2O5 and FK2O are fertilizer N, P2O5 and K2O in kg ha-1, respectively; T is the yield target in q ha-1; SN, SP and SK respectively are alkaline KMnO4-N, Olsen-P and NH4OAc-K in kg ha-1 and ON, OP and OK are the quantities of N, P and K supplied through FYM in kg ha-1.

Nomograms were formulated for a range of soil test values under NPK alone and IPNS for desired yield target of cotton. When NPK was applied along with FYM @ 12.5 t ha-1, the extent of saving was 40, 20 and 34 kg of fertilizer N, P2O5 and K2O, respectively for cotton resulting in economy of fertilizer use under IPNS. The post-harvest soil test values (PHSTVs) prediction

equations were developed and can be used with confidence for making the soil test based fertiliser prescriptions for the succeeding crop in the sequence.

The test verification trial conducted revealed the validity of the fertilizer prescription and PHSTVs prediction equations. The yield target of STCR-IPNS for 40 q ha-1 of cotton proved its superiority over all other treatments in terms of yield, response ratio, BCR and quality parameters. This treatment had recorded an yield increase of 62.4 and 65.6 per cent respectively over blanket and farmer's practice. Both observed and predicted soil test values clearly broughtforth the fact that soil test based fertilisation resulted in buildup of soil fertility and the magnitude of build up was higher with STCR-IPNS as compared to STCR-NPK alone, blanket and farmer's practice.

Therefore, it could be concluded that targeting of 40 q ha-1 for transgenic cotton under IPNS through drip fertigation is found to be ideal in terms of yield, response ratio, benefit cost ratio, quality parameters and soil fertility maintenance on Perianaickenpalayam soil series (Vertic Ustropept) of Tamil Nadu.

Keywords：*STCR-IPNS, fertiliser prescriptions, prediction equations*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Influence of Different Soil Texture on Growth and Nutritional Status of Three New Latex Timber Clones of Natural Rubber (hevea Brasiliensis)

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Rubber tree or Hevea brasiliensis has been main source of natural rubber since last century. Demand for natural rubber has increased tremendously with increasing of crude oil price and other factors. Rubber tree has been planting into marginal soil due to competition with other crops and property development. It is important to use fertilizer efficiently in order to reduce cost of production and optimize the plant growth. Hence, a nursery trial has been carried out to assess performance of three new latex timber clones (RRIM 2001, RRIM 2025 and RRIM 3001) grown on two type of soil texture, clayey and sandy soil. Soils used were Munchong Series (Typic Hapludox) and Holyrood Series (Typic Kandiudult). Several physical and chemical properties of soil were analyzed before and after the study. Fertilizer were applied at current recommendation rate, 18.75 kg/ha using compound fertilizer, RISDA 1 (10.7: 16.6: 9.5: 2.4). After a year, growth (height and girth) were measured and leaves nutritional status (N, P, K and Mg) was analyzed. Results show the texture of soil influence the physical and chemical properties of the soil. Sandy soil, Holyrood Series has low CEC (4.7 cmolc kg-1) than clayey soil, Munchong Series (8.1 cmolc kg-1); would retain much lower nutrient applied from the fertilizer to be available for plant. Initial nutrient status in the soil, total C (1.6%, 0.4%), total N (0.13 %, 0.09%), Available P (250 cmolckg-1, 300), K (0.9 cmolckg-1, 0.7cmolckg-1) and Mg (2.5 cmolckg-1, 0.9 cmolckg-1) for Munchong and Holyrood also show differences respectively. Plant growth also shows some differences. Plants grown on Munchong were significantly higher than plant grown on Holyrood. Girth also shows similar results. Clones from RRIM 3001 shows better performance compared to others. From leaf nutrient analyzed, plant grown on Holyrood significantly lower value compared to plant grown on Munchong series soil. Some of plants show visual symptoms of nutrients deficiencies. It also observed that plant from clone RRIM 3001 more susceptible to magnesium deficiency. It can be concluded that heavy texture, clayey soil, Munchong series much better than light texture, sandy soil, Holyrood series in providing and retained nutrients for plant growth. Based on height and girth, rubber clones, RRIM 3001 performs better than other two clones. Performance of new latex timber clones can be ranked as follow: RRIM 3001>RRIM 2001>RRIM 2025. Different management practice should be carried out for different soil texture.

Keywords：*Clayey, Sandy, Nutrient, Deficiency, Hevea*

P4-371

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluation of Nitrogen Availability Indices and their Relationship with Plant Response on Acidic Soils of India

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A reliable estimate of the soil's nitrogen (N)-supplying capacity (NSC) is essential for determin¬ing the rate of N fertilizer application required to optimize crop yield and quality, and to minimize the adverse impacts of excess N on environment and farm economy. Among the numerous methods proposed for assaying NSC, biological methods (aerobic and anaerobic incubation) are considered to be the most reliable, as their results are highly correlated with the yield and plant N uptake (PNU). However, since biological methods are highly time consuming and tedious, they are not considered suitable as routine tests. In pursuit of developing a rapid, yet reliable, index of soil N availability, many chemical indices have evolved over time, but no single method has performed consistently enough to receive broad acceptance across a wide range of soils. In this study involving a pot experiment with twenty acidic soils varying widely in proper¬ties, we evaluated six chemical indices of soil N-availability viz. organic carbon (Corg), total N (Ntot), acid and alkaline-KMnO4 extractable-N, hot KCl extractable-N (KCl-N) and phosphate-borate buffer extractable-N (PBB-N), based on their strength of correlation with available-N values obtained through aerobic incuba¬tion (AI-N) and anaerobic incubation (ANI-N), and also with the dry matter yield (DMY), N percentage and plant (maize) N uptake (PNU). In general, the soils showed large variability in NSC as indicated by vari¬ability in PNU which ranged from 598 to 1026 mg/pot. Correlations of the N-availability indices with AI-N and ANI-N decreased in the order: PBB-N ($r = 0.784^{**}$ and 0.901^{**}) > KCl-N ($r = 0.773^{**}$ and 0.743^{**}) > acid KMnO4-N ($r = 0.575^{**}$ and 0.651^{**}) ≥ Corg ($r = 0.591^{**}$ and 0.531^{**}) ≥ alkaline KMnO4-N ($r = 0.394^{**}$ and 0.548^{**}) > Ntot ($r = 0.297^{**}$ and 0.273^{*}). Of all the indices evaluated, PBB-N showed the best correla¬tions with plant parameters as well ($r = 0.790^{**}$ and 0.793^{**} for DMY and PNU, respectively). The two commonly used indices of N availability in India, namely Corg and alkaline KMnO4-N did not perform satisfacto¬rily when tested for acidic soils. Based on the highest correlations of PBB-N with biological indices as well as plant responses, we propose PBB-N as an appropriate index of N-availability in the acidic soils of India and other regions with similar soils.

Keywords：*Nitrogen availability indices, maize plant, yield response*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Subsoil Clay and Biochar on Leaching and Availability of Phosphorus in Sands

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Phosphorus (P) leaching in sand decreases fertiliser use efficiency and may limit agricultural production. Application of soil amendments with high active surface area such as clay and biochar can increase nutrient sorption and improve crop biomass and/or productivity on sands. Two types of biochars prepared from chicken manure or wheat straw containing 1.2% and 0.4 % total P, respectively. Additionally, pure kaolinite and clay-rich subsoil dominated by aluminium and/or iron oxyhydroxides at 50 t of clay/ha were selected as amendment materials for their contribution to improve P use efficiency of sandy soils in the south coast of Western Australia. The study in particular investigated the effect of these amendment materials on (i) sorption of additional P from wheat straw (WS) or chicken manure (CM), (ii) P concentrations in soil solution (iii) leaching of P, and (iv) uptake of P by wheat on grey sand collected. 54% more P was released from WS biochar than from CM biochar. After 5 successive desorption steps (with 0.01 M CaCl2), P in the soil solution in CM and WS biochar was 10 and 2 mg/L, respectively. These results suggest that P in biochar from WS and CM was readily soluble and was more prone to leaching losses, more rapidly from WS biochar. A pot experiment was conducted to determine how the addition of both biochar and clay to sandy soils would impact plant growth (wheat) and how it will affect the P balance and the soil properties in a short term study. Adding either kaolin or subsoil clay at 50 t/ha) with WS biochar or CM biochar (10 t/ha) decreased the amount of P leached with or without P fertiliser added. Addition of subsoil clay to sand was more effective and decreased the concentration of P in the leachate by 75 % as well as in the soil solution. Biochar greatly increased P in leachate as well as plant P uptake particularly with kaolinite clay with or without added P fertiliser. The extractable P concentration in sand significantly decreased with clay-rich subsoil addition and biochar suggesting that these have significant P sorption. Wheat straw biochar seemed to increase plant P availability more than CM even though the latter had higher P content. P stored as extractable P was higher in the soil with clay and biochar amendment. Plant P uptake was not significantly changed by adding fertiliser even though the clay and biochar addition increased P uptake. In this experiment soil was fractionated. Of the total soil P There was 41% was HCl-Pi, 30% was labile-Pi and 29% was NaOH-Pi. Phosphorus uptake and the HCl-Pi fraction were strongly correlated (P=0.03). Most of the Ca-bound P was in the 1 M HCl fractions thus the portion of P in CM extracted with 1 M HCl could be more labile than the same portion of P in soils. Kaolinite and WS biochar and combination of them increased the Labile-Pi extract in the soil which in turn was significantly (P=0.01) correlated to P uptake. Phosphorus in the biochars was readily available but also prone to leaching. Addition of clay/subsoil along with biochar maintained adequate P supply to meet the plant P demand but also retained P in forms less susceptible to leaching suggesting that combination of both biochar and clay improved P use efficiency on sand. The labile-Pi and HCl-Pi were plant available P fractions in amended sands.

Keywords：*Phosphorus, Biochar, Phosphorus availability, Phosphorus leaching, Subsoil clay,*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Different Compound Fertilizer Rates on Hevea Brasiliensis Grown on an Oxisol: Nursery Trial

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One of the important commodity crops that contributed a lot to Malaysia's economy was rubber tree or Hevea brasiliensis as this country was the biggest consumer of pure latex and the fifth in term of consumption of natural latex in the world. The precise usage of fertilizer is very important in rubber nursery establishment to ensure quality production of planting materials and optimization of fertilizing cost. This study will assess the current fertilizer suitability rate for latex timber clone and suggest fertilizer rate to be used in advanced planting materials nursery. The study was conducted using complete randomized design (CRD) with four replications. Four different rates of RISDA 1 compound fertilizer (10.7: 16.6: 9.5: 2.4) were used; T1 (0 g plant-1) act as control, T2 (50% or 18.75 g plant-1), T3 (100%: 37.5 g plant-1) and T4 (150%, 56.25 g plant-1). T3 (100%) were the rate recommended by the Malaysian Rubber Board (MRB). Soil used was a Typic Hapludox, Munchong Series. Data on growth such as height, girth and dry weight were taken. Tissue analysis was conducted at the end of the study. Results show that plants growth increased significantly with fertilizer application. Results show that K and Mg content were highest in T4 (150%) and significantly different from other treatments. Compared to established nutrient critical values for immature rubber, T4 met the nutrient sufficiency range for rubber, while current recommendation showed insufficient K and Mg. Visual observation also showed symptoms of nutrient deficiencies. From this study, based on biomass production and comparison of leaves nutrient with critical nutrient value, it can be concluded that the current recommended fertilizer rate were insufficient for the optimum growth.

Keywords：*Rubber, Fertilizer, Nutrient deficiency, Munchong Series,*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Genotypes, Nutrient- and Water-Supply on the Dry Matter Production and Potassium Uptake Dynamics of Maize (zea Mays L.) on a Chernozem Soil of a Long-Term Field Experiment in Hungary

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Nutrient supplying ability of the soil ideally should correspond to the needs of the plants. The aim of our research work is to study as precisely as possible, how the dynamics of growth and nutrient uptake of the plant develop during the vegetation period. For their determination the basis of our research work was a long-term fertilization and irrigation monoculture maize field experiment that has been set up in 1984 near to Debrecen, Hungary. The soil of the experiment is a medium-heavy, loam texture calcareous chernozem type based on loess. The humus soil layer is about 70-90 cm. The natural nitrogen supply of the soil is sufficient, the phosphorous supply is rather weak and the potassium supply is medium. Its upper 30 cm layer has become leached due to the intensive production in the past decades, so it doesn't content any significant lime-amount. Therefore, under stressed conditions (drought, soil acidity) it is in some extent less able to buffer and compensate the negative effect of the unfavorable circumstances. The soil pH is slightly acidic in the production layer, which is considered to be mostly favorable from the aspect of nutrient-mobilization and -uptake. The minimal water retention capacity is 27-29 V/V%. This field represents the production circumstances of the chernozem soils in the region of Eastern Hungary with excellent productivity.

The experimental site consists of two parts: the half of it can – in case it is needed – be irrigated, on the other half of the experimental field plants dispose only of the water amount from the natural precipitation and the soil´s moisture content. This enables us to follow and study the effects of the different crop-years, just as weather anomalies and we can gather information about the achievable yield-increment in case the plants' demand in the critical periods is satisfied. Three different hybrids have been chosen for the study, the length of the vegetation period of the different hybrids was taken into account (FAO-number). Hungarian-bread hybrids with different long vegetation periods were used: Mv 251 (FAO 280), Mv Koppány (FAO 420) and Mv 500 (FAO 510). The reason for that was that according to our hypothesis and knowledge there are differences in both the extent and the dynamics of their nutrient-uptake. In this small-plot experiment the rate of the applied nutrients is fixed. The effect of macro-nutrient fertilization is studied – beside the control – at five levels with fixed 1.0:0.33:0.73 N:P:K rate; the yearly applied N-doses are 0, 30, 60, 90, 120 and 150 kg N ha-1.

Plant samples were collected 7 times (year 2008) or 6 times (year 2009) during the vegetation period, and the above-ground dry matter and the P and K uptake of plants were determined. For characterizing and describing of the plant growth and nutrient uptake dynamics, several types of equation were analyzed. According to our results, the most suitable of them is the so-called "S-type"

(acceleration – saturation) equation as follows: y=A/(1+exp(-k*(x-x0)))*(1-b*x), where “y” is the actual value of the measured (dependent) factor on the day “x” after plant shooting, “A” is the maximum value of “y”, “x0” is the day of maximum growth rate of “y” (point of inflexion) and “b” is the rate of decreasing of dependent value for one unit; the real daily decreasing is by A*b to calculate.

According to our experimental results and calculations it can be concluded, that beside the previously used and considered soil and plant nutrient-content the consideration and calculation of the plant-extracted nutrient-amount – depending on the applied hybrid and other agrotechnological measurements – is suggested in order to be able to characterize precisely the nutrient-supply of maize. This parameter informs us not only about the available nutrient-amount at the sampling time, but about the supply level of the plants until the sampling time as well. We suggest taking following sampling times into consideration: the intensive vegetative growth period, the switch between the vegetative and generative growth phases (silking), just as the grain-filling phase.

Keywords：*Chernozem, Zea mays, biomass and potassium uptake dynamics*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evolution of Soil Fertility under Influence of Soil Erosion and Different Cropping Systems in North-Eastern Romania

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Investigations conducted on a Cambic Chernozem (SRTS - 2003) at the Agricultural Research Station of Podu-Iloaiei, Iasi County (47°12´ N latitude, 27°16´ E longitude) followed the influence of different crop rotations and fertilizers on water runoff and nutrient losses, due to soil erosion. These experiments were carried out on a 14 % slope field with clayey loam texture (423 g clay, 315 g loam and 262 g sand), a neuter to weakly acid reaction and a mean nutrient supply.

Within the experiment, the following rotation scheme was followed: wheat and maize continuous cropping, 2-year crop rotation (wheat-maize), 3-year crop rotation (peas-wheat-maize) and 4-year crop rotation (peas-wheat-maize-sunflower) + outside field cultivated with legumes and perennial grasses (Alfalfa + Lolium). For wheat and maize crops, from different crop rotations, three fertilization systems were applied: mineral fertilization with nitrogen and phosphorus rates until N160P100, manure fertilization (20, 40, and 60 t/ha), with and without mineral fertilization and mineral fertilizers + hashed residue applied in autumn before ploughing. The annual rainfall amounts, registered in the last 28 years, were higher, with values between 12.7 and 279.2 mm, compared to the long-term amount of precipitation (544 mm) in 18 years and lower by 25.3 - 236.7 mm in 10 years. The average yield increases in winter wheat, during 1985-2012, were between 23 and 27 % (648 - 762 kg•ha-1), due to crop rotation, and between 57 and 112 % (1108 - 2162 kg•ha-1), due to applied fertilizer rates. Applying high fertilizer rates (N160P100) in maize has determined, in the last 28 years, an average yield increase of 88 % (2904 kg•ha-1), while the use of low mineral fertilizer rates (N60P40), together with 30 t/ha manure, resulted in getting an yield increase of 92% (3036 kg•ha-1).

On lands from the Moldavian Plateau, maintaining a good supply in mobile phosphorus for field crops (37-72 mg•kg-1) was obtained in case of annual application of a rate of N100P100, and a very good supply in mobile phosphorus (72-78 mg•kg-1) and mobile potassium (over 200 mg•kg-1) was found at a rate of N100P100+60 t•ha-1 manure. In wheat-maize rotation, applying a rate of N100P100 , for 45 years, has determined the pH decrease until the limit of moderately acid interval (5.1-5.8) and was maintained within the weakly acid interval (5.9-6.8) in case of the annual application of a rate of N50P50 + 60 t•ha-1 manure. Soil organic carbon content, in wheat - maize rotation, decreased after 45 years of experiences from 19.8 to 15.8 g•kg-1 in unfertilized variant and until 17.9 g•kg-1 in case of the annual application of a rate of N100P100. In wheat - maize rotation, the significant increase in organic carbon content from soil has been registered on variants N50P50 + 40 t•ha-1 manure and at N100P100 + 60 t•ha-1 manure.

Analyzing the variants maize-continuous cropping and wheat-maize rotation, very significant values of the carbon content were found only in the organo-mineral fertilization, in 4-year crop rotations + reserve field cultivated with perennial legumes and under N160P100 fertilization. In comparison with 4-year crop rotations, with breeder plants (annual and perennial legumes and perennial grasses), in wheat-maize rotation the medium carbon content from soil has decreased from 18.9 to 16.2 g•kg-1C and the content in mobile phosphorus decreased from 52.6 to 35.8 mg•kg-1P-AL.

The 45 year use of 3 and 4- year crop rotations has determined the increase in total carbon mass and mobile phosphorus from soil by 12% (1.9 g•kg-1C) and 34%, respectively (14.8 mg•kg-1P-AL). The use of 3 or 4- year crop rotations with perennial grasses and legumes, which leave in soil great amounts of organic material, also contributes to decreasing soil, humus and mineral element losses; these are 2.7 times lower compared to the ones registered in maize and sunflower crops.

Keywords：*soil erosion, water runoff, fertilizers, manure, crop residues, organic carbon, cropping systems*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluation of the Aquacrop Model to Simulate Rice Growth under Different Water Regimes in Bangladesh

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Due to high consumer needs in the populous Bangladesh, food security and self-sufficiency demand that current rice productivity levels are at least maintained or rather increased in the future. However, there are ongoing pattern changes in the climate of the country, which poses extra challenges. Precipitation patterns are shifting, existing irrigation water resources are stressed, and adaptive measures will likely be necessary to meet food production needs. In order to explore potential adaptive pathways to sustain or increase rice production while increasing water use efficiency, a 2-year dry-season (boro) irrigation experiment has been set up at the research farm of the Bangladesh Rice Research Institute (BRRI) with three treatments: (a) continuous standing water, (b) irrigation 3 days after water disappearance, and (c) irrigation 5 days after water disappearance. The experiment was set up on bunded plots, allowing testing the performance (calibration and validation) of the 1-D AQUACROP simulation model in order to facilitate simulation-based scenario studies using this model. Model performance was examined using five commonly used performance measures that showed reasonable fit of the model to the recorded irrigation water need, canopy cover, biomass production and grain yield. When further tested for varied local field conditions, this widely applicable, user friendly and easy-to-parameterize simulation model may become a tool that helps increase the capacity of local rice growers to adapt to climatic and potentially other (e.g. economic) changes to the crop production environment through e.g. introducing water saving practices in place of traditionally used practices.

Keywords：*paddy rice, AQUACROP model, irrigation, water use efficiency, Bangladesh*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Factors Determining Silicon Uptake by Rice in Southeast-Asian Paddy Soils

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Introduction

Rice (Oryza sativa) is the staple food for more than half of the world´s population and rice demand is increasing due to the growing world population. Rice plants accumulate up to 10 % Si, which helps the plant to decrease biotic and abiotic stresses and the uptake of toxic metals and metalloids and to increase the efficiency of NPK-fertilizers.

Our study is embedded in the LEGATO-project (www.LEGATO-project.net), which aims to improve sustainability in rice production. LEGATO study sites are located in seven regions of Vietnam and the Philippines, which differ in climate, geology, soil, and agricultural practice. The overall objective of our work is to develop recommendations for an adequate management of the Si cycle as a component of sustainable rice production in contrasting regions. An improved management of the Si cycle might be an alternative for the extensive application of pesticides and NPK-fertilizers.

Herein, our objectives are (i) to assess plant-available Si in soils, (ii) to assess Si status of matured rice plants, (iii) to identify controls on Si uptake by rice, and (iv) to study the effect of increasing Si supply on rice growth.

Material and methods

In each of the seven study regions of 15 km x 15 km area, we have chosen ten paddies. We sampled paddy topsoils and extracted plant-available Si (Na-acetate-extract). In the sampled matured rice plants, Si concentration of straw, grains, and hulls were measured.

Additionally we conducted a pot experiment to investigate the relationship between Si availability in soils and Si uptake by rice. Rice was grown in two Vietnamese and two Philippine soils with two treatments, with and without the addition of silica gel, a source of rapidly dissolvable Si. Si concentration was continuously measured in the soil solution. Biomass production and Si concentration in shoots were assessed after 29 days.

Since rice variety can differ from farmer to farmer even within a region, we conducted a hydroponic experiment to investigate the influence of rice variety on Si uptake. We therefore grew one traditional (Tinawon) and one modern (IR 64) rice variety in two treatments, with and without the addition of silica gel to the nutrient solution. Plants were harvested after 28 days to measure biomass production and Si concentration in shoots.

Results and discussion

Plant-available Si concentrations in the fields were significantly higher in the Philippines than in Vietnam; differences between both countries are much larger than differences within the regions. We refer this finding to differences in geo- and pedologic conditions between both countries. In Vietnam, land surfaces are in comparison to the Philippines older and soils are stronger weathered and thus desilicated. In the Philippines, rocks were more recently formed due to active volcanism and high amounts of plant-available Si are released during mineral weathering. Also Si concentrations of rice plants were higher in the Philippines than

in Vietnam. Si concentration in straw positively correlates with concentration of plant-available Si up to a level of 9-10 % Si in plants and 0.3 g kg-1 acetate-extractable Si in soils. Higher concentrations of plant-available Si do not lead to an increase of Si uptake.

In the pot experiment, Si concentration in the soil solution was significantly increased by the addition of silica gel in all soils, even in the Philippine soils with high initial concentration of plant-available Si. Likewise Si uptake by rice was significantly increased by the addition of silica gel in all soils. Si concentrations of plants were equal in all soils after Si addition.

In the hydroponic experiment, Si concentrations of rice shoots under high Si supply differed significantly between both varieties; Si concentration was higher in the modern variety than in the traditional variety.

Conclusions

We conclude from our results that geo- and pedologic conditions are main determinants for Si availability over large geographical scales. Si uptake by rice is controlled by Si availability in soils and by rice variety. Especially in Vietnam, an increase of Si availability might largely increase Si uptake by plants, thus might improve rice growth and yield. Our subsequent research focuses on opportunities to improve Si supply to rice in Vietnam. Potential strategies might be Si fertilization and changes in harvest residue management.

Keywords：*silicon, rice, fertilizer, harvest residue management, Southeast Asia*

P4-378

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Adaptive Environmentally Friendly Grain Production Technology and Reproduction of Soil Fertility

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Two rotations effectiveness was evaluated in stationary experiments in GNU Tatar Agriculture Research Institute in 1997-2004 years. The first rotation grain-pair-grass: sidereal pairs, winter rye, spring wheat + alfalfa, alfalfa 1-3 year of use, spring wheat, oats (cover soils 50%). Second rotation - grain-pair-row: sidereal pairs, winter rye, spring wheat, peas, winter rye, corn, spring wheat, oats (62.5% grain, soil improvers 37.5%).

In rotations were tested the effectiveness of different fertilizer systems and basic soil tillage. Experiment on primary tillage included variants with moldboard plowing to arable layer depth (25-26 cm), cultivation without overturning (14-16 cm). Organic and mineral fertilizers system on their background was studied.

At the end of the rotation on the background rotation grain-pair-row plowing without fertilizers humus content decreased by 0.07 % (3.02% original content, was 2.95%). In grain-pair-grass rotation in all its variants recorded a positive balance. On the background without fertilizer humus content at the end of the rotation was 3.25% with initial content of 3.10% (an increase of 0.15%). Nitrogen , P2O5, K2O content in the soil was greater in grain-pair-grass rotation in comparison with grain-pair-row on 10,7-24; 50-51, 20-30 mg/kg soil , respectively.

In general, during 8 field crop rotation with three fields of alfalfa without fertilizer humus content increased according to RS Shakirov depending on tillage system by 0.15 ... 0.21%, nitrogen - 4.6 ... 7.1 mg/kg, available phosphorus (P2O5) - 22.5 and 25, exchangeable potassium (K2O) - 5 ... 14 mg/kg, in relation to the initial indicators. Here the highest values correspond to the variant with cultivation without overturning.

In the present crop rotation humus accumulation without fertilizer was 660 kg/ha, and the use of organic-fertilizer system with the introduction of green manure and straw, it reaches 1.06 t/ha. Consequently, in crop rotation with three fields of alfalfa (or other legumes) can make humus mineralization without organic fertilizers. It should be noted that this is only possible when overground productivity of green matter at least 300 ... 350 kg/ha.

nd when plowing - decrease (0.07 %) due to increased mineralization during plowing. Application of organic-fertilizer system on the background of cultivation contributed to the increase of humus in the arable layer, compared to baseline, 0.33%. With intensive technology using only mineral fertilizers, as well as systematic moldboard tillage for crop rotation, humus content remained at baseline. Thus, the rotation grain-pair-row unlike grain-pair-grass make some fertilizer does not provide restoring soil fertility. In this regard, on gray forest soils in such rotations need organic fertilizers at the rate of 7 t/ha of arable land per year with the addition of the necessary calculated doses of mineral fertilizers.

In grain-pair-grass crop rotation using resource-saving technology (maximum use of biological agriculture factors, gentle soil tillage, organic fertilizers) yield reached 4.94 t/ha of grain units per year, with the plan of 4 t/ha of grain units. This required additional use of 16 kg/ha of active substance of nitrogen and 20 kg/ha of active ingredient of potassium.In the same crop rotation, in intensive classical technology to achieve productivity of arable land 4.55 t/ha of grain units per year (Plan - 4 t/ha) was required the annual introduction of 172.8 kg/ha of active ingredient (N68P16K89).

In grain-pair-row crop rotation for 4 t/ha of grain units (obtained by 4.52 t / ha of grain units) using alternative technology was used 106 kg/ha mineral fertilizers active ingredient (N43P23K40) per year. With intensive technology to achieve almost the same arable land productivity (4.34 t/ha of grain units) has required 219 kg of active ingredient per 1 ha of NPK per year (N78P51K90).

In both crop rotations production the most cost-effective (70.9 ... 177.5%) was for resource-saving technology. The cost of one c. grain units in grain-pair-grass crop rotation was 93,5 rubles 50, grain-pair-row ? 115,5 rubles.Thus, the adaptive resource-saving technology based on crop rotation increase the yield of crops and productivity of arable land in 1.5 to 2 times, saving 40-50% of fertilizer, fuel - by 25-35%, improves soil fertility and profitability of grain production to 177 %.

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Repeated Application of Organic Fertilizers on Winter Wheat in a Humid Mediterranean Climate Zone

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The application of organic fertilizers to crops has clear advantages. First, as an organic amendment, because soils of Mediterranean areas of Europe have usually a low soil organic matter content. Second, because of its nutrient content, these nutrients can be used by crops, thus replacing mineral fertilizers. Regarding nutrients, nitrogen is the most important one when considering cereal fertilization. The N applied along with organic fertilizers can be divided in a mineral fraction and an organic fraction, which mineralizes the first weeks after application and can be used by the growing crop. The rest of the organic fraction is released more slowly and may be available for subsequent crops. The aim of this study was to evaluate the influence of nitrogen applied as organic fertilizer on a wheat crop, taking into account the contribution of the fertilizer to the soil Nmin content. A field was carried out in the Basque Country in northern Spain during three wheat growing cycles from 2009 to 2012. Three organic fertilizers were evaluated: cattle slurry, composted sheep manure and a compost mixture of sheep, horse and pelleted chicken manure, certified for organic farming. The total N dose applied was 170 kg N/ha. A control treatment without fertilizer and a treatment in which mineral fertilizer was applied were also established. Yield and yield components were measured, and also the grain protein content. Besides soil Nmin was analyzed in three moments each year: before sowing, at the end of winter and after harvest. The unfertilized plots produced only 25-30 % when compared to the control treatment with mineral fertilizer (170 kg N/ha). During the first year the treatments with only organic fertilization, increased yield significantly compared to unfertilized treatments, producing about 1,000 kg/ha more grain. These results became more evident in subsequent campaigns and in the third year organic treatments produced between 2,000 and 3,500 kg/ha more grain than the control treatment without N. Anyway, the maximum yields were achieved in the treatments where only mineral fertilizer was provided. This increase in production over the years in the case of treatments with organic products was accompanied by a higher content of soil Nmin at the end of winter compared to the control treatment. The number of spikes/m2 was the yield component that determined the mentioned yield differences. As a matter of fact, soil Nmin content at the end of winter is essential for a number of spikes/m2 high enough (450 espigas/m2) to ensure a good yield of about 7,000 kg/ha in the humid Mediterranean climate conditions in which the field assay was conducted. Grain protein values when only organic fertilizers were applied were low the three years, being generally below 8 % and similar to the values obtained at the control plots. The use of organic fertilizers allow significant savings in fertilizer costs, but to achieve optimal wheat yields and quality, supplemental N applied as mineral fertilizer is necessary. Yield improvement when only organic fertilizers are applied is achieved making repeated applications, due to increased availability of N at the beginning of the vegetative growth. However, the protein content in grain, which is most affected by the soil nitrogen content at more advanced stages of the crop, did not improve compared to unfertilized plots.

Keywords：*mineralization, slurry, soil nmin*

P4-380

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Strategies to Increase N-Fertilizer Use Efficiency for Potatoes under Subsurface Irrigation

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For decades, subirrigation (seepage) irrigation has been the predominant irrigation practice for potato production in Florida and other important vegetable crops in Florida. In seepage irrigation the water table is managed according to a target water table level to irrigate the crops. This type of irrigation involves pumping a significant volume of groundwater to maintain a high water table. As a result, in many agricultural production areas in the state of Florida, seepage management requires excessive water to raise the field water table, which frequently results in water and nutrient/fertilizer loss by deep drainage and runoff. In addition, high water table increases the risk of flood losses during rainy periods. Potato production is extremely sensitive to soil water availability, depletion or excess of available soil water during the growing period results in lower yields. The water use of potatoes typically ranges between 330 and 480 mm of irrigation water per season, but small variations from optimum seasonal water application have the potential to decrease potato yield. Therefore, growers tend to be extremely conservative in their irrigation techniques and the trend has been towards over-irrigation in potato production. One potential method to increase irrigation water use efficiency is to improve irrigation scheduling.

The objective of this study is to determine yield and fertilizer use efficiency of potato in response N-fertilizer rates under three water table levels. Field experiments were conducted in Hastings, FL. The experimental design was split-plot, evaluating N-rates at 0, 112, 224, 336 kg ha-1 with variety as the split-plot factor (‘Atlantic’ and ‘FL1867’). Each treatment was replicated three times in each of three adjacent potato fields, for a total of nine replications. The three fields were automatically controlled to maintain a different water table height, targeting 36, 53, and 71 cm below the top of the raised potato row and root zone soil moisture was used as a covariate factor for each replicate. A pressure transducer installed in center of the field measured the water table levels every 15 min. The water table measurement data were send wirelessly to an irrigation valve control node which commanded the irrigation events. The valve control node maintained the irrigation valve shut off if the water table level was at or above a preset threshold of water table level. The effects of N-rate, variety, and soil moisture on soil nitrogen levels, plant biomass, plant nitrogen content, and potato yield were quantified. Soil mineral nitrogen content at 0-15 cm throughout the season was influenced by both N-rate and soil moisture ($p<0.01$). Marketable yield ranged from 0.3 to 34.0 Mg ha-1 and was impacted by potato variety ($p=0.02$). Frito Lay yielded 1.3 Mg ha-1 higher on average than Atlantic. Treatments receiving above 224 kg ha-1 N had the highest yield, with high soil moisture impacting marketable yield at all N-rates ($\alpha=0.05$) The results of this study suggest that water table management in conjunction with N-rate are necessary to ensure optimized potato growth, yield and potato quality.

Keywords：*seepage, water use efficiency, fertilizer timing*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Photosynthesis and Morphological Responses of Rice Cultivars to Seedling Moisture Deficit

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Rice seedling establishment in direct and dry seeded rice cultivation will be affected by fluctuating soil moisture levels. Cultivars that perform well during this period will establish quickly and attain their genetic potential. The objective of the study was to identify cultivar variability to early season soil moisture stress using root and short morphological and photosynthesis traits. An experiment was conducted under greenhouse conditions in pots by varying soil moisture during seedling growth. Six cultivars with diverse genetic background, CL152, R4100412, Antonio, Bowman, Niponbare, and Rex, were seeded in 6 by 12 inch PVC pots filled with 3:1 sand: soil as the rooting medium. Pots were arranged as a randomized complete block in 8 rows with 6 pots per row. All plants were irrigated with full-strength Hoagland nutrient solution, delivered three times for 28 days after sowing (DAS). Then, half the plants in each cultivar were supplied with 20% of control irrigation solution for another 4 weeks. Irrigation to control plants was based on replacing 100% of soil moisture depletion by sensor-based soil moisture measurements. Plant height, leaf and tiller numbers, leaf area, plant dry weight, and root by shoot ratio were recorded at 56 days after seeding. Root growth parameters, cumulative root length, root surface area, average root diameter, and root volume were estimated using win RHIZO root imaging system. Also, photosynthesis, stomatal conductance, electron transport rate, transpiration, fluorescence, water use efficiency and chlorophyll reading using SPAD were measured prior to the final harvest. Cumulative shoot, root and photosynthesis indices were calculated by summing each response index value as a ratio of treatment by control values. Cultivars were classified based on total cumulative water stress response index (TCWSRI), the sum of all the traits measured, into different groups based on mean and standard error. Significantly lower shoot and root morrphological and photosynthesis and electron transport rates were recorded under soil moisture deficit conditions compared to the well-watered plants. Cultivars, however, showed significant variation in their response to soil moisture stress. The reductions in most of the measured traits were less in CL152 and R4100412 rice cultivars than others to soil moisture stress. Based on total cumulative water stress response indices, the cultivars were classified. The cultivar R41004122 was identified as tolerant, CL152 as intermediate, and Antonio, Bowman, Niponbare and Rex were sensitive to soil moisture deficit. The identified soil moisture stress tolerant and intermediately tolerant cultivars may be useful not only for breeders to develop new genotypes for water limited conditions but also farmers and agronomists will have a decision aid to select cultivars best suited for dry seeded rice culture.

Keywords：*rice cultivar soil moisture root morphology photosynthesis*

P4-382

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Response of Pinus Radiata to Slow Release Boron Fertiliser, Ulexite

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Pinus radiata (P. radiata) or radiate pine is an important exotic forest species in New Zealand. This forestry sector generates in the order of NZ $ 3.1 billion in forestry export revenue to destination all over the world. However, most New Zealand soils planted with P. radiata are found to be B deficient, and the soil status of this micronutrient is the greatest production limiting factor for the New Zealand radiata pine industry. The effect of B deficiency on plants is manifest through growth defects such as leader tip dieback, multiple leaders and yellowing of new growth in radiata plantations.

Greenhouse study was conducted using radiata pine grown on a B-deficient pumice soil collected from the central volcanic plateau of the North Island of New Zealand treated with different levels of the slow-release B fertiliser ulexite. Boron application at rates of 8-16 kg/ha resulted in the maximum plant height and dry weight, although toxicity was observed at rates higher than this. Plants responded to B application by increasing the tissue B concentration throughout the plant, particularly in needles. Results showed that B translocation from below-ground plant parts (root) to above-ground plant parts (needle) improved with B application, but translocation was restricted under conditions of both deficiency and toxicity. One-year-old needles were recognized to be the major site of B accumulation in the current study.

Soil microbial and microbiological properties, such as ectomychorriza density and soil dehydrogenase activity improved with B application. Boron application at the rate of 4-8 kg/ha led to the greatest level of soil dehydrogenase activity.The overall results showed that B application at an optimum rate improved not only plant growth, plant B uptake, and soil B concentration but also have positive impact on soil microbial and microbiological properties were also improved under conditions of optimal B application.

Keywords：*Ulexite, Pinus radiata, boron, Ectomycorrhizae, dehydrogenase*

P4-383

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Phosphorus Budget as a Tool to Monitor Soil P Changes under Grassland Production

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Monitoring and managing soil P changes under different agro-ecosystems to improve P use efficiency and sustain agricultural production while protecting terrestrial surface water bodies remains a major issue for agronomists. Soil test P (STP) dynamics/changes over a period of several years can be characterized using the cumulative P budget over the same period. However, few studies have analyzed the stability of the relationships across a range of STP values under grassland production systems. Our main objective was to analyze the stability of the relationship between STP and cumulative P budget in several grassland experiments covering a large range of STP values as a result of long-term applications of varying P fertilizer rates. Six long-term grassland sites with two to four annual P fertilizer rates (0 to 45 kg P ha–1) were selected in four countries [France (Ercé and Gramond), Finland (Maaninka and Siikajoki), Switzerland (Les Verrières), and Canada (Lévis)]. The STP was assessed according to existing guidelines in each country: Olsen P (POl) in France, acidic ammonium acetate P (PAAC) in Finland, mixture of ammonium acetate, acetic acid, and EDTA (PAAE) in Switzerland, and Mehlich-3 P (PM3) in eastern Canada. The stability of the relationship over a range of STP values was assessed by using the Cate-Nelson method to determine the presence of deflection points (d0) in the relationship between STP and cumulative P budget. At five of the six sites, a d0 in the relationship between STP and cumulative P budget was observed. The (x, y) coordinates of the d0 were (-133 kg P ha–1, 10.06 mg Pol kg–1) at Ercé, (-150 kg P ha–1, 22 mg Pol kg–1) at Gramond, (-116 kg P ha–1, 11.32 mg PAAC kg–1) at Siikajoki, (-79 kg P ha–1, 26.42 mg PM3 kg–1) at Lévis, and (-61 kg P ha–1, 9.25 mg PAAE kg–1) at Les Verrières. Above the d0, significant linear relationships were obtained ($0.33 < r2 < 0.72$), while below the d0, the relationships were not significant. A single linear relationship across the range of STP values was obtained only at Maaninka where STP continuously decrease with time in the absence of P addition. We conclude that the relationships between STP and cumulative P budget in grasslands is stable over a range of STP greater than a critical value at which there is less or negligible decrease of STP relative to total P removed in the crops and this value depends on the site and STP method.

Keywords：*fertilization, grassland, long-term field experiments, P budget, phosphorus, soil test P*

P4-384

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Sidedress Application of Nitrogen in Wheat Using Chlorophyll Meter

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Nitrogen fertilizers are known to be the most limiting factor among all over the plant nutrients. Efficient use of nitrogen fertilizer is important to economical wheat production and to the quality of the ground and surface water. One of the easiest and most economical ways to recommend nitrogen fertilizers seems to be to rely on chlorophyll meter to ascertain wheat demand for nitrogen. Accordingly an experiment was conducted to determine a correlation between wheat yield, soil and leaf nitrate status and the leaf chlorophyll meter readings. A randomized complete block experiment was used in field condition with ten levels of urea fertilizer as a nitrogen source in three replications. Soil and plant samples were collected at five leaf stage, tillering and stem elongation time while chlorophyll meter readings were also recorded from the mid section of well developed first top most plant leaf. The results showed a significant correlation between the chlorophyll meter readings and leaf nitrate at tillering and stem elongation stages. The readings of 45.2 and 47 at tillering and stem elongation respectively were found to be dependable readings for nitrogen fertilizer recommendations. Similarly the significant correlation between soil nitrate and leaf nitrate concentrations during stem elongation is a dependable criterion for the nitrogen fertilizer recommendations.

Keywords：*Chlorophyll meter, nitrogen, nitrate, wheat*

P4-385

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

A Proposed Land Suitability Index for Assessment of Maize Production in the Humid Tropics

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Grain yield for dryland maize (Zea Mays L.) in the humid tropics determined by soil and climate characteristics. Therefore, land suitability index needs to be taken into account in the development of highly commodity because it is based on knowledge of the requirements of crops, soil characteristics, and soil management. The result of evaluation process would give more information about the important of land management to increase maize yield. The primary aim of this study is to built proposed of Land Suitability Index (LSI) based on actual maize yield for humid tropics of Indonesia. Maize yield and soil data were collected at South Sulawesi, one of the major maize-producing province in the eastern part of Indonesia. Optimal maize yield of study area measured by RPP_DAICROS method. Land suitability index equation were determined by principles of Analytic Hierarchy Process (AHP). According to RPP_DAICROS methods, estimated maize yield in the study area ranges from 5.21 to 7.79 tons ha-1. LSI_proposed showed that soil fertility, climate, soil physics and topography affecting maize yield for 0.4, 0.3, 0.2 and 0.1 respectively. It was found that correlation between LSI_proposed and maize yield reaches an r value of 0.831 ($p<0.01$). The scatter points in the diagram depict a good indication that the higher the LSI_proposed the better maize yield can be produced in the area under consideration.

Keywords：*land suitability index, maize, humid tropics*

P4-386

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Role of Mycorrhizal Symbiosis in the Aluminum - Phosphorus Interaction in Al Tolerant Wheat Cultivars Growing in Acid Soils

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The main features of acid soils are the low levels of available phosphorus (P), low amounts of exchangeable bases and high aluminum (Al) levels, which cause deleterious effects on root physiology and growth. In order to produce better crop yields the recommendation is to apply liming materials to decrease Al activity in the soil solution together with high doses of phosphate fertilizers to increase levels of available-P. However, soils have a great buffer capacity that difficult the effectivity of these agricultural practices rendering them unsustainable. In addition, in developing countries, as Chile, which have limited access to P fertilizer, there is a need to develop plants that are Al tolerant and more P efficient. Then, the third option is to mimic plants habitually growing in acid soils which surely have effective mechanisms related to Al tolerance and P deficiency. Therefore, the objective of this research is to understand the Al-P interactions and how arbuscular mycorrhizal (AM) symbiosis affect the growth and development of wheat when cropped in acidic volcanic soils. Several screening for Al tolerance and P efficiency were carried out with 46 commercial wheat cultivars habitually cropped in south of Chile. Such screening were performed in mineral solution under 0 and 200 uM of Al as AlCl3 and 20 and 200 uM of P as KH2PO4 as well as in pots to see the responses at liming (0.15 and 23% Al-saturation in soil) measuring the detrimental effect on principal root length and shoot/root P-Al concentration at 15 days of Al exposure. After screening two wheat cultivar Al tolerant and P efficient (‘Invento’ and ‘Crac’) and one Al sensitive and P no efficient (‘Tukan’) were selected and a couple of new experiments were carried out under two Al concentration (35 and 0.14 % Al-sat) and three P levels (0, 100 and 200 ppm). The effect on root architecture was observed in rhizoboxes using sand or agar nutrient as support. In addition, the exudation of organic acids (OA) and phosphatases (P-asa) were quantified. Also, glomalin related soil protein (GRSP) production, Al bound to GRSP (Al-GRSP), AM root colonization and AM spores density were determined. Based in root architecture the results showed that ‘Invento’ had high P efficiency by a longer root hair than ‘Tukan’. The high Al saturation and low P availability affected all factors studied whereas AM fungi colonization was not inhibited under this condition. Mycorrhizal propagules, P-asas and GRSP production were increased at high Al levels and low P. ‘Invento’ and ‘Crac’ had a high GRSP production (10.75 and 11.98 mg g-1 respectively). In addition, Al-GRSP ranged from 5.6 to 8.3 % of total GRSP being higher in ‘Invento’. The highest citrate and malate production was observed at short-term of Al exposure and at 200 μM Al. After 2 h of Al exposure, citrate exudation was higher in ‘Atlas 66’ a gold standard for Al-tolerance. However, ‘Invento’ showed a constant pattern of citrate exudation over time, while ‘Crac’ and ‘Atlas 66’ showed a marked decrease over time. The mycorrhizal symbiosis could be giving an additional P efficiency in Al tolerant wheat cultivars through increased AM propagules, GRSP production and higher Al-GRSP and P-asas. We suggest that the presence of AM fungi populations adapted to these conditions is raising the adaptation of plants present in acidic soils oriented to annual crops. In other hand, the higher organic acid exudation in P-deficiency treatments and Al-tolerant cultivars could be related with a high P solubilization. For the above, this results will be complemented with the capacity to solubilise P of citrate and malate, exuded by roots of the Al tolerant and P efficient wheat cultivars. At the same time, we will study the relationship between the P efficiency of these wheat cultivars with the strigolactones production, a new hormone related to stimulate AM fungal hyphal branching which supplies P to plant hosts producing early benefits to P efficient plants.

Acknowledgment: FONDECYT 3140623 grant (A. Seguel) and FONDECYT 1130541 grant (F. Borie) from Comisión Nacional de Investigación Científica y Tecnológica (CONICYT) Chile

Keywords： *aluminum tolerant wheat cultivars, arbuscular mycorrhizal, glomalin related soil protein, P efficiency*

P4-387

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Fifty Years of Nitrogen and Phosphorus Fertilization on Soil Properties and Production of Irrigated Continuous Corn in the USA

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Inorganic fertilizers are routinely used to increase crop production, but there is limited information on the long-term effects on soil chemical properties. Nitrogen (N) and phosphorus (P) fertilizers were applied annually for 50 years to irrigated continuous corn (Zea mays L.) grown on a Ulysses silt loam (Aridic Haplustoll) in the central Great Plains of the United States. The study was conducted at the Kansas State University, Southwest Research-Extension Center near Tribune, Kansas. Treatments were a factorial of six N rates (0, 45, 89, 134, 179, and 224 kg ha-1) and three P rates (0, 20, and 40 [first 31 years at 20 and last 19 years at 40] kg P ha-1). The treatments were broadcast applied in the spring and incorporated prior to planting of corn. The entire study was irrigated (furrow irrigation for the first 40 years and sprinkler irrigation for the latter 10 years) to minimize water stress. Soil samples were collected after 50 years of fertilization and analyzed for selected chemical properties. In the surface soil (0-15 cm), application of N to corn decreased pH, Ca, Mg, Na, and S while increasing NO3, Mn, and soil organic matter (SOM) concentration. Fertilizer P increased soil test P and SOM concentration with minimal effect on other chemical properties. Profile soil samples (300 cm depth) indicated some movement of NO3 to 300 cm depth at the higher N rates with P fertilization and at lower N rates without P fertilization. Over the long-term, application of combinations of N and P fertilizers on irrigated continuous corn were superior to either applied independently for enhancing crop production, maintaining or enhancing soil properties (when applied at rates not to exceed crop requirements), and minimizing environmental risk from nitrate leaching.

Keywords：*nitrogen, phosphorus, soil chemical properties, irrigated corn, long-term fertilization*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

An Investigation into the Release Dynamics from Different Si Sources

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The recent recognition by the Association of American Plant Food Control Officials (AAPFCO) that Si is a plant beneficial substance means that knowledge of soil Si status and the availability of Si in commercially available fertilisers is essential.

Plants absorb Si as monosilicic acid or plant available Si (PAS). A chemical extraction method is demonstrated to be a reasonable indicator of plant available soil Si status across a range of soils in Australia and India. However, a complication occurs when Si is added to the soil. There are many types of Si sources suitable as fertilisers and their effectiveness is known to be more dependent on their reactivity in the soil rather than their total Si content. Consequently, a number of laboratory chemical extractant methods have been developed in an attempt to estimate the plant available Si of Si fertilisers. Several of these methods were employed to estimate the plant available Si of a range of Si fertilisers that were then incorporated into different soils in replicated pot trials. A poor correlation was found between the laboratory chemical extraction methods for determining plant available Si of the Si fertilisers and plant tissue uptake.

Whilst it is not surprising that a simple, dependable laboratory method for measuring plant available Si of fertilisers that correlates well with corresponding plant tissue levels is challenging, AAPFCO recently proposed such a method. The plant available Si measured using this recently published method and other known methods is shown to not be a reliable prediction of Si in the plant tissue and is not consistent between different sources of Si, particularly amorphous silica and calcium silicates.

Most proposed methods for estimating the plant available Si are demonstrated on predominantly silicate slag materials, as historically these have been readily available. A separate replicated pot trial was conducted that demonstrated the difference in Si release dynamics in the soil between silica and silicate chemistries and the corresponding uptake of Si by the plant. It is further demonstrated in a separate large pot trial with two Si responsive soils, that rice plants taken to harvest showed similar levels of Si in plant tissue despite the chemical extraction methods predicting vastly different levels of plant available Si of these fertilisers.

Consequently a number of factors were identified in these experiments that impact the uptake of Si by the plants and complicate the estimation of plant available Si: soil type, dynamics of Si release, application rate of the Si fertiliser and chemistry of the Si fertiliser.

Much like the phosphorus analytical testing methodology, these results indicate that that there is perhaps not one universal extractant that is suitable for determining plant available Si that will cover all types of Si fertiliers for all soils and soil conditions.

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Role of Boron on Physiological Features in Highbush Blueberry Grown in Acid Conditions

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Highbush blueberry (Vaccinium corymbosum L.) is cultivated in Chile on the area of 8,500 ha with a total fruit production of 70,000 t during the 2011-2012. In Southern Chile, acid Andisols represent the greatest area of arable lands with 2,600,000 ha of which 2,000 ha are plantations of highbush blueberry. This fruit bush has been widely developed under acidic soil conditions (pH ≤ 5.5) where availability of many nutrients can be a restrictive factor for its growth and yields. Boron (B) is an essential micronutrient required for growth and development in higher plants due to its primary role on plant structure and in a great variety of physiological processes. In highbush blueberry grown in acid conditions, showing extractable values bellow 0.5 mg kg-1, it has been reported that B deficiency or toxicity cause shoot tips die and leaves chlorosis. These soils are deficient in B. However, their requirements remains little studied for highbush blueberry. The aim of this work was to study the B addition to highbush blueberry, on mineral content, oxidative stress and antioxidant capacity in blueberry.

One year old plants of highbush blueberry cultivar (Brigitta and Legacy) were grown in at pH 4.5 for 30 days under greenhouse conditions (temperature controlled 20-25 ºC, 16/8h light/dark regimen, 80% RH and photosynthetic photon flux density of 300 mmol photons m-2 s-1, were treated with increased B concentrations (0, 50, 200, 400 y 800µM B applied as H3BO3). The study considered the following determinations: leaf and root B content (LBC and RBC respectively), radical scavenging activity (RSA), oxidative stress and total phenol content (TPC).

In two cultivars LBC and RBC were increased by B treatments in comparison to control (0 µM) ($P \leq 0.05$). Brigitta and Legacy had a significantly increased RSA and TPC in all B treatments respect to the control ($p \leq 0.05$). Oxidative stress was increased under the highest B treatment for two cultivars. The study provides evidence that an adequate B level in highbush blueberry play an important role in the B content in tissues, RSA and TPC. In summary B could be an important factor to improve physiological and antioxidant performances in highbush blueberry subjected to a potential stress in acid soil conditions.

Acknowledgments: FONDECYT Nº3140622.

Keywords：*Antioxidant, Boron, Highbush Blueberry*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Integrated Nutrient Management for Yield and Storability of Sweet Potato

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Sweet potato (Ipomoea batatas) is a nutritious food. It contains appreciable amount of starch, vitamin-A, minerals especially in orange flesh sweet potato. The average yield of sweet potato is around 10 t ha-1, which is much below than the crop production potential. Yield can be increased by the improved production agrotechnologies, involves manure and fertilization. Current fertilization rates are insufficient to sustain high yields and to replenish nutrient removal by the crop. Balanced fertilization is a prerequisite for getting optimum yield potential of sweet potato. Integrated use of both organic manure and chemical fertilizers are the best approach in providing greater stability in production and improving soil fertility status. An experiment was conducted to study the effect of organic manure and chemical fertilizers on the yield and storability of sweet potato in Grey Terrace Soil (Aric Albaquept) under AEZ (Agroecological Zone) - 28 at Gazipur, Bangladesh. There were seven treatments - T1 (Control, native nutrient), T2 (100% recommended dose of fertilizers, RDF), T3 (Poultry manure, PM@ 3t ha-1+ rest from RDF), T4 (Cowdung, CD @ 6 t h-1+ rest from RDF), T5 (PM@ 3 t ha-1+70% RDF), T6 (CD@ 6 t h-1+ 70% RDF) and T7 (Farmer's practice, FP). The experiment was laid out in a randomized complete block design (RCBD) with four replications. Sweet potato (Ipomoea batatas) variety BARI SP8 was planted on 28 November of 2012 and harvested on 18 April of 2013. Data were recorded on selected characters, namely vine length, vine weight, root length, root weight, yield and storage parameters. The yield data and dry weight were collected at harvest and storage data were recorded at different days after storing. The gross return, net return and return per taka invested in different nutrient management systems were assessed by computing the cost of the inputs and price of the produce/output. Economic analysis was performed through partial budgeting followed by marginal benefit cost ratio (MBCR). The analysis of variance for crop characters was done following the ANOVA test and the mean values were compared by DMRT. Soil samples were analyzed following standard laboratory methods. The yield of sweet potato was significantly ($p \leq 0.05$) influenced by the integrated use of organic manure and chemical fertilizers. The highest root yield (22.7 t ha-1) was obtained in T4, where CD @ 6 t ha-1 along with reduced rate of recommended dose of chemical fertilizers were applied. The combination of cowdung @ 6 t ha-1 + reduced rate of RDF was found to be best for the cultivation of sweet potato. T3 and T4 showed better performance in respect of storage behavior at ambient temperature. The highest marginal benefit cost ratio (MBCR) was also recorded in the same combination. Cowdung @ 6 t ha-1 + reduced recommended dose of chemical fertilizer can be recommended for cultivation of sweet potato and to maintain soil health in Grey Terrace soil.

Keywords：*Organic manure, chemical fertilizer, Ipomoea batatas, yield, storability*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Manipulating Root-Soil Zone Processes by Localized Nutrient Supply to Improve Nutrient Use Efficiency and Grain Yield in Maize Cropping Systems

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The nutrient resources in soil profile are heterogeneously distributed. Plant roots exhibit high plasticity in response to nutrient heterogeneity in order to exploit the nutrient resources effectively. Plants have evolved numerous strategies to capture soil nutrients such as root proliferation and increased capacities for nutrient uptake. Plant roots can not only highly regulate morphological traits to adapt to soil environmental conditions, but also significantly modify rhizosphere processes through their physiological activities, particularly the exudation of organic acids, phosphatases, and proton release. Root exploration in soil and root-induced rhizosphere processes plays an important role in controlling nutrient transformation, and efficient nutrient acquisition. However, the underlying strategy of root/rhizosphere processes and management in intensive cropping systems remain largely to be determined despite advances in rhizosphere research for many years. In the study, we want to test (1) if root growth and rhizosphere processes can be effectively manipulated and thus enhanced by localized supply of nitrogen (N) and phosphorus (P), and (2) quantitative contribution of enhanced root proliferation and intensified rhizosphere processes to nutrient use efficiency and crop yield in intensive maize cropping systems.

Maize was treated with localized application of P with NH4-N, NO3-N or urea, with or without a nitrification-inhibitor (NI) in a calcareous soil. To examine the responses of root proliferation and rhizosphere processes to the nutrient-rich patches, eight treatments were designed in the rhizobox experiment: (1) NO3-N: homogenous NO3-N and P, (2) Localized NO3-N: localized NO3-N and homogenous P, (3) Localized NO3-N+P: localized NO3-N and P, (4) NH4-N+NI: homogenous NH4-N and P with NI, (5) Localized NH4-N+NI: localized NH4-N with NI and homogenous P, (6) Localized P: Localized P and homogenous NH4-N, (7) localized NH4-N+P: localized NH4-N and P, (8) Localized NH4-N+NI+P: localized NH4-N with NI and P. There were four replicates for each treatment in a completely random design. In a two-year field experiment, three treatments were established and each treatment had four replicates in a completely randomized block design: (1) CK: both urea and P homogeneous broadcast, (2) NBPB: both NH4-N (ammonium sulphate) and P homogeneous broadcast, (3) NLPL: localized application of both NH4-N and P. The localized nutrients were applied at depth of 10 cm from the soil surface and at 10 cm away from the planting row.

Localized supply of NH4-N plus P enhanced total root length, specific root length, and lateral root density compared to homogeneous supply, resulting in evident root proliferation. Rhizosphere pH decreased in the patches with NH4-N due to large amount of proton release. The activity of secretory acid-phosphatase on root surface or in rhizosphere in the patches significantly increased because rhizosphere acidification may provide an optimal environmental conditions for improved acid phosphatase activity. Localized supply of NH4-N plus P enhanced expression of ZmAMT1;1 and ZmAMT1;3 encoding ammonium transporters but not for P transporters. Localized application of NH4-N plus P significantly improved nutrient uptake and maize growth compared to NO3-N plus P. Field experimental results also indicated that the density and average length of the first-order lateral roots in local patches increased by 50% compared with nutrient brocasting as a control at seedling stage. Maize-yield increased by

10% compared with homogeneous broadcast of urea and P. Agronomic N efficiency and N-use efficiency increased by 41-48% and 25-57% compared with the control.

In conclusion, our findings highlight that plant roots can effectively coordinate root morphology, root physiology and subsequent rhizosphere processes in response to different nutrient patches to maximize resource acquisition. Localized application of NH4-N plus P stimulated nutrient uptake and plant growth by integrating root proliferation and physiological traits involving increased proton release, acid-phosphatase activity and expression of ammonium transporters. There was a significant positive correlation between ammonium proportion in the localized patches and root proliferation or N or P uptake, suggesting a crucial role for ammonium in stimulating plant growth and nutrient uptake through intensifying root proliferation and rhizosphere processes in calcareous soils. Based on the priciple mentioned above, an effective technology of banding specific nutrients in maize cropping system was developed and significantly enhanced nutrient use efficiency and maize yield.

The study was supported by the Natural Science Foundation of China (31330070, 31210103906, 30925024, 31121062).

Keywords：*Root zone management, root-soil interface, localized nutrient supply, nutrient use efficiency, yield*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluating the Growth Promotry Effect of Plant Water Extracts on Maize

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Allelochemicals, in plants, may have concentration dependent influence on plant growth. At low concentrations these chemicals promote the plant growth and may suppress the same when applied at higher concentration. In this study, application rate of 3, 5, 10, 25, 50, and 100% of water extracts of allelopathic crops (maize, sorghum and rice) were optimized for growth promotion of maize seedlings in pot trial. It showed that all the extracts at 3% concentration were the best one. The water extracts of sorghum, maize and rice were prepared by soaking the mature dried herbage in water for 24 h, filtered and boiled to reduced volume by 20 times, while moringa extract was prepared by crushed fresh leaves, frozen over night and then passed through manual press to collect extract. Extracts were foliage applied twice(3% concentration) at 30 and 50 days after sowing in field sown maize alone and in combination with moringa extracts and also with each other. All the treatments significantly promoted maize growth than the control. The individual extracts increased the yield moringa>maize>sorghum>rice. While interestingly sorghum and moringa extracts mixture each at 3% increased the yield by (30-31%), it followed by sorghum and maize water extracts mixture with (25-29%), rice and maize extracts mixture increased the yield by (24%) and moringa and maize (25-27%).This suggests that allelopathic plant extracts at low concentrations can effectively be used either alone or in combinations with each other to get remarkable higher yield of maize.

Keywords：*Allelochemicals, Growth promotion, Maize, Water extracts, Maize*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Mavuno and Manure Fertilizer Applied Singly or in Combination on Soil Properties, Striga Weed Density and Maize Yield

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The on-farm study to assess the effect of organic and inorganic fertilizers on soil properties, striga weed density and Imazapyr Resistant (IR) maize yield (maize resistant to striga weed) was conducted in Vihiga and Siaya districts of Western and Nyaza provinces in Kenya respectively. The hypothesis was that mavuno (a locally made fertilizer) and farm yard manure fertilizer applied in combination would improve soil fertility and hence decrease the occurrence of striga weed and also increase IR Maize yields. This is also in view of the fact that soil properties are bound to change, positively or negatively with applications of fertilizers.The experiment was set up in a completely randomized block design with a split plot arrangement. The main plots where the fertility gradients and the sub-plots were the treatments, without fertilizer -control; IR+manure; IR+mavuno+ manure. IR maize was the test crop. FYM was applied at a rate of 60kg N per ha and mavuno at a rate of 20kg P/ha. Maize yield was determined at maturity and striga density data were collected during the growing season. Soil pH, organic carbon (OC), phosphorus (P) and total nitrogen (N) were analyzed at initial planting, flowering and at crop maturity. Mineral N, exchangeable bases and CEC were analyzed at crop harvest. Organic carbon respiration was recorded at days 3, 7 and 14 of incubation.

Significant differences in maize yields were observed across sites and treatments ($P<0.01$) with the highest maize yields observed in Nyalgunga (4833 kg/ha) in the high fertility field with mavuno +manure treatment. This site also showed high levels of P (11.78mg/kg) at crop maturity. The lowest maize yields were observed in Emusutswi (263kg/ha) in the control treatment of the low fertility field. Results also indicated that the treatment was highly significant ($P<0.01$) in striga density with the highest striga density observed in the control (54,379 plants/ha). Soil organic C and total N showed significant differences across sites and treatments prior to planting and at harvest ($P<0.01$). There were significant differences in soil pH across sites prior to planting. The mineral nitrogen showed significant differences across treatments. Exchangeable bases; K and Ca and CEC showed significant differences across treatments whilst Mg showed significant differences across sites. Soil respiration showed significant differences across fertility gradients after 7 and 14 days of incubation but no significant differences were noted between sites or treatments. Integration of both organic and inorganic fertilizer in the plots enhanced both soil biological and chemical properties, reduced striga weed density and showed higher maize yields than the control and manure only treatment plot. Inorder to increase on productivity, it is therefore recommended to use a combination of local farm yard manure with inorganic fertilizers than sole applications of FYM and mavuno.

Keywords：*mavuno, farmyard manure, soil properties, striga density, maize yield*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Variability of Soil Organic Carbon with Landforms and Land Use in the Usambra Mountains of Tanzania

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A study was carried out to examine variability of soil carbon levels in relation to landform and land use in West Usambara Mountains to assist in formulation conservation technologies for the landscape sustained productivity. Convention soil survey methods were used develop a basemap on which 55 profile pits were randomly located on representative landforms and land use mapping units. Soils were studied and samples collected from top-soils for laboratory analysis of soil carbon using the wet digestion method. Descriptive statistics and linear regression models were used to establish relationships between landforms and land use and soil organic carbon levels. Results show that carbon levels range between 0.55 % and 10.8% for the bushland and forest plantation in the plain and plateau respectively. Under cultivation, soil organic carbon levels vary between 1.03% and 6.34% for mid-slope and lower slopes of the plateau respectively, with an average of 3.73%. Soil organic carbon in vegetable growing valley bottom average was 4.5% while in the forest plantation the average was 5.5% with minimum and maximum of 0.8% and 10.8% respectively. Linear regression model indicate that factors explaining variability apart from land use are slope form, soil pH, electrical conductivity and CEC-clay which are thought to generally influence availability of plant nutrients. It is concluded that soil organic matter in the study area is mainly determined by elevation, slope form and type of land use and management. It is recommended to introduce soil erosion control measures and incorporation of crops residuals to areas where soil organic matter has been depleted for sustainable crop production.

Keywords：*Soil organic carbon, West Usambara, Land use, Landforms*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Study on Soil Nutrient Loss and Distribution Characteristics in Coal Mining Subsidence Area

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The arable area of many plains rigorously decreased due to coal mining in China.Hard coal mining is the dominating industry in the study area of northern Anhui Province, China. Meanwhile it is a important food producer. As a mining activity,consequence subsidence of the surface takes place. Damage of land and soil degradation is obviously in different degrees there. Especially in the plain area where is high water table, the subsequent flooding of the former terrestrial area mainly affects farmland.

This article chose a certain coal mining area which is a producing zone as research site. The site is just above a producing working face. Tatal area is 11ha with 120m wide and 900m long. After a coal seam was excavated, surface above the working face form a subsidence basin with 3ºslope.

The distribution and content of organic matter, ammonium nitrogen,effective phosphorus.potassium in soil got to monitoring and study. Monitoring period is one year, once every three months . Monitoring results show that the mining surface subsidence, though time is not long, and the basin subsidence range is not big, the content of organic matter and the main nutrition elements in the soil markedly and rapid erosion. Compared with the without mining area, the soil of mining subsidence area overall performance for the lack of phosphorus and nitrogen. The nutrition elements loss in surface soil within subsidence zone in the short term is not only surface runoff.what is more important fissure preferential flow in the process of surface subsidence, increasing the vertical soil erosion.

Keywords：*Plain mining area, Soil, Mining subsidence area, Soil nutrient loss*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Temporal Changes in Soil Fertility and the Attempt to Maintain the Land Productivity Under Slash-And-Burn Cultivation in the Northern Laos

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Slash and burn cultivation is the predominant farming system in the mountainous areas of the northern Laos. This system is thought to be a sustainable cultivation method, which doesn't need fertilizer if farmers can plant in the traditional way based on their experiences. But the National Poverty Eradication Programme and the policy limiting access to land have enhanced the frequency of cultivation at the confined lands in Laos. The area of land farmers can cultivate has became half of that in 1980's and the average yield also has decreased form 1.2 t / ha to 0.6 t / ha because of the reduction of fallow period from 5 ~ 6 years to 2 ~ 3 years in the investigation village. Therefore, we should estimate the soil degradation quantitatively in order to propose the adequate land use plan, which can realize sustainable agriculture. In this research, we investigated the temporal change of soil properties from 2004 to 2010 at some fields according to the topographical situation and land use. Furthermore, we estimated the effect of rain-fed lowland rice field on maintaining land productivities.

The studies were carried out in a village of Houayyen, which is located in the Xiengnguen District in the Province of Luang Prabang in the northern Laos. Utisols, Alfisols and Entisols were distributed along hill slopes. We have investigated soil profiles and collected the depth-incremental soil samples on the 4 sites as follows from September 2004 until October 2010. Corn field (CF): surrounded with irrigated lowland rice fields and continuously cultivated for over 10 years, Upland rice field (URF): located on the steep slope (30 degree) and regarded as typical land use system, Teak tree field (TTF): showed same topographical condition with URF and planted teak from 2008, Corn and rice field (CRF): located on the bottom of URF slope and continuously cultivated corn or upland rice from 2007.

The soil in CF originally had rich nutrients, particularly humus and calcium. Increasing pH and decreasing total carbon and nitrogen were recognized during 7 years. However another nutrients still had been maintained in top soil and the corn yield had been constant according to the farmer. This fertile soil was attributed to the inflow from upper paddy field. The temporal changes of most soil chemical properties showed fluctuation influenced by farmer operations in another fields. The degree of the changes relatively high in CRF compared with URF on the upper slope. The nutrients stored in fallow vegetation were released by burning and easily flowed down along the slope. Therefore, the big increase recognized in CRF caused by inflow including soil materials and nutrients from upslope area. In contrast, soil nutrients declined by soil erosion during the crop season in URF. After 2 years fallow, some properties except for phosphate and calcium recovered. The soil in CRF has been kept in fertile condition in spite of continuous cultivation after 2007. The nutrients inventory in soil gradually decreased in TTF partly due to the uptake by teak.

Because the teak contained some nutrients after 15 years planted will be removed as harvest from the field, the teak cultivation seemed to directly lead to the soil degradation.

We attempted the examination about the possibility of continuous planting based on the results mentioned above. The rain-fed paddy field without bank on the upslope side was introduced to the lowest production area. The 8 times yield compared with slope site was recorded and was more than that of the outside paddy field. In the previous research, it was suggested that phosphate deficiency control the upland rice yield. The amount of available phosphate in paddy soil was almost constant though out the cultivation season in the first year, because of the supply from the upper slope area by soil erosion. Furthermore, soil water content in the paddy field was higher than that of outside. In the second season, the rice yield decreased to 65% and soil phosphate also decreased to 80%. We expected the phosphate in paddy soil after 4 seasons would fall below the state of slope soil just after burned. To maintain the rice product, the land use plan based on soil material movement and nutrients cycle in soil biomass system is indispensable

Keywords：*slush and burn, sustainable agriculture, soil degradation, rain-fed paddy field*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Nutrient Management Strategies for Crops Grown in Problem Soils

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Because of the rising challenges due to climate change we hope to come up with nutrient management strategies to increase crop productivity in a suitable manner to help improve the wellbeing of the farming community specifically in areas with physical, chemical or biological constraint for crop production

Several initiatives were conducted in selected areas in the Bicol Region to determine the effect of nutrient management on problem soils such as saline-prone areas, acidic and low fertility soils and lahar-laden areas.

Field experiments were conducted for two years in a lahar-laden lowland rice area in Padang, Legazpi City, Philippines. The objectives of the study were to determine: the effect of cocopeat on some soil properties, yield of PSB Rc 18 and its economic benefits in lahar-laden lowland rice areas. The randomized complete block design with three replications was used during the first and second cropping. The following were the treatments: control (no fertilizer), recommended inorganic fertilizer, recommended coco peat, 25% coco peat + 75% inorganic fertilizer, 50% coco peat + 50% inorganic fertilizer and 75% coco peat + 25% inorganic fertilizer. During the third and fourth cropping seasons, the split-plot design was used with cocopeat frequency of application as main plot and combined rate of cocopeat and inorganic fertilizer as the subplot treatments.No specific trend was observed on the effect of cocopeat on soil properties. The combination of 25% cocopeat and 75% inorganic fertilizer had the highest yield and return on investment which was comparable with the recommended inorganic fertilizer. Reapplication did not show better results with those where it was applied once.

A study was conducted to determine the response of adlay to fertilization strategies in a lowland area after rice with four treatments replicated three times using randomized complete block design. The treatments were: 1 - No fertilizer, 2 - Recommended inorganic fertilizer, 3 - Recommended organic fertilizer (vermicompost) and 4 - 50% recommended inorganic fertilizer + 50% recommended organic fertilizer. Fertilizers were applied at planting and one month after planting. The soil had low nitrogen, medium phosphorus and deficient potassium. The nutrient requirement was 60-30-30 based from sweet sorghum since adlay has no established fertilizer recommendation yet. No significant differences were observed on the growth parameters of adlay as influenced by fertilization. In terms of number of panicles, the fertilized plots were 85% higher than the unfertilized plots but the plants with organic fertilizer were comparable with the unfertilized plants. The length of panicles at harvest in the fertilized plots was longer of about 84% than the unfertilized. The weight of grains was highest in plots fertilized with 50% inorganic and 50% organic fertilizer which was 82% higher than those fertilized with the full recommended inorganic fertilizer.

Another study was conducted in a floodplain often affected by salt intrusion during the dry and wet seasons. The objectives of the study were: (a) to monitor changes on some soil chemical characteristics (b) to determine the effect of tillage on direct seeded rice

in saline-prone areas (c) to identify the appropriate nutrient management strategy for direct seeded rice in saline-prone areas, and (d) to determine the interaction effect of tillage and nutrient management strategies on direct?seeded rice production in saline-prone areas.The study was laid out in a split plot design with tillage as main plot and nutrient management strategies as subplot. There were three replications with the following treatments: Tillage: T1 - Minimum tillage and T2 - Conventional Tillage while the Nutrient Management Strategies: NMS1 - no fertilizer application, NMS2 - organic - Rec Rate, NMS3 - Inorganic - Rec Rate, NMS4 - Zinc - Rec Rate, NMS5 - ½ Organic + ½ inorganic, NMS6 - ½ Inorganic + Zinc, NMS7 - ½ Organic + Zinc and NMS8 - ½ Organic + ½ inorganic + Zinc. Minimum tillage had been found capable of replacing conventional tillage. Some changes have been observed on soil properties. The appropriate nutrient management strategy identified was the utilization of one-half inorganic fertilizer and one-half organic fertilizer based on the recommended rates from soil analysis. No tillage and nutrient management strategy interaction effect had been observed on the growth and yield indices except on plant height at 90 DAE during the dry season.

Results of these initiatives proved that appropriate nutrient management strategies is location specific. Either inorganic or organic fertilizer alone or the combination of organic and inorganic fertilizer proved effective.

Keywords：*saline-prone areas. lahar-laden areas, acidic soils,organic fertilizer, inorganic fertilizer*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of the Application of Biosolid and Vermicompost in the Recovery of a Saline Soil

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The main objective of this research is to evaluate the effect of applying bio solid and vermicompost to the recovery of saline degraded soil, caused by excessive irrigation. To assess the soil's recovery degree, the following were used as indicator plants: feed barley (Hordeum vulgare L.) and white clover (Trifolium repens L.). The evolution and extraction of macronutrients, micronutrients and heavy metals after the application of biosolid and vermicompost was evaluated in each experimental unit plant pots. A rigorous analysis was made, concerning changes in the percentage of organic matter, macronutrients, electrical conductivity (EC), cation exchange capacity (CEC) and the production of fresh and dry biomass.

The representative sample of saline soil for this study was collected from The Irrigation Unit of National Agrarian University - La Molina (UNALM). The technique applied is described in the Standard Operating Procedures performed Soil Sampling EPA (U.S. EPA Environmental Response Team 2000). In the case of sewage sludge, the sample was obtained from the riverbed sludge of the Pilot Wastewater Treatment Plant, property of National University of Engineering (UNITRAT), using the technique described in the POTW Sludge Sampling and Analysis Guidance Document . (U.S. EPA 1989) and The Official Mexican Standard NOM - 004 - SEMARNAT - 2002 (Secretary of Environment and Natural Resources 2002).

For this research, 33 plant pots containing 3 kg of soil, with more than 8mS.cm -1 of salt concentration, each were used. No organic fertilizer was applied to the blank sample, for the other 30 samples 5 doses for each fertilizer (15 samples per each fertilizer) with 3 repetitions each were applied; 33 experimental units were reported. The applied doses of organic fertilizer were 30g, 60g, 90g, 120g and 150g. Two campaigns were developed for the first indicator plant: feed barley I and II, and one campaign of white clover. During these campaigns, size measurements on the tallest plant, the number of tillers and qualitative assessments were performed. For statistical analysis of the results, the analysis of variance (ANOVA) was applied.

The application of biosolid allowed feed barley and white clover to grow faster, not only regarding plant height, the number of tillers formed or plant pot coverage, but also in the production of fresh and dry matter. This happened, because the application of biosolid increased levels of EC, CEC, K+ , Na+ , Mg+2, CaCO3 and the sum of exchangeable cations. In the course of this research, increasing levels of micronutrients (Na, Zn, and Cu) absorbed by plants were evidenced. However, there were decreasing levels of macronutrients (N, P, K, Ca and Mg) registered. Except for sulfur and iron, that had a similar evolution throughout the research period.

In the case of heavy metals, Pb and Cr had a slight increase in their plant assimilation levels. At the end of the research period, a slight decrease Cd was also observed. In those tests, where vermicompost was applied to the soil, a slight decrease in pH, EC, Ca,

MO, Mg+2 was evidenced. This happened from the beginning to the end of the research period, while the rest of the variables increased. All other parameters experienced small differences throughout the period of investigation. Regarding macronutrients, in biosolid and vermicompost the concentration of K and P increased, even the percentage of N augmented in the case of vermicompost.

Weather conditions, temperature, humidity and precipitation were the best for proper growth of crops. The application of biosolid and vermicompost in the soil had a positive effect on plants and the soil itself. However, in the case of treatments where biosolid was used, there was a prolonged effect despite adverse conditions - salinity.

It is correct to say that it is possible to obtain more production and better quality crops, using organic fertilizers such as biosolid and vermicompost.

Keywords：*Biosolid; worm humus; recovery saline soil, feed barley, white clover, ANOVA.*

P4-399

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Effect of Salinity Stress, Potassium, and Zinc on the Nutritional Responses of Wheat

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Salinity is considered as one of the most striking abiotic and restrictive stresses in agricultural production. In order to study the interaction effects of potassium and zinc on reducing the adverse effects of salinity on plant growth characteristics in wheat, an experiment was conducted in factorial based on completely randomized design with three replications in both saline and non-saline soil. The studied treatments included three levels of zinc (zero, 5, and 10 mg Zn per kg of soil) from a zinc sulphate source, and three levels of potassium (zero, 200, and 400 mg K2O per kg soil) from potassium sulfate source. Results from analysis of variance regarding nutritional properties of wheat showed that different levels of potassium on the shoot and root potassium uptake was significant ($p<0.001$). Potassium uptake from 155 mg/pot in the control treatment was increased to 183 mg/pot in 400 mg of potassium, and showed an increase of 18%. The main effect of salinity on potassium uptake of shoot was also significant. Potassium uptake from 182 mg/pot on the first level of salinity reached to 152 mg/pot at the second level of salinity, and showed 19.7% reduction. Potassium to sodium ratio reaches from 87 at the first level of salinity to 3 in the second level and was decreased to 29 times. The use of 5 mg per kg of zinc increased the uptake in shoots than the control treatment 3.87 and decreased the salinity effects, meanwhile potassium also showed beneficial effects on studied parameters.

Keywords：*Potassium, Nutrient Uptake, Sodium, Salinity, Wheat*

P4-400

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Different Approaches of Nutrient Application and Management Practices on Yield of Maize (zea Mays L.) and Finger Millet (eleusine Coracana) in Eastern Dry Zone of Karnataka

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In the state of Karnataka, India; the NPK recommendations for finger millet and maize crops included in the package of practice and being adopted by to farmers were developed over 40 years ago by the scientists of agricultural universities in collaboration with ICAR institutions and development departments. These recommendations may not be relevant in the present day context as there is appreciable decline in the organic matter level and fertility levels of soils. The present farming condition warrants the need for revalidation of the package of practice recommendations for different crops. Hence, revalidation of the present package of practice (POP) for important crops particularly maize and finger millet in Eastern Dry Zone of Karnataka is very much needed. The experiments conducted in sandy loam soils of rainfed ecosystem receiving rainfall of 830 mm/annum for 2 years under farmer's field of different locations covering the Eastern Dry Zone of Karnataka. Based on soil analysis and LMH concept, the following treatments viz., T1: Rec. NPK as per Package of Practice, T2: STCR approach for rainfed crop (NPK) , T3: Soil test based NPK recommendation (LMH approach) (STL method), T4: Soil test based NPK recommendation (± 25%) , T5: Soil test based NPK recommendation (+ 25% N, P and K if medium) , T6: Soil test based NPK (NK ± 50% and P ± 25%) and T7: Soil test based NPK recommendation + 75% RDP if soil test for P is medium or 50% RDP if soil test for P is high or RDP if soil test for P is Low+ Rec. PSB were tried with 3 replications. Based on soil test values, 13 experiments were conducted on finger millet and 6 experiments conducted on maize crop.

The results showed that application of fertilizers based on soil test NPK recommendations with N and K ± 50% and P ± 25% recorded 23.93% higher grain yield (23.98 q/ha) as compared to present recommended dose of fertilizers (19.35 q/ha) in finger millet crop. Similarly, application of 25% more NPK even in soil with medium fertility status recorded 12.91% higher grain yield (74.0 q/ha) as compared to present recommended dose of fertilizers (65.54 q/ha). These results clearly indicate that there is urgent need for revalidation of package of practice recommendations for maize and finger millet crops for enhancing yield of maize and finger millet crops.

Keywords：*nutrient management, maize, finger millet*

P4-401

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Nitrogen Fertilization on Soil Nutrients, Leaf Nutrient Composition, Growth and Yield of Oil Palm on Tropical Peat

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Being a versatile perennial crop, oil palm becomes one of the important national economic crops in the tropics. Malaysia is one of the largest producers and exporters of palm oil, accounting for 37% of world palm oil production and 46% of world exports in 2010 (Oil World, 2011). Tropical peatland is the last frontier of arable land available for agricultural development in Sarawak, Malaysia. A study has shown that oil palms planted on peat in most mature years can produce comparable yields as coastal mineral soil (Hasnol, 2007). To achieve that, good understanding of the basic agronomic of oil palm is necessary to maximize effectiveness of fertilizer application (Goh et al., 1999). To date, there are still very limited studies on the fertilization application in oil palm on tropical peat. Therefore, a study was carried out from 2009 to 2012 at an oil palm plantation in Sibu, Sarawak, Malaysia to investigate the effects of different nitrogen rates on soil nutrients, leaf nutrient composition, growth and yield of oil palm on tropical peat.

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The five-year-old mature palms were planted in a triangular pattern with a planting distance of 8.5 × 8.5 × 8.5 m. The four treatments evaluated were: 0 kg N (N0), 0.21 kg N (N1), 0.42 kg N (N2), and 0.84 kg N (N4). Standard fertilizer rates of 0.525 kg P, 3.12 kg K, 0.4725 kg Mg, 0.0315 kg Zn, 0.0345 kg Cu, and 0.0225 kg B were applied per palm per year. Three peat soil samples at two depths of 0-25 cm and 25-50 cm were collected monthly from each plot. Sixteen palms per plot with frond 17 were sampled at half yearly interval, dried using oven and grinded into 2 mm size for nutrient analysis. For vegetative growth, leaf and rachis physical measurements were also conducted to calculate leaf area, leaf area index (LAI) and frond dry weight. Bunch number, bunch weight and yield for 16 palms in 12 plots were measured at every 10 days interval.

According to the average data of four years, the treatment at N1 level produced the highest reading for exchangeable and total Ca at both soil layers, and total Mg at 0-25 cm soil depth. As compared to other treatments, the control treatment generated the highest reading for exchangeable and total K, and exchangeable Na at the two depths. Inputs of N fertilizer at N4 level elicited the minimum reading for exchangeable and total Mg, exchangeable K at 25-50 cm depth, and total K at both soil layers. In all treatments, there was generally an increasing trend in exchangeable K and exchangeable Na at the two soil depths, total Ca at 25-50 cm depth, total Mg and total K at both soil depths. Conversely, exchangeable Mg in general exhibited a decreasing trend during trial period. It was shown that all exchangeable and total cations except exchangeable Na declined with soil depth.

The results demonstrated that increased N rates improved leaf N, P and K content. In contrast, negative response to high fertilizer rates were generally noted in leaf Ca and Mg. It was shown that the mean leaf N and P concentrations with treatment at N4 level were highest. Leaf N concentration at N4 level increased by 8.1% over the 4 years period compared as to the control treatment. Similarly, leaf P and K content also increased marginally with highest N rates but significantly reduced leaf Ca concentration due to the antagonistic effect of soil ammonium. It was also shown that leaf area and frond dry weight were improved with the application of N fertilizers although no significant differences were observed among treatments. Oil palms at N4 level produced the highest yield among all treatments coincided with larger leaf area, higher frond dry weight and leaf N concentration.

Keywords：*Nitrogen fertilization, oil palm, tropical peat*

P4-402

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Optimization Of Nitrogen Level In Field Grown Quinoa

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Quinoa (Chenopodium quinoa Willd.), a pseudo cereal, is a new introduction in Pakistan. Crop is abiotic stress tolerant and low input requiring with grains of superior nutritional profile as compared to common cereals. Its production technology has yet to be explored. For obtaining high crop yields nutrient in balanced amount is a basic requirement. A field experiment was conducted to evaluate the influence of different Nitrogen doses (0, 50, 75, 100, 125 kg ha-1) on the productivity of two promising genotypes A9 and CPJ-2. N fertilization did not affect the stand establishment of both the tested genotypes. N fertilization (75 kg N ha-1 and higher N levels) caused early completion of vegetative phonological stages like days to multiple leaves up to panicle emergence stage, different time to flowering and milk stage of both tested genotypes while delayed maturity of genotype A9. Genotype CPJ2 was early maturing as compared to genotype A9. 75 kg N ha-1 and higher N levels improved all growth and yield related traits resulting in increased biomass production, economic harvest and harvest index of both tested genotypes. Maximum value of % increase in grain yield over control (145%) was recorded in genotype CPJ2 at 75 kg N ha-1 and in genotype A9 peak value (166%) was observed at 100 kg N ha-1. Comparably Genotype A9 (3122.7 kg ha-1) was high yielding than CPJ-2 (2015.3 kg ha-1). N (75 kg N ha-1 and higher N) improved leaf chlorophyll content. However negative relationship was found between N levels and leaf proline /MDA contents of both genotypes. We conclude that quinoa responds well to N. Soil applied N @ 75 kg N ha-1 was best level to attain maximum economic harvest of both quinoa genotypes under test.

Keywords：*Quinoa, Pakistan,Nitrogen*

P4-403

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Increasing Nitrogen Use Efficiency in Rice Through Nitrogen and Water Management

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Reduced nutrient use efficiency in cereal cropping systems has come to the fore for the worldwide challenge of meeting ever increasing food demand. Synthetic fertilizer application contributes 43% of the 70 million ton (MT) of the nutrients taken up by crop production across the world; the above percentage tended to increase with soil fertility depletion. Increasing nutrient use efficiency of the rice production system and uses of nutrient efficient rice varieties are imperative for increasing economic returns. Three experiments were conducted at Soil Science Field Laboratory, Bangladesh Agricultural University, Mymensingh with management practices like water and fertilizer along with nitrogen efficient variety selection to increase nitrogen use efficiency of rice. The interlinked experiments conducted to achieve the goal are: N fertilizer trial, fertilizer in combination with water trial, variety selection trail. The fertilizer experiment consisted of 7 treatment combinations of different forms of urea fertilizer (Prilled urea (PU), and USG 1.8g & USG 2.7g) and cowdung. Split application of PU instantly increased pore water NH4-N and NO3-N and came down to ground state after 6 days of application during the all three splits of PU. USG application specially 78 kg N /ha from USG (1 x 2.7 g/4 hills) generated available NH4-N and NO3-N slowly rather spontaneously over a long time indicating a beneficial role of USG over PU. The application of USG alone or in combination with organic manure performed significantly better in terms of yield and yield parameters compared to 100% dose of PU. The highest value of NUE was obtained in T3 (78 kg N/ha from USG (1*2.7g/4 hills)) and the lowest value was found in T4 (5 t CD+PU on IPNS basis (@140kg N/ha)). The range of NUE varied from 20 to 75. The fertilizer in combination with water management experiment was laid out in split plot design using water in the main plot and fertilizer N in the subplot. The two water regimes, alternate wetting and drying (AWD) and continuous flooded (CF) used in the experiment did not show marked variation in growth and yield of rice may be due to inaccurate AWD water management. Like the fertilizer experiment the USG alone or in combination with cowdung gave better yield and the highest NUE was obtained in N3 (104 kg N/ha from USG (2 x 1.8 g/4 hills)) and the lowest value was found in N2 (140 kg N/ha from PU). The variety selection experiment was conducted using 15 boro cultivars taking 3 local varieties and 12 high yielding varieties. BR15 and BRRI dhan 29 are two varieties that performed better and have potential to be used for increasing NUE in rice culture. The overall results indicate that the application of N as USG alone or in combination with cowdung had better performances on NH4-N and NO3-N dynamics in pore water and maintained a steady supply over the rice growing period leading to a better rice growth, grain and straw yields, nitrogen content in grain and straw and nitrogen use efficiency as compared to that from PU.

Keywords：*rice, prilled urea, urea super granule, niyrogen use efficiency, alternate wetting and drying*

P4-404

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Nitrogen Mineralization and Utilization of Silkworm Litter as Organic Fertilizer on Growth and Yield of Pak Choi (Brasica Rapa Var Chinensis)

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An experiment was conducted on Kamphaengsaen soil series (Fine-silty, mixed, semiactive, isohyperthermic Typic Haplustalfs) to determine nitrogen mineralization and effect of silkworm litter as organic manure on growth and yield of Pak Choi ((Brasica rapa var chinensis). Nitrogen mineralization in ammonium(NH4+) and nitrate(NO3-) form was investigate by incubation techniques within 44 days after application. Ammonium nitrogen(NH4+-N) release in soil increased rapidly in the first 5 days after incubation (DAI). The highest increase in NH4+-N was recorded in treatment applied with silkworm litter only and thereafter, it decreased. Highest nitrate nitrogen (NO3--N) in soil was found in the 23 days after incubation (DAI) then constant. Pot-experiments performed on comparison of silkworm waste and urea at recommended dose of fertilizer. The results indicated that the application of chemical fertilizer alone recorded highest Pak Choi yield but not significantly different when compared with mix-application between chemical and silkworm litter and silk worm litter. These results are discussed in alternative possibility for using silkworm litter to improve Pak Choi yield.

Keywords：*silkworm litter, pak choi, organic fertilizer*

P4-405

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Modelling of Nutrient Management for Increasing and Maintaining Irrigated Lowland Rice Productivity in West Java Province Indonesia

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Application of imbalance input of inorganic and organic fertilizers in long period on irrigated lowland rice area has been claimed as the main factor in decreasing of irrigated lowland rice productivity. Based on the above issues, field experiment on modeling of nutrient management for increasing and maintaining irrigated lowland rice productivity particularly in West Java Province Indonesia has been done from January-November 2013. The objectives of the research were to find out the optimum combination input of organic and inorganic fertilizers to increase and maintain lowland rice productivity on several nutrient statuses at a level of 13.0 tones milling dry weight ha-1year-1. Nutrient status of lowland areas was determined based on the status of P and K map of irrigated lowland areas with assuming that status of organic matter and nitrogen were low. The research was done using dynamic system approach, collecting primary data by conducting interview to the selected farmers and also secondary data by conducting focus group discussion (FGD) with involved stakeholders. The selected data was analyzed using Power-ySim software with the time horizon of the developed model was 6 year, from 2012-2017

The results showed that there were six P and K statuses of irrigated lowland rice areas, namely PmediumKlow, PmediumKmedium, PmediumKhigh, PhighKlow, PhighKmedium, and PhighKhigh. The developed model showed that rice productivity of lowland areas was controlled by any factors such as nitrogen (as Urea fertilizer), phosphate (as SP-36 fertilizer), potassium (as KCl fertilizer), organic matter (as rice straw), seed quality, and crop damage attack organism. On the PmediumKlow status, the farmer's practice usually use Urea, SP-36, KCl, and organic matter at a rate of 240 kg, 80 kg, 55 kg, and 100 kg per ha per cropping season, followed by application of 80% of high yielding varieties. It was observed that intensity of crop damage organism attack around 5.5%, and this condition cannot support the targeted productivity only about 10.10 tones milling dry weight ha-1year-1 on 2017. The targeted productivity (13.0 tones milling dry weight ha-1year-1on 2017) could be achieved by simulated the farmer's practice input into 300 kg Urea, 80 kg SP-36, 100 kg KCl, and 5000 kg organic matter per ha per cropping season, followed by application of 100% high yielding varieties. Interestingly, the targeted productivity also could be achieved by modifying the simulation input during the last 3 years period (2015-2017) into a rate of 300 kg Urea, 75 kg SP-36, 100 kg KCl, and 4000 kg organic matter per ha per cropping season. On the PhighKhigh status, the farmer's practice of input consisted of 250 kg Urea, 100 kg SP-36, 50 kg KCl, and 1000 kg organic matter per ha per cropping season, followed by 100% high yielding varieties. The crop performance showed that intensity of crop damage organism attack about 5.0%, while rice productivity lower than targeted around 12.10 tones milling dry weight ha-1year-1. The targeted productivity could be achieved by simulated the input into 300 kg Urea, 50 kg SP-36, 50 kg KCl, and 2500 kg organic matter, followed by 100% high yielding varieties. The targeted productivity also could be achieved by modification of the simulation input during the last 3 years period (2015-2017) into 300 kg Urea, 50 kg SP-36, 50 kg KCl, and 1750 kg organic matter. There were any slightly variation input and productivity level of irrigated lowland rice among the 4 others of lowland areas status

Keywords：*modelling, nutrient, management, lowland rice, productivity*

P4-406

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Silica Application on Improving Rice Resistance to Blast Disease and Growth in West Java, Indonesia

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Indonesia is the third biggest rice producer in the world (FAOSTAT, 2013). However, nowdays the rice productivity in Indonesia has fluctuated and stagnated over the past decade. Several cultivation methods have been adopted to improve rice production in Indonesia such as improved varieties, fertilizers, and water management, however silicon (Si) application in rice production has not been applied in Indonesia. Si is a beneficial element for rice and sugarcane (Epstein 1999; Imaizumi and Yoshida 1958; Matichenkov and Calvert 2002). Si also contributes to improve resistance of rice to blast disease, lodging problem, absorption of elements such as N, P, and K, and to improve tolerance to biotic and abiotic stresses (Mengel and Kirkby, 1987; Deren et al. 1994; Hu and Wang, 1995; Savant et al. 1997; Neumann and Niede, 2001; Liang et al., 2007). Over the past three decades, availability of Si in "sawah", i.e. a leveled and banded rice field with inlet and outlet for irrigation and drainage, respectively (Wakatsuki et al., 1998), has decreased by 11-20% (Darmawan et al., 2006) and DSi concentration in irrigation water in Indonesia has also decreased by 10-20% (Husnain et al., 2009) which has manifested in the occurrence of blast disease attack in sawah and related with fluctuation in rice productivity in Indonesia. Based on this background, we conducted a research on the effect of Si application on improving rice resistance to blast disease.

Field experiment was set up at sawah field at Bojong Village, Sukabumi District, West Java Province. This research was consists of 2 treatments, Si+ (with Si application of 900 g/plot of silica gel) and Si- (without Si application) with 8 replications. The plot size was 3m x 3m and we used "Ciherang" rice variety. Fertilizers NPK was applied three times at 7, 25 and 45 DAT (day after transplanting) and Si was applied before transplanting. We took soil samples and plant samples at 7, 40 DAT and harvest time. Growth parameters namely plant height, number of tillers and number of leaf, was observed at 7, 42 and 77 DAT and also yield component. Blast disease intensity was observed at 14 and 42 DAT for leaf blast and 77 and 91 DAT for neck blast.

The result showed that at 7 DAT the soil pH at Si+ and Si- was the same level, 5.7 and 5.6 respectively. Soil available Si was 39.78 and 38.54 mg SiO2.kg-1 for Si+ and Si-, respectively. Meanwhile Si content in rice leaves at 7 DAT was 100.2 and 96.6 g SiO2.kg-1 for Si+ andSi-, respectively. Reffered Analyses of the others soil properties and plant samples with different sampling time are under going. For growth parameter, there was generally no significant difference for plant height. Number of tiller and number of leaf at Si+ treatments were.higher than those in Si- by 4% and 3%, respectively.

On blast disease intensity, rice plants in Si+ had lesser blast infection comparing to Si- treatments. From each plot we observed 16 plants. The score value of leaf blast (Ministry of Agriculture Republic of Indonesia, 2008) for Si+ ranged from 1 (small dot) to 3(oval shape with 2 – 20 mm sized, 2% of infected leaf surface area) and for Si- was 1 to 5 (>2 - < 10% of infected leaf surface area). At Si-, blast disease with score value 3 was up to 87.5% and Si+ 43.75% in average. Moreover, neck blast also occured in the both treatments, which attacked up to 11.47% at Si+ and 17.37% at Si- treatments. Si application clearly showed the positive effect on improving rice plant resistance. Additional Si could increase Si deposition on plant tissues surface that might be responsible for the protective effect of Si on biotic stress such as blast disease (Ma and Takahashi,2002) The yield showed a slight difference between Si+, 4.02 and Si-, 3.87 kg/plot.

Based on the results, Si fertilizer application at sawah field in Indonesia could give positive effect on increasing rice plant resistance on blast disease.

Keywords：*Silica application, blast disease, rice growth*

P4-407

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluation of the Potential of an Accelerated Compost as a Fertilizer for Maize Production on an Ultisol

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Accelerated compost (compost that matures within one month) saves time and increase the tendency to boost up the production capacity of the commercial compost producers thereby increasing the availability of compost to farmers. This study therefore evaluates the performance of a microorganisms-accelerated compost using maize as a test crop on an Ultisol. Completely Randomized Design (CRD) replicated three times was used for both the incubation and screen house studies. Major treatments were accelerated compost (AC) at the rate of 30, 60, 90, 120 and 150 kg N / ha. Mineral fertilizer (NPK 15-15-15) and unaccelerated compost (UC), both at the rate of 60 kg N / ha as well as the absolute control (no soil additive) were used as control treatments. Both the incubation and screen house studies were conducted for six weeks using Ultisol. Data were collected on nutrient release from the incubated soils weekly from 2 - 6 weeks after incubation. Data were also collected on N, P and K uptake of maize from the screen house study weekly from 2 - 6 weeks after planting. The data obtained in incubation study were represented using trend line graph while the one from screen house study were compared using standard error of means. Correlation analysis was also carried out to test the relationship between the nutrient release in the incubated soils and the nutrient uptake by the maize in the screen house. The incubation results showed that accelerated compost (AC) gave a similar nutrient release pattern compared with NPK and unaccelerated compost (UC) as revealed by the result of the N, P and K release pattern. Also, the screen house results showed that accelerated compost (AC) compared favourably with mineral fertilizer (NPK 15-15-15) and unaccelerated compost (UC) as revealed by the N and P uptake of maize plant at 6 weeks after planting. It also showed that 90 kgN / ha AC compared favourably with 60 kgN / ha NPK while 60 kgN / ha AC compared favourably with the 60 kgN / ha UC. The correlation analysis showed that there is significant relationship only between the P release and uptake in 30 kgN / ha AC and K release and uptake in both 60 kgN / ha UC and 60 kgN / ha NPK. It could therefore be concluded that accelerated compost (AC) has the potential to release nutrient for crop growth and development compared to mineral fertilizer (NPK 15-15-15) and unaccelerated compost as revealed by its nutrient release pattern and that it could support the growth of maize and other crops with similar nutrient requirement (in spite of its shortness in duration to maturity) as adequate as NPK and UC as revealed by the nutrient release from the incubated soils and uptakes by maize plants in this study.

Keywords：*Accelerated compost, Ultisol, Incubation study, Zea mays*

P4-408

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

System Based Nutrient Management for Maize-Groundnut and Maize-Sunflower Sequences in Eastern Dry Zone of Karnataka

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The imbalanced and inadequate use of chemical fertilizers under maize based cropping sequences in eastern dry zone of Karnataka state is the main cause for stagnation in productivity. This problem became a big challenge to the scientific community and this necessitating for new research agenda. So several fertilizer recommendation approaches have been used based on soil test to tackle above mentioned problem with respect to fertilizer application and to attain maximum yield per unit of fertilizer use. However, these fertilizer recommendations are not well suited when the different cropping sequences and different soils are considered. In order to overcome these, a study entitled "System based nutrient management for maize–groundnut and maize-sunflower sequences" was taken up by conducting experiments in farmer's field in Eastern Dry Zone of Karnataka during the years 2010-11 and 2011-12. The soils of the experimental sites were sandy loam in texture with medium status of available nitrogen, phosphorus and higher status of potassium. The major portion of normal rainfall (690-700 mm) was received during May to November. The experiments were conducted in irrigated condition with maize as kharif crop and during rabi-summer season, the experimental plots of kharif season were divided into 2 plots to raise sunflower and groundnut crops and respective treatments viz., T1: Rec. NPK as per package of practice, T2: STCR approach for irrigated crop (NPK), T3: Soil test based NPK recommendation (LMH approach) (STL method), T4: Soil test based NPK recommendation (± 25 %), T5: Soil test based NPK recommendation (+ 25 % N, P and K if medium),T6: Soil test based NPK (NK ± 50% and P ± 25 %), T7: Modified T3 with respect to P (Rec. NK & 75 % P if P is medium)+ PSB and T8: SSNM approach for targeted yield of 100 q ha-1 for maize,37.5 q ha-1 for sunflower and 25 q ha-1 for groundnut were imposed based on soil test results and soil fertility ratings of major nutrients after the harvest of kharif maize crop.
The experimental results showed that, plots receiving nutrients through SSNM approach recorded higher total maize equivalent yield (177.8 q ha-1) with higher nutrients uptake, soil available nutrients, soil microbial population, net returns (` 1,13,819 ha-1) and B:C ratio (2.71) in maize-sunflower cropping sequence as compared to all the other treatments. Whereas, soil test based NPK recommendation (+ 25 % NPK under medium soil fertility) recorded higher total maize equivalent yield (140.8 q ha-1), net returns (` 84,099 ha-1) and B:C ratio (2.43) in maize-groundnut cropping sequence as compared to all the other treatments. Thus it is concluded that adoption of SSNM approach for cropping sequence involving exhaustive crops and soil test based NPK recommendation (+ 25 % NPK under medium soil fertility) for legume based cropping sequences were found to be effective nutrient management practices in getting higher crop productivity and B:C ratio.

Keywords：*cropping sequences, nutrient management, maize, sunflower, groundnut*

P4-409

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Bio-Composting from Residual Waste: A Success in Soil Properties and Soil-Borne Plant Pathogens Control

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High dose of inorganic fertilizer use of farmers' practice has led to high disease infection, low crop yield and high investment. The objectives of this study were to evaluation the effect of bio-compost (sugar-cane filter cake plus Trichoderma spp.) on improvement of soil fertility, crop yields and control of soil-borne diseases on some upland crops. Crops were selected for field experiments through two consecutive crops such as onion (Allium cepa), ginger (Zingiber officinale) and water melon (Citrullus lanatus (Thunb.). Bio-compost was applied at 10 tonnes.ha-1 in combination with 75% dose of recommended inorganic fertilizers to compare to farmers' practice. The results showed that application of bio-compost at the levels of 10 tonnes.ha-1 with reduction in inorganic fertilizer led to a significant increase in soil organic matter content, soil nitrogen mineralization, soil respiration, exchangeable Ca, soil structure stability. The onion bulb disease caused by Colletotrichum sp. was low (below 1%) in organic amended compared with inorganic management (5%). Rhizoctonia solani infected on ginger was reduced from 32% to 18%; and from 8% to 0.3% for Fusarium wilt infected on watermelon, . Concerning crop yields, using bio-organic amendment with low dose of inorganic fertilizer resulted in increasing yield from 32-40% in comparison to farmers' practice ($p<0.05$). These results encourage farmers to reduce risk from soil-borne disease and to increase soil quality and crop yields by applying bio-compost.

Keywords：*Bio-compost, soil-borne disease , soil bio-chemical physical properties, crop yield*

P4-410

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Long-Term Tillage Systems Impacts on Soil Physical Properties and Agronomic Productivity of a Romanian Cambic Chernozem

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As in the many countries of Europe, the application of conservation tillage (CT) in the Romania is still limited but interest is growing.

This paper seeks to review the current knowledge on soil cultivation and its effects to both soil physical properties and crop productivity when using noninversion tillage system. Reduces tillage systems have been widely promoted the entire world as an important tool to raise soil quality and improve the productivity of soils.

Retention of vegetal residues of the previous crop on 30% of soil surface is considered the lower limit of the classification of tillage systems for soil conservation.

Conservation tillage (minimum, reduced, no-tillage) has a positive influence on different soil properties, such as water stable aggregates, penetration resistance, bulk density or soil water content, mostly after a few years of experimentation. The aims of this study were to assess the long-term (9 years) effects of tillage systems (i.e., conventional – CT with two variants: plough at 20 and plough at 30 cm (control variant) and reduced tillage – RT with three variants: disc harrowing at 12 cm, chisel at 25 cm and paraplow at 25 cm) on soil physical properties of Cambic Chernozem from Moldavian Plateau – Romania, to 30 cm depth and to assess the relationship between soil physical properties and crop yield. Except for the soil tillage and seedbed preparation, all the other technological sequences of sowing, fertilizing and weed control were identical in all treatments. Each tillage treatment remained on the same plot for the duration of the study and had two level of fertilization: N0P0 and N80P80.

The crop rotation comprised a 3-year cropping sequence involving three crops with soybean (Glycine max, L. Merril), maize (Zea mays L.) and winter wheat (Triticum aestivum L.) In the case of conservation tillage, 1/3 of the previous crop residues were shredded and left on the top of soil.

A field experiment was established since 2005 at experimental station of the Agricultural University and Veterinary Medicine located in the city of Iasi, in the NE region of Romania (47o07’36” N latitude, 27o30’45”E longitude), 125 m elevation. The soil has a clay-loamy texture, 6.8 pH, 2.7% humus content and a medium level of fertilization with the ground water level at 10 m depth and no irrigation system. Treatments were arranged in a “split plot” design with three replicates. All subplots were separated by a 1 m buffer zone. Plots covered an area of 60 m2.

Long-term amount of precipitation at this site is 517.8 mm at an average air temperature of 9.4oC but, significant deviations from the long term average and temperature have been observed in recent years.

The comparison between the two agricultural systems, conventional agriculture and conservation agriculture, was based on the data collected in the field, concerning the The present study mainly focuses on the agricultural years 2011/2012 and 2012/2013 maize (Zea mays L.) growing seasons.

The bulk density ranged on 0-30 cm in 2011/2012 from 1.24 g•cm-3 on plough at 30 cm to 1.29 g•cm-3 on disk harrow treatment at the beginning of vegetation seasons and from 1.40 g•cm-3 on chisel to 1.50 g•cm-3 on disk at maize crop harvesting. Also have been identified compacted layers on disk and plough treatment.

Aggregate stability was only measured on the smaller soil fraction as this particle size is usually responsible for sealing the soil.

he water stable soil aggregates (WSA) were measured using the procedure of Kemper and Rosenau (1986) and a Eijkelkamp Sieving Machine. The highest values of WSA has been observed on conservation variants, chisel and paraplow, 80.2 and 76.9 % respectively.

In the drought conditions of 2012, the highest maize yield, 3956 kg•ha-1 has been recorded on chisel and fertilized, significantly higher then control treatment, 2387 kg•ha-1 (LSD 0.1%). The lowest yield was found on plough at 30 cm and unfertilized 1723 kg•ha-1, with very significant differences at LSD 0.1%.

Penetration resistance determined in the field at a water content around field capacity at 0–50 cm depth, using a digital penetrologger (Eijkelkamp Equipment) ranged from 0.35 MPa on first five cm to 2.60 MPa at 30-35 cm depth.

Keywords：*Reduced tillage cropping systems, bulk density, penetration resistance, yield*

P4-411

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Long-Term Effect of Application of Edible Fungus Residue on Soil Physicochemical Properties Under Rice - Edible Fungus Rotation System in East China

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Long-term heavy application of chemical fertilizers causes soil degradation and environmental pollution as well. In contrast, organic fertilizers can improve soil fertility. Hence, application of organic and chemical fertilizers in combination is recommended based on soil test. Rice is the most important staple food crop cultivated in China. Yet, the rice cultivation area tends to decrease due to little economic profit to grow rice for the small hold farmers in developed areas such as in Zhejiang Province, east China. In recent years, Auricularia auricular, a type of popular edible fungus, is grown in bar-sized substrates standing in the paddy field to achieve double wins (high rice production and high economic profit). Consequently, a new crop rotation regime has been introduced in the traditional rice production regions. Moreover, after harvest of the edible fungus the residue of the substrates can be used as organic fertilizer to improve soil fertility. To understand the effect of the fungus residue on improving soil properties and rice yield, a long-term field experiment was conducted (July 2010 - October 2012) based on chemical fertilizer application recommended by local agricultural service station. A two-factor experiment was designed with total of nine treatments: three rates of chemical fertilizers (0, 50% and 100% of the recommended, named as C0, C50 and C100 respectively) and three rates of the fungus residue (0, 10600 and 21200 kg/ha, named as F0, F50 and F100 respectively). Results showed that the effect of fungus residue on rice yield and soil properties gradually became apparent. For rice grain yield, there was no difference between treatments in the first year. In the second year, rice grain yield was not affected by residue application. In contrast, it was significantly affected by fertilizer treatments: it was significantly decreased by F0 and slightly decreased by F50 compared with F100. In the third year, the interaction between F and C became apparent although the rice grain yield increase compared with C0F0 was still greatly attributed to the chemical fertilizer application: The combined application of C and F, C100F50 and C100F100, resulted in the highest rice grain yield (8850 and 8969 kg/ha, respectively), and C0F0 the lowest (5055kg/ha). There were yet not significantly different between C100F0 (8767kg/ha) and C50F50 (7250kg/ha). Compared with the original soil (at start of the experiment, July 2010), soil physicochemical properties showed that, after two years of rice - edible fungus rotation at third rice harvest in October 2012, soil pH was greatly increased regardless of the treatments, being the highest increase of 1.3 pH units by C50F100 (from pH 5.64 to pH 6.95). Soil organic matter (SOM) content was decreased slightly although soils in plots with residue addition had greater SOC contents (19.42-26.90 g/kg) in years 2010 and 2011 than the original (19.15 g/kg). The soil bulk density was decreased by residue addition (from 1.3 to 1.1 g/cm3). However, soil available N, P and K were significantly decreased in all treatments. While comparing properties of soils sampled at rice harvest and prior to the next rice seedling transplant, i.e., during the edible fungus cultivation in the field, it showed that the edible fungus cultivation resulted in remarkable decrease of SOC content and increase of soil pH and available P and K, so that soil available P levels could be recovered to the original level at rice seedling transplant, but soil available K could not. By contrast, changes of soil available N were complex: soil available N increased in year 1 (December 2010- June 2011) but decreased in year 2 (December 2011- June 2012) by the fungus cultivation in all treatments. In general, C100F100 and C100F50 were best to improve soil properties and to maintain soil available nutrient levels while also to achieve high rice grain yield. Therefore, the combined application of C and F could ease the problem of soil degradation caused by long-term application of chemical fertilizers, although soil available K tended to be depleted under current recommended rate of chemical fertilizer application. Consequently it's necessary to optimize the rates and proportions of organic and inorganic fertilizers to improve paddy soil fertility.

Keywords：*chemical fertilizers, edible fungus residue, rice - edible fungus rotation, yield, soil fertility*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Nitrogen Nutrition and Intensity of Thinning in Peach Production

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Low productivity of peach orchards [Prunus persica (L.) Batsch] in Brazil is caused partly by low doses of lime and fertilizers, especially nitrogen (N). N is required in large quantity by this crop, but its application should be accompanied by thinning to increase the size of the remaining fruits. Besides this, further field experiments are necessary to improve the recommendations for N fertilization under various growing conditions, with the use of more efficient and/or complementary methods of nutritional diagnosis. The present article reports the results of an experiment to evaluate the effect of nitrogen doses and two thinning intensities and their relations with the activities of the enzymes urease and nitrate reductase and with fruit yield. The experiment was conducted on the farm maintained by Pontifical Catholic University of Parana, located in the municipality of Fazenda Rio Grande, Parana, Brazil. Climate in the region is classified as Cfb on the Köppen scale and soil was classified as Oxisol, with clayey texture. The experimental design was randomized blocks, distributed in a factorial scheme, with three repetitions. Treatments consisted of seven N doses: 0, 40, 80, 120, 160, 200 and 240 kg ha-1 year-1, using urea as N source, applied on the surface under the crown projection. The thinning was done by hand in two intensities, measured by the number of fruits left per plant: Treatment 1 - 150 fruits/plant; Treatment 2 - 200 fruits/plant. Activities of the enzymes urease (UR) and nitrate reductase (NR) were determined during the phenological stages of the crop, using the methods described by Hogan et al. (1983) and Mulder et al. (1969), respectively. The fruits were harvested at the start of December 2011 and 2012. The data were submitted to analysis of variance (ANOVA) and regression analysis was used to evaluate the effect of the N doses. There was a significant interaction between N doses and phenological states for activity of UR, with a gradual increase in enzyme activity with rising N doses and phenological state. Based on these results, it can be stated that the plants store N in the branches, stems and leaves, acting as a reserve for subsequent development of new tissues. Activity of NR was low during the entire cycle and was not influenced by treatments or phenological states. Enzyme evaluations indicate that peach trees present substantial recycling of N during the vegetative and reproductive stages. The values for NR activity varied from 0.42 to 1.89 μmol NO2- g MF-1 h-1, showing that apparently the nitrogen applied in one year is absorbed and stored for the following year's harvest. Since the activity of NR was low, this indicates that the absorption can be low and continuous, suggesting splitting N fertilization in small portions rather than in a single yearly dose to improve the efficiency of its use by the plants. The productivity was significantly influenced by interaction of fertilization and thinning in 2011. Highest yield was obtained at a dose of 240 kg N ha-1 and thinning intensity of 200 fruits/plant, producing an average of 27.4 t ha-1. There was an increase of 41 kg of fruits for each kg of N applied. For the thinning intensity of 150 fruits/plant, the maximum yield obtained was 22.8 t ha-1, presenting an increase of 23 kg of fruits for each kg of N. In 2012 there was no effect of the treatments on the productivity, due to the climate conditions and greater incidence of pests and diseases. Nevertheless, the average yield in 2012 (14.24 t ha-1) was 10% and 20% greater than the state and national averages, respectively. The high yields in 2011 and 2012 can be associated with the productive potential of 'Chimarrita' cultivar, good soil fertility and crop treatment practices during vegetative and reproductive stages. It can be concluded that peach trees have the capacity to remobilized N, but the low NR activity demonstrates the importance of split N fertilization during phenological stages. The evaluation of the nutritional state by measuring the activity of UR proved to be a promising technique for this crop, and can be considered a tool to help determine fertilization management

Keywords：*Enzyme activity, Urease, Nitrate reductase, Foliar diagnosis*

P4-413

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

A Microbiological System to Improve Soil Fertility and Maize Plants P-Uptake in Field Conditions in Mali

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The Tilemsi phosphate rock (TPR) of Mali is a good and cheaper alternative to imported phosphate fertilizers. Many soil microorganisms can also mobilize sparingly soluble inorganic phosphates, and several have a good potential to improve plant growth. With the aim of improving the response of maize cultivated in Mali to fertilization with TPR, in this work we describe the isolation and selection from four different Malian soils of TPR-solubilizing actinomycetes (TSA) with high P-mobilization activities. Initially 28 actinomycetes were selected, but after 10 subcultures on agar plates and a liquid medium only 4 actinomyctes were retained for their high P solubilizing trait. A field inoculation trial was established during the growing season 2012–2013 in Bamako (Mali). Maize cv. Dembagnuman was inoculated with the 4 selected TSA and fertilized with 30 kg ha-1 P added as TPR or diammonium phosphate (DAP). The non-fertilized maize plants were used as control. The growth parameters measured were plant height at 30 and 60 days, the number of leaves per main stem at 60 days, and root and shoot dry matter yields 60 days after planting. Root colonization by indigenous arbuscular mycorrhizas (AM) was also measured in 45-day-old plants. Significant interactions were observed between TSA inoculation and P-fertilization for root colonization with AM, plant height at 30 days and root dry matter yield. The Actinomycetes isolates significantly enhanced wheat seedling emergence very early (5 days after planting) under fieldcondition, and caused 160% increase in root dry matter yield. The choice of the TSA BR2, C1 and C13 for further field trials to improve soil fertility and maize growth and P-uptake is discussed.

Keywords：*Actinomycetes, Phosphate-solubilizing bacteria, Plant growth promotion, Maize, Mali*

P4-414

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Black Urea, A Fertilizer with Lower Ammonia Volatilization

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Urea is the most consumed fertilizer in the world, however their agronomic and economic efficiency is compromised by NH_3 volatilization.Volatilization is less intense in soils with high buffering capacity of acidity (ionizable acidity) and, consequently, high CEC. The mixture with humic acid (HA) extracted from peat or soil (5,200 - 8,327 mmol kg^{-1} CTC) reduces volatilization of NH_3 from urea. However, the production of AH farrowing soil or peat provides environmental impacts arising from the collection of these materials. Compounds produced by the oxidation of charcoal HNO_3 are equivalent to the HA of the soil or peat. They have high acidity ionizable consisting, predominantly, of phenolic and carboxylic radicals and thus with high CEC. Thus, we have worked with the production and characterization of coal produced from Eucalyptus and evaluated its effects in reducing NH_3 volatilization from urea AH. Coal is produced by carbonization of Eucalyptus at 350 ° C. The pulverized coal (< 74 μM) is oxidized with HNO_3 4 mol L^{-1} at boiling under reflux for 4 h.The oxidation residue is subjected to the fractionation of humic substances from International Humic Substances Society (IHSS). The insoluble fraction obtained is equivalent acid AH and is called here CVox. The alkali-soluble fraction, which is equivalent to the fulvic acids (FA) is discarded. The oxidation residue without fractionation of humic substance is also used. These compounds are equivalent to humic substances (HA AF and humin) and is here called CVox-OH. The yield CVox and CVox-OH was 327 g kg^{-1} and 784 g kg^{-1}, respectively. The concentration of oxygen in CVox and CVox-OH were 1.8 and 1.6 times greater than the charcoal, resulting in increased reactivity. Potentiometric titration indicated that the total of ionizable acidity was 4.850 and 4.170 mmolckg^{-1} to CVox and CVox -OH, respectively. The carboxylic radicals were responsible for 75% of this acidity. The presence of these radicals, as well as amines, were confirmed by infrared spectroscopy analysis. The CVox and CVox-OH had five similar pKa, but varying from 1.2 to 9.6. These were estimated by multiparametric regression to the potentiometric titration of a mixture of a strong acid and n weak acid with a strong base. The pKa indicate ionizable acidity to pH 9.6, which is interesting considering that the hydrolysis of urea provides increased pH near 8.0. The prill urea (diameter 1 mm) was coated with 50, 100, 150 or 200 g kg^{-1} of CVox or CVox-OH. Granular urea was produced with the same proportions of CVox or CVox-OH. For this purpose, urea has been cast in glycerin bath (137 ° C) and mixed with the oxidized coals. The mixture was dropped into a steel to produce granules (tablets) of 5 mm diameter and 4 mm in height. These forms of urea showed 440, 420, 390 and 370 g kg^{-1} N. The NH3 volatilization was evaluated in the laboratory using a system composed of incubation chambers (glass containers of 340 cm^3) containing 100 cm^3 of an Ultisol (pH 6.8). These chambers were connected to collectors of ammonia (erlenmeyer flasks with 40 mL of H_3BO_3 20 g L^{-1}). Amounts of coated or prilled urea CVox or CVox-OH equivalent to 100 mg of N was applied on top of the soil. Unit with prill urea and granular urea without the oxidized coals were controls. The chambers were sealed and immediately applied a flow of NH3-free air (300 cm^3 min^{-1}). The NH_3 collected at 12, 24, 48, 72, 96, 120, 144 and 168 h after starting the air flow was measured by potentiometric titration of H_3BO_3 to pH 4.6 with HCl 80 mmol L^{-1}. The granulated urea CVox-OH or CVox was more effective in reducing the volatilization than coated urea prill. Granulated urea CVox or CVox-OH showed similar efficiencies. The largest reduction in volatilization was 44% and achieved with granular urea with 160 g kg^{-1} or CVox CVox-OH. With such a ratio of CVox-OH or CVox the N content in the granular urea was 400 g kg^{-1}, which is a small reduction in the N content of the urea fertilizer. The CVox-OH or CVox has the potential to improve the efficiency of urea fertilizer, considering the effective reduction of the volatilization and their production from a renewable carbon source.

Keywords：*Hydrolysis, urease, nitrogen fertilizer, biochar*

P4-415

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluation of Integrated Use of Poultry Manure, Sewage Sludge,fym with Chemical Fertilizers in Maize(zea Mays)-Chilli(capsicum Annum L.,) Cropping System

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The present investigation entitled "Evaluation of Integrated Use of Poultry Manure, Sewage Sludge, FYM with Chemical Fertilizers in Maize-Chilli Cropping System" was carried out under field conditions at College Farm, College of Agriculture, Rajendranagar, Hyderabad. Sewage sludge is rich source of major and micronutrients as well as heavy metals. The present studies were conducted to study the effect of sewage sludge, poultry manure and FYM on performance of crops in terms of yield and uptake of nutrients and trace metals by crops and also to find out the extent of accumulation of these metals in different plant parts of sewage sludge applied crops and the extent of safety in their (human) consumption.

The experimental soil for maize-chilli cropping sequence was low in available N (210.8 kg ha-1), medium in available P2O5 (21.2 kg ha-1) and medium in available K2O (273.6 kg ha-1). In order to support the field observation green house studies were also conducted on the soil brought from same field

The treatments for maize crop in the kharif, 2007 includes four main treatments viz., 0, 50, 75 and 100 per cent RDF and seven sub treatments viz., two levels of each poultry manure (2.5 and 5.0 t ha-1) sewage sludge and FYM (10 and 20 t ha-1) and control (without manure) and combination of fertilizer levels along with organic manurial levels. A field experiment with a total of 28 treatments, each replicated thrice was laid out in split plot design. The recommended dose of fertilizers were applied to maize crop (120 N, 60 P2O5 and 60 K2O kg ha-1). In the second season (rabi) chilli crop was grown to study the residual effects of organic manures applied to the previous season maize crop. No organic manures were added. However, recommended dose of fertilizers (300 N, 60 P2O5 and 120 K2O kg ha-1, respectively) at 0, 50, 75 and 100 per cent levels were added in the same pattern as followed in kharif.

In maize highest grain yield (5336 kg ha-1), stover yield (6308 kg ha-1) and plant dry matter yield (11644 kg ha-1) were obtained with sewage sludge applied @ 20 t ha-1 along with 100 per cent RDF. Green house experiment also showed grain yield (50.82 g pot-1), plant dry matter (112.06 g pot-1) and stover yield (61.24 g pot-1) with same treatment i.e., SS applied @ 20 t ha-1 along with 100 per cent RDF. Application of manures either alone or in combination with fertilizers have significantly influenced the protein content of maize grain at harvest. The highest protein contents were observed in sewage sludge applied @ 20 t ha-1 along with 100 per cent RDF both under field and greenhouse conditions. Maximum soil enzyme activities of urease (6.37 µg NH4+-N released g-1 soil h-1), dehydrogenase (730 µg TPF produced g-1 soil d-1) and alkaline phosphatase (101.04 µg PNP released g-1 soil h-1) were observed with applied SS @ 20 t ha-1 with 100 per cent RDF and organic fractions of soil humic acid (3.74 g kg-1) and fulvic acid (2.03 g kg-1) obtained with sewage sludge applied @ 20 t ha-1 with 100 per cent RDF after harvest of chilli.The highest benefit: cost ratio obtained in treatment with sewage sludge applied @ 20 t ha-1 along with 75 per cent RDF for maize (2.55) and residual sewage sludge applied @ 20 t ha-1 for chilli (2.13). However, pooled data of economic analysis (from both the crops i.e., maize-chilli) indicated that the highest benefit: cost ratio (2.29) was obtained with sewage sludge applied @ 20 t ha-1. To obtain higher income and to maintain better soil conditions, application of sewage sludge @ 20 t ha-1 for maize-chilli cropping sequence is recommended.

Keywords：*INM,Poultry manure,Sewage sludge,FYM,Fertilizers,Maize-Chilli cropping System*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Potato Tuber Formation as Affected by Soil Mineral Nitrogen

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In order to test the influence of soil mineral nitrogen (Nmin) content on potato tuber formation, a field trial was conducted in Yinshan mountain, with potato cultivar 'KeXin 1' by setting different nitrogen levels. Field soil Nmin content, tuber formation time, tuber number and weight per plant were measured or recorded dynamically. The results showed that soil Nmin declined with potato development. The soil Nmin content in a range of 18 — 50 mg/kg benefited tuber formation, and the soil Nmin in 18.64 — 19.94 mg/kg was the best level for early tuber formation. When it was more than 50.57 mg/kg, tubers could not form. It also revealed that the higher soil Nmin content could reduce the number of tuber formation, and 39 days after emergence in Yinshan area tuber number would not increase any more. Although increased soil Nmin postponed the tuber formation, the potato tuber weight per plant increased with soil Nmin.

Keywords：*potato; soil Nmin content; tuber formation*

P4-417

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluation of Urea-N Based Compound Fertilizer on Cucumber Grown on Clay Soil

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This study evaluates the yield of cucumber grown on clay soil to a locally produced and an imported compound fertilizer. Treatments consisted of locally produced urea-N based compound fertilizer (UNc) and an imported ammonium+nitrate-N based compound fertilizer (ANc). Both have the same formulation (N:P2O5:K2O:MgO = 12:12:17:2 +Te) at 2.5 t/ha, with poultry manure (PM) added, at 10 and 20 t/ha. Poultry manure was applied as basal and worked into the soil on 6m x 1m plots. The treatments were arranged in a randomized complete block design with 3 replicates. Cucumber seeds (MTi2) were sown in two rows, with a planting distance of 60 cm x 60 cm to give 20 plants/plot. Routine agronomic practices were followed for crop management and pest control. The first harvest was at 40 days after sowing (DAS) and the last harvest was at 75 DAS.

Results obtained show that there were no significant differences in yield, fruit number and mean fruit weight between the locally produced compound fertilizer UNc and the imported compound fertilizer ANc, at both rates of poultry manure. The yield obtained with 10 t/ha poultry manure for compound fertilizer UNc was 26.86 kg/plot and for ANc, it was 25.97 kg/plot. With 20 t/ha poultry manure, UNc yielded 28.27 kg/plot and ANc yielded 28.43 kg/plot. However, treatment with 10 t/ha and 20 t/ha poultry manure alone yielded 22.48 kg/plot and 24.32 kg/plot respectively and there were no significant differences between treatment with added compound fertilizer. The control plot yielded only 7.68 kg/plot. Generally, the fruit number/plot followed the same trend as yield/plot. There were no significant differences in the mean fruit weight which ranged from 246-274 g, with the exception of the control treatment with a mean fruit weight of 184 g. It is concluded that the locally produced and cheaper urea-N compound is as good as the imported compound.

Keywords：*clay soil, compound fertilizer, poultry manure, urea-N, cucumber*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Leguminous Intercropping on Tomato Yield, Soil Nutrients and Enzyme Activities

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To study the effects of leguminous intercropping on the growth and yield of tomato under the organic farming system, a field experiment was carried out in a vegetable garden in the suburbs of Shanghai, China. The experiment includes four treatments: (A) single cropping of tomato; (B) intercropping tomato and leguminous kidney bean (Phaseolus vulgaris L.); (C) intercropping tomato and leguminous Phaseolus vulgaris L. var. humilis Alef; (D) intercropping tomato and non-leguminous amaranth (Amaranthus mangostanus L.). The results indicated that the leguminous intercropping could significantly increase the height of tomato plants and the yield of tomato. Compared with the control (Treatment A), the leguminous intercroppings, Treatment B and C, increase the height of tomato plants by 10.0% and 10.1% respectively, and the yield of tomato by 15.7% and 4.3% respectively. The leguminous intercroppings could also significantly increase soil nutrients. Compared with the control, Treatment B could increase total N in the soil by 16.9%; ammonium N by 14.0%; total P by 44.6%; available P by 26.6%; total K by 8.3%; available K by 23.4%. Likewise, Treatment C could increase total N, ammonium N, total P, available P, total K and available K by 10.7%, 8.0%, 26.9%, 22.9%, 9.6% and 10.5%, respectively. The leguminous intercroppings could improve the activities of soil enzymes, especially urease. Compared with the control, Treatment B increases the activities of catalase, urease, sucrase and phosphatase by 4.8%, 64.6%, 26.8% and 25.5%, respectively; Treatment C increases the activities of urease, sucrase and phosphatase by 18.9%, 17.2% and 7.5%, respectively. In contrast, the non-leguminous intercropping has no obvious increasing effects on the height of tomato plants and the yield of tomato. Compared with the control, Treatment D reduces the yield of tomato by 11.1% on the contrary, possibly due to the competition of soil nutrients. The non-leguminous intercropping doesn't raise soil N and P contents, but significantly increases total K and available K by 63.9% and 11.6% respectively, and also increases the activities of sucrase and phosphatase by 17.4% and 14.2% respectively, possibly due to the rhizosphere effects. The activity of urease is significantly correlated with total N, ammonium N, total P, available P and available K ($p<0.05$). The correlation between urease and ammonium N is the most significant, with the coefficient 0.928 ($p<0.01$). The activity of sucrase is also significantly correlated with total N, ammonium N, organic matter, total P, available P and available K. All the above suggest that the leguminous intercropping could increase soil fertility, soil enzyme activities and tomato yield; the non-leguminous intercropping has no effects of yield increase due to its inability for N fixation and the competition of soil nutrients. Besides, the leguminous intercropping could make the full use of space and sunrise and therefore is a better mode of tomato cultivation under the organic farming system.

Acknowledgements: This work was supported by the National Natural Science Foundation of China (No. 41130526).

Keywords：*Leguminous intercopping; Tomato; Soil nutrients; Enzyme activities; Organic farming system*

P4-419

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Co-Application of EFB Compost and Red Gypsum to Heavy Clay Acidic Soil

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INTRODUCTION

Organic material is a popular choice for soil amendment as it is derived from biological matter and often requires little pre-treatment before it may be directly applied to the soils. In many cases, an organic material is usually applied as a single amendment and it helps in ameliorating the soil physical and chemical properties such as improve water holding capacity and aeration of the soil as well as the fertility status of the soil. Co-mixing two byproducts can turn the byproducts into a more useful soil amendment as the amending capability of the byproduct can be complemented and further enhanced by the co-mixed byproduct. Red gypsum (RG) is a byproduct from the extraction of titanium for industrial purposes. Also, an earlier study on this RG indicates that it can be a good soil amendment. Hence, through co-application of RG and organic material, the value-added of these byproducts can be increased in improving the physico-chemical characteristics of the soil and also enhance plant growth.

MATERIALS AND METHOD

This study was conducted in the glasshouse unit of the Faculty of Agriculture, UPM. Sweet corn (Zea mays L.) was used as the test crop. Thirty two polybags were arranged in a randomized complete block design (RCBD). Air dried surface soil (0-15 cm depth) from Kuala Brang series were mixed with red gypsum + compost and compost only. Two set of experiments were established with 4 treatments and 4 replications for each set experiment. First set experiment is:

RG1 + Co1: 25 t/ha red gypsum + compost
RG2 + Co2: 50 t/ha red gypsum + compost
RG3 + Co3: 100 t/ha red gypsum + compost
RG4 + Co4: 200 t/ha red gypsum + compost

Rates of compost used were 2 times the volume of red gypsum. Another set of experiment, with the objective of looking into the effect of applying compost only on plant growth was treated with compost at the same rate used in the first set of the experiment.

Polybags were filled with 20kg air dried soil and applied with basic fertilizers (180 kg N as urea, 150 kg P2O5 ha-1 as triple super phosphate and 75 kg K2O ha-1 as muriate of potash each. Three plants per polybag were grown in each polybag. This plant planted for 70 days and it was harvested after that. The soil samples were air dried, grind and sieve through a 2.0mm sieve for soil chemical analysis and heavy metal. Corn was harvested at maturity (70 days after sowing) and the fresh weight of plants was record. The corn tissue was dried in the oven (65-700C) and grind to pass a 0.1mm sieve and analyze for macronutrients and heavy metal. The data obtain was subjected to analysis of variance (ANOVA) using statistical analysis system and the means were compared using LSD's multiple-range test.

RESULTS AND DISCUSSION

Co-application of RG with EFB compost gives significantly increases in soil pH with increasing rate of RG; compare to the use of EFB compost alone. At 200 t/ha of RG with EFB compost shows the higher soil pH compare to lower rate of RG. This shows that increasing RG rate can increase the soil pH; RG has the ability to increase soil pH. This is due to the presence of residual CaCO3 during the extraction of titanium process.

For N concentration in soil, no significant difference between RG and EFB compost, application of EFB compost alone at higher rate give significantly difference compare to the lower rate. For available P content in soil, co-application of RG with EFB compost shows increasing value with the increase rate of RG with EFB compost, same trend shows by the application of EFB compost alone. Co-application of RG with EFB compost shows significant increase compare to the control and other treatment. For K concentration in soil, co-application of RG with EFB compost at rate of 200t/ha significantly higher compare to control and other treatment; with no significant different with high rate of EFB compost application alone. This shows that, K was provided by the EFB compost. For Ca concentration, co-application of RG with EFB compost significantly higher at rate of 200t/ha, compare to other treatment. RG can supply the Ca because of high Ca content in it. Co-application of RG with EFB compost at higher rate shows significantly higher compare to other rate and compare to the application of EFB compost alone.

For the effect of co-application of RG with EFB compost on soil micronutrients, Co-application of RG with EFB compost significantly decrease the concentration of Fe in soil at rate of 50,100 and 200 t/ha compare to the lowest rate of RG. For Zn concentration, co-application of RG and EFB compost and application of EFB compost only shows no significant difference for all treatment. But decreasing concentration of Zn was shown with increasing application of RG rate. For Cu and Mn, no significant different for co-application of RG with EFB compost, but for Cu through the application of EFB compost only, there is significant increase compare to the control.

CONCLUSION

In glasshouse study, 200t/ha of RG and EFB compost application shows the optimum rate, but the application need to be monitored due to deficiency in Zn concentration.

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Keywords：*red gypsum, efb compost, kuala brang series soil*

P4-420

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Evaluation of the Effeciency of Various Nitrogen (n) Sources Fertilizer on Oil Palm Seedlings Growth at Three Types of Soil in Malaysia at Oil Palm Main Nursery

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Introduction

Oil palm is widely cultivated in tropical countries such as Malaysia and Indonesia. The role and activity of Nitrogen (N) has received considerable attention and well known in oil palm cultivation. The functions of nitrogen are increasing the leaf area, improves leaf production and the net assimilation rate of oil palm. Its deficiency will affects chloroplast development and resulted in poor palm growth and effect to oil palm yield production. Apart from optimal rate and better selection of N sources fertilizer, it's very important to identify type of soil and their characteristic matching with accurate N sources.

Material and methods

This trial was conducted at the main oil palm nursery located at Pahang, Malaysia. Three types of soil series (Munchong, Apek & Tok Yong) with different soil fertility were selected. The compound fertilizer consists of three types of N source were used to fertilizer the main nursery. The experiment was laid down using a randomized complete block design with three replicates. Each treatment consisted of 5 DxP oil palm seedlings (4 months old). Watering was carried out twice a day using overhead sprinklers. Manuring program run as nursery standard practices. Vegetative growth measurements were made at 3, 6 and 8 months after transplanting. Dry matter analysis was carried out at the end of the experiment. The data obtained were tested for their significance using the two-way analysis of variance (ANOVA) and the mean values were ranked using Tukey test by using SAS package version 9.1 for windows.

Result and Discussion

Vegetative measurement for main nursery seedling shown that there are no significantly different in term of girth radius, height and number of frond production for Tok Yong, Munchong and Apek soil series, which representing high fertility, moderate and low fertility soil respectively. For Tok Yong soil, compound with urea base gave the worst growth performance to seedling especially leaf area index where leaflet for seedling are 10% smaller. Compound with ammonium sulphate base promote most conclusive growth under Munchong soil, compare to seedling treated with compound with ammonium nitrate and urea base. Apek series are among the poor fertile soil if compare to Tok Yong and Munchong soil series. There have no significantly different between all N sources at vegetative growth except for leaf areas at 8MAP which shown seedling treated with compound with urea base are significantly smaller, which indicate that less photosynthesis can be processed and seedling growth will be stunted. Overall results shown that Tok Yong series gave significantly higher total dry matter production as compare to Munchong and Apek series. Good fertility soil able to provide better oil palm seedlings growth. Respond on different N sources are clearly to shown in leaf dry matter at three types of soil, while AS base produce significantly high leaf dry matter. It is clear to show that compound with

ammonium sulphate base compound fertilizer promotes the best seedling performance in all soil especially for Tok Yong series, indicate that soil type will be the main factor to promote seedling growth. The seedling treated with compound with ammonium nitrate base obtained lowest dry matter production which reveal that compound with AN base may not be suitable for seedling planted with Munchong soil. Apek soil series has the poorest soil fertility and standard rate of any compound fertilizer (neither ammonium sulphate base, ammonium nitrate base nor Urea base) application may not sufficient to support seedling growth in this soil. Further that, seedling treated with standard rate of compound with urea base contained the lowest dry matter production among all treatments. Inherent soil fertility and soil fertility at end of the trial shown that soil fertility for Munchong and Apek series has depleted almost 2–3 times lower compare to inherent soil fertility for soil pH and soil total N (%). As most of the FELDA Plantations group nurseries are set up in inland area where most of the soil inherent fertility is low to moderate. Therefore, high fertilizer input is needed to promote good growth of main oil palm seedlings. Cost of fertilizer will determine types of fertilizer to be use in nursery with fertile soil.

Keywords：*oil palm, Tok yong, Munchong, Apek, Nitrogen*

P4-421

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Integrated Use of Fertilizer with Manure on Mustard, Potato and Wheat and their Residual Effects on Succeeding Crops

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Low soil fertility is a major constraint to higher crop production in Tista Meander Floodplain (AEZ # 3) soil of Bangladesh. Characteristically the soils are light textured, acidic and low in organic matter content. For improvement and sustenance of soil fertility and crop yield, a study was undertaken with application of manure and fertilizer in an integrated way over three cropping patterns across the six locations (two locations for each cropping pattern). The patterns were mustard-Boro-T. Aman rice, wheat-mungbean-T. Aman rice and potato-Boro-T. Aman rice. These experiments were conducted at farmers' fields in Kurigram Sadar upazila. Evaluation was made in terms of crop yield, nutrient uptake, nutrient balance, economic benefit and improvement of soil fertility. There were six treatments for every cropping pattern – control (no fertilizer or manure), farmer's practice, 100% recommended rate of nutrients from fertilizers, and the rest three treatments on IPNS basis i.e. 100% nutrients adjusted from manure (cowdung, poultry manure or compost) and fertilizers. The rate of manure application was 5 t ha-1 for cowdung, 3 t ha-1 for poultry manure and 10 t ha-1 for compost. In each crop cycle, manure was applied to the first crop and their residual effect was evaluated on the succeeding crops. For the second and third crops, equal amounts of N, P, K & S fertilizers were applied to all the plots, except farmer's practice and control treatments. Dolomite lime @ 1 t ha-1 was once added to the experimental fields in the beginning of the field trials. The experiments were laid out in a randomized complete block design, with three replications. Each pattern experiment was carried out in two farmers' fields for consecutive two years (2009-10 and 2010-11). The crop varieties were BARI Sarisha9 for mustard, Shatabdi for wheat, Granola for potato, BINA mung5 for mungbean, BRRI dhan28 for Boro rice and BINA dhan7 for T. Aman rice. Integrated use of manure with fertilizers produced significantly higher seed/grain/tuber yield at all the sites over sole fertilizer treatment. Poultry manure or compost based treatment performed better compared to cowdung. The yield of all crops showed positive correlation with the yield contributing characters. Manure based treatments had significant influence on the N, P, K, S, Zn and B uptake by the crops. Economic analysis also showed poultry manure or compost containing treatment as the best option for all the three cropping patterns across the sites. Integrated use of fertilizer with poultry manure or compost demonstrated a 15-20% yield increase over 100% sole fertilizer treatment and thus a 25-30% reduction of fertilizer use is possible through adoption of integrated nutrient management practice. Residual effect of manure was evident on the next crops (Boro rice, mungbean and T. Aman rice). Apparent nutrient balance analysis indicated a nutrient mining for N & K and a nutrient accumulation for P, S, Zn & B for all the cropping patterns. Soil organic matter and nitrogen contents increased in manure treated plots. Overall result indicates that use of chemical fertilizers with 3 t ha-1 poultry manure or 10 t ha-1 compost on IPNS basis may help sustain higher crop yield without incurring loss to soil fertility.

Keywords：*Fertilizer, Manure, Mustard, Potato, Wheat*

P4-422

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Phosphorus Fertilizer Rates on Changes of Soil Phosphorus Fractions in Cassava Growing Soils of Thailand

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Phosphorus (P) is one of major nutrient which can be limited Cassava (Manihot esculenta Crantz) growth and yield in Thailand. Cassava is grown mainly in northern and eastern part of Thailand which grown in various soil texture i.e. sandy, loamy and clayey soils as differ in phosphorus sorption capacity. The phosphorus transformation and changes in phosphorus fractions of both soils was different. The field experiments were conducted in loamy sand and red clayey soils at Rayong and Nakhon Ratchasima province, respectively. Two soils namely Sattahip soil series (Sh) and Chokchai soil series (Ci), respectively. Phosphorus fertilizer was applied to both field experiments at the same rates i.e. 0, 12.5, 25, 50, 75 and 100 kg P_2O_5/ha with 4 replications in randomized complete block design. Soil samples were collected before planting and after harvested cassava. The total P and availability P were analyzed by digested with NHO_3+$HClO_4$ and Bray 2, respectively. Phosphorus fractions were analysis for soluble and loosely bond P, Aluminum bound P (Al-P), iron bound P (Fe-P), reductant soluble P, and calcium bound P (Ca-P) using 1M NH_4Cl, 0.5 M NH_4F, 0.1 M NaOH, 0.3 M $Na_3C_3H_6O_7$+ 1 M $NaHCO_3$ + $Na_2S_2O_4$ and 0.25 M H_2SO_4, respectively. The residual P was calculated by minus total P with all P fractions. Cassava yields in both experiments were responded to P fertilizer at the rate 12.5 kg P_2O_5/ha. Total P in soils after harvesting of all P fertilizer application rates in both experiments were decreased and significant different with P before planting. Available P of Sh soil series after harvesting which P fertilizer applied at the rate 0 and 12.5 kg P_2O_5/ha was decreased and significant different with P before planting. While, available P of Ci soil series after harvesting in all P fertilizer application rates were not significant different with P before planting and increased in the plots which P fertilizer applied at the rate 12.5, 25, 50, 75 and 100 kg P_2O_5/ha. The results from P fractions analysis showed that Al-P, Fe-P, reductant soluble P and Ca-P in soil after harvesting of Sh soil series was decreased when compared with soil before planting. Whereas, Al-P and Fe-P of Ci soil series after harvesting in the plot which P fertilizer applied at the rate 0 kg P_2O_5/ha were decreased while Al-P and Fe-P of P in the plot which applied P at the rate 12.5 kg P_2O_5/ha were not different with soil before planting. Al-P and Fe-P of other plots of Ci soil series were increased. Reductant soluble P and Ca-P of Ci soil series were decreased in all P application rates. The results showed that P transformation and fractions in loamy sand and red clayey soils were different. It might be due to high Al and Fe contents of Ci soil series which led high P sorption and reserve in this soil. So, P fertilizer recommendation rate for cassava should consider the properties which effect their transformation.

Keywords：*Cassava (Manihot esculenta Crantz), P fractions, Thailand*

P4-423

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

A Multivariate Approach to Study the Effect of Integrated Nutrient Management on The Maintenance of Soil Fertility and Soil Health in Relation to Yield And Nutrition of Rice (Oryza Sativa)

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Field experiment to study the effect of integrated nutrient management (INM) on the maintenance of soil fertility and health in relation to rice using different combinations of organic manures and recommended doses of inorganic fertilizers was conducted in an Aeric Haplaquept soil [pH (7.75), organic carbon (5.4 g/kg), available N (352.88 kg/ha), P2O5 (37.45 kg/ha), K2O (277.54 kg/ha) , DTPA extractable Fe, 8.52 mg/kg; Mn, 2.62 mg/kg; Cu, 0.74 mg/kg; Zn 0.28 mg/kg, microbial biomass carbon (MBC), 57.43 µg/g dry soil; and microbial biomass nitrogen (MBN), 3.28 µg/g dry soil] of West Bengal, India for consecutive 2 years. The treatments were, T1- organic manure (OM) at 8t/ ha, T2- NPK as basal, T3- NPK + OM at 2t/ ha, T4- NPK + OM at 4t/ ha, T5- N in 2 splits + PK + OM at 2t/ ha, T6- N in 2 splits + PK + OM at 4t/ ha, T7- OM at 8 t/ ha+ Zn-EDTA at 0.5kg/ ha, T8- OM at 2 t /ha + Zn-EDTA at 0.5 kg/ ha + NPK as basal, T9- OM at 8 t/ ha + N in 2 splits + PK as basal. The results revealed that the organic and inorganic combination significantly increased the organic carbon, available N, P2O5, K2O, Fe, Mn, Cu, Zn and MBC and MBN contents in soil.

The results further show that the fertility build up in soil was recorded highest with respect to organic carbon (+ 3.4 g/kg), N (+ 79.55 kg/ha), P2O5 (+ 17.01 kg/ha), K2O (+ 90.19 kg/ha), Fe (+ 24.95 mg/kg), Mn (+ 2.74 mg/kg), Cu (+ 1.50 mg/kg) , MBC (+ 51.51 µg/g) and MBN (+ 3.19 µg/g) in the treatment T8 while that of Zn (+ 1.34 mg/kg) in treatment T7. The treatment T8 exhibited highest yield (4.26 t/ha) and benefit : cost ratios (1.74).

Apart from normal one way analysis of variance, canonical correlation analysis technique (CCA) was conducted to determine the linear association between nutrients content in the soil, plant (considered as predictor variable) and yield vis-a-vis yield attributes (considered as criterion measures) such that their ordinary (product moment) correlation was maximal. Following CCA for all parameters it was concluded that in the first set of canonical variate - grain P, Mn, Cu; straw Mn; plant dry matter N, P, K, Zn; soil K2O were highly associated with the grain yield, straw yield and no. of panicle/m2.

Second set of variate revealed significant association of grain yield, number of panicle/m2, filled grain/panicle and test weight with soil K2O, Cu, Fe; straw Fe; N, grain Zn, Fe and plant dry matter K, Zn.

In third set of variate the soil pH, organic carbon, Mn, Cu; plant dry matter K, Fe, Zn ; rice grain P, Fe, Zn and rice straw K, Fe, Cu ere significantly associated with filled grain/panicle and test weight, whereas, soil N, Fe, Zn, MBC; plant dry matter P, Cu; grain N, K, Mn, Cu and straw N, P, Mn, Zn were significantly associated with grain, straw yield and number of panicle/m2. Factor structure (component loading) for predictor set resulted available N, Cu, Zn content in soil and N content in grain as minimum data set (MDS) variables where other variables were all explained by such MDS variables. Means of all data for MDS variables were subjected to linear index scoring indicates higher mean values for preferring soil quality, higher productivity with higher nutrient content in plant as observed in T8 through stacked column diagram. Thus it was inferred that application of organic manure at 2 t /ha + Zn-EDTA at 0.5 kg /ha + NPK as basal was the best treatment in augmenting the soil fertility build up as well as maintenance of soil health in relation to yield and nutrition of rice.

Keywords：*Soil fertility, Soil health, INM, Rice, Yield, Nutrition, Canonical Correlation*

P4-424

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Capacity of Humic Acids Extracted at the Large Scale From Mae Moh Leonardite to be Used as Soil Amendments Based on their Chemical Properties

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Leonardite is a low grade coal naturally occurring in soils. Its reduced form, lignite, which may be present in soils near leonardite layers, can be mined for energy generation. Since leonardite cannot be used for such application, this mineraloid can be collected as a waste product at lignite mine sites, such as the one in Mae Moh power plant site, Lampang Province, Thailand. Leonardite can be used as an agricultural soil amendment given its high contents of organic matter, macro and micro nutrients, as well as its ability to retain cations and water in soils (Pertuit et al., 2001). Its chemical properties, however, may vary depending on the sources of leonardite. Preliminary analyses of the leonardite from Mae Moh mine showed that it contained a high amount of arsenic, which is toxic to human. Therefore, this study aimed to characterize the chemical properties of leonardite from Mae Moh, with an emphasis on arsenic distribution in the mineraloid, using three sequential extraction techniques: 1) CIEMAT (Larios et al., 2012) 2) Keon (Keon et al., 2001), and 3) Hall (Hall et al., 1996) methods. Additionally, this research provided a method to effectively remediate arsenic from the leonardite sample, as well as recommendations on possible uses of Mae Moh leonardite as a soil amendment. Results showed that the leonardite sample was acidic (~ pH 4) and had a high organic matter content (43 %), cation exchange capacity (53.78 centimoles per kilogram), as well as macro and micro nutrients, especially iron, sulfur, calcium, nitrogen, potassium, and magnesium. Low contents of toxic elements, e.g. cadmium, chromium, lead, and mercury were measured, except arsenic (As), which was present at a concentration of ~ 41 milligrams per kilogram. Results from Fourier Transform Infrared (FTIR) spectroscopy analyses indicated that the leonardite sample from Mae Moh had similar functional groups than the leonardite standard from the International Humic Substances Society (IHSS). These analyses also showed that the sample contained inorganic minerals and thus did not consist of purely leonardite. This was supported by results from X-ray diffraction (XRD) analyses, which showed that the sample contained primary and secondary minerals. Results from the three sequential extraction methods indicated that less than two percents of As in leonardite was readily soluble. Most As was adsorbed on surfaces of the sample's components, especially on iron oxyhydroxides, while the As amount contained in the recalcitrant part of leonardite represented a minor fraction of the total amount of As in the mineraloid (i.e. less than 20 %). Washing the Mae Moh leonardite with 0.5 M NaH2PO4 or water at pH 2 (adjusted with HCl) could decrease the concentration of As in the leonardite by more than 50 %. This study thus demonstrated that the use of leonardite from Mae Moh for agricultural purposes is possible, but its pH should be increased before use as soil amendment in regular pH soils, and the amount of As should be reduced in the mineraloid.

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Keywords：*Organic soil amendment, leonardite, humic acid, soil health, Arsenic removal,*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Biotic and Abiotic Processes Affecting Nitrogen Immobilisation in Submerged Paddy Soils

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Nitrogen (N) is generally the most limiting nutrient in rice cropping systems. Both biotic and abiotic mechanisms of N immobilisation are responsible for limiting N availability in paddy soils, leading to a low fertiliser-N use efficiency. In fact, 40–60% recovery of applied N is characteristic of irrigated rice systems. The interaction between alternating redox conditions and the complexity of agronomic management practices may strongly affect N immobilisation and its distribution among different soil fractions. To evaluate the importance of biotic and abiotic factors in affecting N immobilisation, a laboratory experiment was conducted in which a typical paddy soil collected from an ongoing long-term experimental platform (Vercelli, NW Italy) was incubated for 30 days under (i) sterile or non-sterile anoxic conditions, (ii) with or without the addition of rice straw. Enriched ammonium-15N was applied to follow the fate of fertiliser-N while the distribution of immobilized N among soil fractions was assessed by combining aggregate size and organic matter density fractionation. Results suggested that abiotic processes were responsible for the fast immobilization of applied N (～40% of applied N) with the finer soil fractions in both macro- and microaggregates serving as the greatest sink of immobilised N. These soil fractions are rich in expandable clay minerals able to fix NH4+. On the other hand, biotic processes had a strong influence on aggregation and consequently on the distribution of immobilised N between macro- and microaggregates. Moreover, SEM analyses revealed that presence of clay particles on the surface of vegetal fragments could be responsible for the transfer of fertiliser-N onto the light fraction under sterile conditions. However, SS-15N-CPMAS-NMR spectra of this fraction in non-sterile soils showed a strong amide-N signal indicating that microbial-mediated processes involved in the degradation of rice straw may immobilise significant amounts of applied N. Both biotic and abiotic processes represent key factors controlling N dynamics in paddy soils and may strongly influence N availability for the rice crop as well as losses to other environmental compartments.

Keywords : *fertiliser, clay fixation, microbial immobilisation, sterile, light fraction.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Soil Quality in Continuing Rice-Wheat Cropping System in India: Impact of Combined Tillage, Water and Nutrient Management

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Highly productive rice-wheat systems are fundamental to employment, income and livelihoods for hundreds of millions of rural and urban poor in the Indo-Gangetic Plains (IGP) of south Asia. Much of the rice-wheat production that occupies an area of 10.5 Mha, produces low yields because of inadequate nutrients and inappropriate water management. The objective of the present study was to identify important indicators of soil quality and incorporating these into unified soil quality index (SQI) for assessing the integrated impact of tillage, water and nutrient management in rice-wheat system. Field experiment was carried out involving two tillage management, three water management and nine nutrient management treatments allocated to both rice and wheat. For wheat, again splitting was done in each nutrient management plot to impose conventional tillage and no-tillage. Seventeen different soil physical, chemical biological indicators were analyzed after harvest of each crop. Subsequently, the soil quality index (SQI) was developed under the soil management assessment framework (SMAF) using Non-linear scoring function (NLSF) and Principal component analysis (PCA) under two management goals: productivity (P) and environmental protection (EP). PCA-screened indicators of SQI which were common under both productivity goal (PCASQI-P) and environmental protection goal (PCSQI-EP) after harvest of rice were maximum water holding capacity (MWHC), water stable aggregate (WSA), potentially mineralizable nitrogen (PMN) and microbial biomass carbon (MBC) and that after harvest of wheat were PMN, available Mn, dehydrogenase activity (DHA) and soil organic carbon (SOC) The PCA screened indicators which were not common to both the management goal were available Fe, available Mn, hydraulic conductivity (HC) (under productivity goal) and microbial quotient (MQ), available Cu, available N (under environmental protection goal) after harvest of rice and available Cu, WSA, available P, soil respiration, (under productivity goal) and MBC, available Zn, MWHC, available N (under environmental protection goal). The study clearly indicated that management goal strongly influenced the variations in the type of sensitive soil quality indicators and these indicators might provide early warning against further deterioration of soil quality. Puddling and irrigating rice after three days of drainage and no tillage and two irrigations in wheat emerged as the promising management practices for higher soil quality. Substitution of 25% recommended fertilizer N dose with FYM in rice and domestic sewage sludge in wheat could be recommended for higher soil quality. As the existing management system did not achieve fully to the SQI scale ranging between 0 to 1.0, there are still enough scope to further enhance the soil quality by modifying the existing management practices. Principal component analysis could be used as a powerful tool for creating minimum data set by identifying most sensitive parameters for development of soil quality index for monitoring soil health under long-term rice-wheat cropping system. PCA-screened indicators, are hence suggested for monitoring periodically the management induced changes in overall quality of soil after harvest of both rice and wheat. Non-linear scoring function could be adopted for its greater sensitivity to create wide variations in score to the existing data set for developing more sensitive SQI. The novel finding of the study lied on the emergence of sensitive soil quality indicators under integrated tillage, water and nutrient management in a long-term rice-wheat cropping system using the soil management and assessment framework. The protocol used for indexing soil quality could not only be extended to the neighboring areas of IGP but also expected to be validated in south and south-east Asian countries with similar soil type and management under rice-wheat system.

Keywords：*soil quality index , nutrient management, PCA, rice-wheat, tillage*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Nitrogen Fertilization Response of Improved Potato (solanum Tuberosum L.) Cultivars

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Proper nitrogen (N) fertilization is crucial for optimizing growth and yield of potato. Optimal N management is important to improve N uptake efficiency, and minimize N losses while maintaining high yields. Imbalanced fertilizer application, particularly of N, is very common practice of the potato growers in Indo-Gangetic plains of West Bengal. It contributes to excess vine growth at the cost of the tuber yield and quality. On the contrary, application of right amount of N at right rate and time could be more economically sustainable. Taking due cognizance of the above facts, a field experiment was conducted for 2 consecutive years (winter season of 2011-12 and 2012-13) at University Research Farm, BCKV, West Bengal, to determine the effect of N fertilization rates on the quantitative traits of potato grown on a soil low in N. Experimental design included five rates of N application (0, 75, 150, 225 and 300 kg N/ha) in combination with three potato cultivars (Kufri Himalini, Kufri Shailja and Kufri Jyoti as local check). A sufficient uniform dose of P and K (150 kg/ha) were applied in all plots to avoid P and K deficiencies.

Results revealed that growth attributes, namely plant height and compound leaves per plant, responded positively to N fertilization. Across all the varieties, nitrogen application at 300 kg/ha produced significantly taller plants at harvest, which is 54% more over control (without N). Application of N at 300 kg/ha produced maximum number of compound leaves (64.66% over control), which was however statistically at par with 150 (58.76% over control) and 225 kg N/ha (56.03% over control) for all the varieties when counted at 90 days after planting (DAP). Significant increase in Leaf Area Index (LAI) was noticed with the increase in N level from 0 to 150 kg/ha. Total dry matter (haulm + tuber) for crops at 90 DAP increased significantly with increase in N dose from 0 to 225 kg N/ha. Further increase in N dose to 300 kg N/ha however showed declining trend for dry matter production, although it was statistically at par with 225 and 150 kg N/ha. Total number and yield of tubers were significantly influenced by the N levels for all the varieties. Tuber number was increased with increasing level of N from 0 to 225 kg N/ha. Further increase in N level (300 kg N/ha) resulted in 3% reduction in tuber number from that of 225 kg N/ha. Nitrogen at 225 kg N/ha recorded the highest N uptake (both haulm and tuber) and it was statistically at par with 150 and 300 kg N/ha. Nitrogen uptake was more with Kufri Shailja than other tested cultivars. There was a positive balance of N in all the treatments except in one plot (Kufri Jyoti with 300 kg N/ha). Net gain (+) of N was higher in plots with Kufri Shailja while lower in plots with Kufri Jyoti. Agronomic efficiency (AEN) and physiological efficiency (PEN) was more in Kufri Himalini at all levels of N. Present study also showed high degree of correlation (R2=0.984) between nitrogen and tuber yield. Thus it can be concluded that optimum level of N (derived Nopt. as 202.675 kg N/ha) in combination with 150 kg each of P2O5 and K2O/ha can guarantee high levels of potato production and can successfully be used as effective guide for efficient N management by increasing fertilizer use efficiency, keeping environment pollution free and maintaining soil health.

Keywords：*Nitrogen, response, Potato,*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Catalytic and Fertilizing Potentials of Blood-Meal as Applicable to Accelerated Compost Maturity / Quality and Performance of Sesame (sesamum Indicum Linn.), under Degraded Soil Conditions

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Duration of time required for compost preparation / maturation and relatively low concentration of nutrients per unit volume of composted organic residues are amongst major constraints to use of organic fertilizers. Two field experiments were conducted in the year 2012, at the Teaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, to assess the contributions of cattle blood-meal to both the compost quality and time required for decomposition and its effects (when applied) on growth, yield and nutrient uptakes of sesame. In the 1st experiment, the treatments introduced were: (T1= Fresh blood solution, T2 = Dried blood / Blood meal solution, T3 = Non-sterile top soil solution, T4 = Sterile top soil solution). These solutions were sprinkled on each corresponding compost layer at the onset of compost preparation, but before total covering (except T0 = control, which received no solution). However, in the 2nd experiment, sesame (Sesamum indicum) was used as the testcrop for evaluating the fertilizing potentials of all the product composts obtained from the 1st experiment. The trials were laid out in Completely Randomized Design (CRD) in Randomized Complete Block Design (RCBD), replicated three times. The biochemical properties of the composts were determined. Data were collected on growth and yield parameters and analyzed using ANOVA at $p<0.05$. Application of cattle blood (fresh or dried) significantly enhanced compost nutrient concentrations, microbial populations / types and reduced duration of compost maturation by 30-55%, compared to the other treatments (including the control). Soil sterilization significantly reduced microbial populations but elongated duration of compost maturation. Although, application of dried blood significantly promoted nutrient uptakes of sesame, compared to other treatments, fortification of compost with blood (irrespective of its nature-at-application), significantly improved plant height, number of leaves, stem circumference and seed yield by 60.2 %, 151.2 %, 58.4 % and 78.1 % respectively. Thus, incorporation of blood meal application into compost preparation procedures may be suitable for time saving, improved compost quality and enhanced sesame growth and yield.

Keywords：*Blood meal, degraded soil, sesame, duration of composting, catalyzing and fertilizing potentials.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Yield Sustainability and Phosphorus Utilization in Sole Soybean Cropping on Alfisols in Response to Interactive Effects of Fertilizer Nitrogen and Phosphorus

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Low native soil phosphorus (P) availability coupled with poor utilization efficiency of added P is a major constraint limiting the productivity of soybean in the derived savanna of Nigeria. We evaluated in a 2-year field experiment (1995-1996) the effects of fertilizer P on yield sustainability, P utilization and soil P fertility under sole soybean cropping in a low P alfisol. The treatments consisted two rates (0 and 60kg/ha) of fertilizer N and four rates (0, 15, 30 and 60kg/ha) fertilizer P (using the fractional recovery P model) arranged in a split-plot design with three replications. Soybean responded significantly to the application rate of fertilizer N and P. For the same level of N input, the yield increases were greater with P than without fertilizer P. Soybean P uptake increased with increasing rates of fertilizer. The per cent phosphorus recovery from fertilizer P decreased with increasing fertilizer P rate, while it was improved in the presence of N. The available P status of the soil showed a significant build-up during the second year due to fertilizer P and the increase was greater when fertilizer P was applied in combination with 60 kg/ha fertilizer N. The integrated use of fertilizer N and 60 kg/ha fertilizer P is a promising strategy to improving soil P fertility status and to obtain higher and sustained productivity of soybean in the Nigerian alfisols.

Keywords：*Alfisol; soybean; grain yields; derived savanna; model; phosphorus.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Tomato Varietal Responses as Influenced by Glomus Mossae under Screenhouse and Field Conditions

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Variation in the populations of the fungi and their symbiosis with plant roots is related to both soil properties and host plants. The objective of the study is to determine the potential of glomus mossae to colonize the root of three cultivars of Tomato and subsequently its effect on their growth and yield parameters. Both field and screen house experiment were conducted to determine the response of three tomato varieties to glomus mossea. The experiment was conducted on a field behind the department of Agronomy, University of Ibadan. It was a factorial experiment laid out in randomized complete block design and complete randomize design (for field and screen house respectively) with three replications. Tomato seeds of variety 'Ibadan local, Besue and Hausa variety were sown in the nursery for four weeks and thereafter transplanted to the field at a spacing of 50cm × 60cm. Arbuscular mycorrhiza treatment include with and without mycorrhiza inoculation. Data generated on plant height, stem diameter, number of fruit, fresh fruit weight, shoot and root biomass was subjected to analysis of variance and means were separated using Duncan multiple range test. It was observed that Ibadan local variety was significantly affected by Glomus mossae inoculation with respect to the fresh fruit weight. Besue variety had the highest yield potential with its consistently higher growth attribute with Glomus mossae. Therefore, Glomus mossae inoculation was beneficial to the growth and productivity of Ibadan local and Besue varieties.

Keywords：*Arbuscular mycorrhiza, Glomus mossae, Tomato yield,*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Phosphate Rock as an Alternative Fertilizer for Organic Farming of Wheat in Gypsiferous Soils

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A pot experiment was conducted to evaluate effectiveness of phosphate rock (PR) either alone or combined with different organic materials and their effect on growth and yield of wheat and some soil characteristics. The experiment included four sources of phosphorus (P) viz. TSP, PR, PR+1%peat, PR+1% manure and four levels of P i.e. , 0, 30, 60, and 90 mgP kg-1soil in three replicates using RCBD. The study was conducted in a greenhouse by packing 6 kg of a gypsiferous soil in pots. Nitrogen and potassium fertilizers were applied by the same level of each to all pots. The soil was mixed with mineral and organic fertilizers and packed in pots. The soil was cropped to wheat (Triticum aestivum L.) variety Tamouz. After harvest the following parametes were measured and determined, grain yield, root weight, soil organic P, and soil organic matter. Results showed that the main effect of treatment was for the benefit of the treatment PR+1% manure which was superior in weight of grains, root weight, and organic P, while the treatment PR+1% peat was superior in soil organic matter remained after harvest. The best factorial treatment was PR+1% manure at the level 90 mgP kg-1soil which was superior in weight of grains, root weight, and soil organic P, while the factorial treatment PR+1% Peat at the level 0 mg kg-1soil was superior in soil organic matter which did not differ significantly with the level 90 mgP kg-1soil.

Keywords: Phosphate Rock, Gypsiferous soils, Organic Farming, Peat, Manure *Corresponding author

Keywords：*Phosphate Rock, Gypsiferous soils, Organic Farming, Peat, Manure*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Yield and P Use Efficiency of Five Rice Genotypes under Two P Model Calculated Rates in the Moist Savanna of South West Nigeria

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Sustainable agricultural growth in most of the developing countries of the tropics implies sustainability of growth in yields through intensive land cultivation. This however requires developing crop varieties with high yield potential as well as effectively tackling soil fertility constraints, particularly P. Two years field experiment were conducted in the moist savanna of Nigeria in an Alfisol, classified as Typic Kanhaplustalf and locally classified as Iwo series. Five upland rice varieties (ITA128, ITA 150, ITA 212, ITA 257 and SIPI 692033) and two P rates (0 and 80 kg/ha) were arranged as a split plot in a randomized complete block design, with three replications. Varieties showed differences in grain yield to P fertilization; SIPI 692033 significantly (P>0.05) produced maximum grain yields of 3.09 t/ha across P rates in both years, while ITA 257 produced the highest stover and chaff yields. ITA 257 and SIPI 692033significantly accumulated more P in the grain in both years than other cultivars. The cultivar, SIPI 692033 gave the highest (P>0.01) phosphorus harvest index (PHI) of 0.52 kg grain P/kg total P. ITA 212 had the highest P use efficiency (PUE) of 36.0 kg grain/kg fertilizer P. The optimal model calculated 80 kg P/ha had the highest PHI and PUE and was adequate for grain yields of four of the cultivars.

Keywords：*Alfisol; grain yields; varieties; phosphorus; fractional recovery model.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Tillage and Fertilizer Effects in Sole Maize (zea Mays L.) Cropping in a Degraded Nigerian Alfisol

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The choice of appropriate tillage is crucial for sustainable farming in tropical ecosystems. With high levels of soil erosion and nutrient leaching in the tropics, reducing tillage and good fertilizer management becomes an attractive option to consider for environmental conservation. A field study in a degraded alfisol in Ibadan; south western Nigeria was conducted to determine the effects of four tillage systems (TS): (plow + harrow, plow, chisel + harrow and chisel) and three fertilizer NPK 15:15:15 rates: (0, 300 and 600 kg ha-1) arranged as a split plot in a randomized complete block design, with three replications on maize yields. Measurements showing significant response to treatment effects were root length, grain yield and hundred seed weight. Maize under plow + harrow TS had the highest mean root length (23.1cm), which was 38% and 28% significantly higher than chiseling and chiseling + harrowing. Root length decreased with increasing fertilizer rates in all systems (except chisel + harrow). Grain yield showed significant increase only with increasing fertilizer rates. A grain yield of 1.4 Mg ha-1 was obtained when 0 NPK kg ha-1 was combined with plow + harrow TS. Plow alone had grain yields of 1.9 and 2.0 Mg kg ha-1 with 300 and 600 kg NPK kg ha-1 fertilizer rates. These grain yields were not significantly different from those under plow + harrow TS at the same fertilizer rates. Only 100 - seed weight property significantly responded to TS by fertilizer interactions. From the results, plowing TS when combined with 300 NPK kg ha-1 fertilizer rate was sufficient for maize production.

Keywords：*Tillage; NPK 15.15.15 fertilizer; alfisol; maize; grain yields.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Hairy Vetch Influence on Soil Nitrogen and Maize Grain Yield in the Mid-Atlantic United States

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Fertilizer nitrogen (FN) demand in maize (Zea mays L.) production is expected to increase with global population growth, and alternative sources for plant available nitrogen (PAN) will need to be optimized. Hairy vetch (Vicia villosa Roth) utilized as a winter annual cover crop (WCC) in the United States has been shown to supply subsequent maize with substantial PAN. However, a common no-tillage maize-soybean (Glycine max L. Merr.) rotation leaves fields fallow following soybeans. Our objective is to evaluate hairy vetch's capacity to supply PAN to subsequent maize following soybeans in the mid-Atlantic coastal plain region of the United States. Four sites were seeded into standing soybeans with rye (Secale cereale L.), hairy vetch, and a mixture of the two in the fall of study years. The experimental design was a split-plot with WCC species as main plots and ten N rates as subplots. Soil and WCC tissue samples were collected and analyzed at WCC termination to determine WCC N supplying capacity. In season soil and maize tissue N were determined to evaluate maize N uptake. Maize yield response to WCC treatment and N rate were determined. Winter cover crop treatment did not result in differences in preplant soil test N (any method). However at maize growth stage V5, differences in soil test N levels due to WCC were observed at total inorganic N at 0-15 cm and nitrate at 0-15 and 0-30 cm. Winter cover crop effect on presidedress nitrate test (PSNT) soil N test was highly significant ($P<0.001$) for V5 sampling period. Winter cover crop affected grain yield at one site where high cover crop biomass levels were observed. Preliminary results indicate that hairy vetch can supply subsequent maize with PAN, however biomass levels of hairy vetch observed in this study were too low to significantly affect maize grain yields at most sites.

Keywords：*maize, hairy vetch, nitrogen, nitrogen fixation, cover crop, legume, plant available nitrogen, conservation agriculture*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Sugarcane Yield as a Function of Nitrogen and Silicon Fertilization

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INTRODUCTION

N is an important factor affecting sugarcane yield and crop longevity. However, in intensive production systems, where higher N fertilization is required, there are reports that plant tissues are tender, as well as self shading of plants in the field. Si is characterized as a beneficial element for sugarcane and other crops because it gives greater resistance to lodging, increases the photosynthetic rate due the improvement of leaf architecture and reduces self-shading, especially in conditions of high population densities and high N rates. The source of Si most suitable for agriculture is steelworks slag. This material is an industrial waste consisting of silicate of calcium and magnesium, which gives the property of soil acidity correction similar to limestone. Therefore, the objective of this study was to evaluate the sugarcane yield in relation to N and Si fertilization.

METHODS

A field experiment was carried out in Jaboticabal, State of Sao Paulo, Brazil in an Rhodic Hapludox during two agricultural years with sugarcane cultivation (cane plant and first ratoon). The sugarcane variety used was RB855156. The experimental design was randomized complete blocks in a factorial scheme 2x5 (two soil acidity corrective materials and five rates of N) with four replications. The corrective materials used were the steelworks slag, called Agrosilício® (Effective Neutralizing Power – ENP = 72.3%, CaO = 42.1%, MgO = 12.4%, total Si = 8.1%, and soluble Si = 6.0%), and lime (ENP = 86.2%, CaO = 41.4%, and MgO = 10.6%). The amount of slag and lime applied followed the recommendation to raise V% (base saturation) to 60 for sugarcane in Sao Paulo state, applying 2.61 and 2.19 t ha-1, respectively. At planting of sugarcane, N was applied at five rates: 0, 30, 60, 90, and 120 kg N ha-1, determined from the rate standard of 90 kg ha-1 indicated for sugarcane with the goal of high productivity in Sao Paulo state. For ratoon, the rates applied were: 0, 40, 80, 120, and 160 kg N ha-1. In both cases, N source used was urea (44% of N). Sugarcane yield was determined by manual harvest of the stems in the useful area of each experimental unit. Data were submitted to analysis of variance and polynomial regression, using the SAS system of analysis.

RESULTS AND DISCUSSION

There were no effects of N fertilization with limestone application in the cane plant yield. This lack of response possibly is due to some factors such as the mineralization of organic matter that occurs during the soil preparation, the existing reserves in oarlock planting and the root system of cane plant contributes to the absorption of nutrients (Segato et al. 2006). However, increasing the N application rate in the presence of Si induced a quadratic relationship in cane plant yield, with 48.2 kg N ha-1 providing the greatest yield of 111.0 t ha-1; although, in the absence of Si, the yield average was 95.8 t ha-1. There are no studies reporting the

interaction of N and Si in sugarcane. However, positive results of this interaction has been observed in marandu palisade grass (Fonseca et al. 2011, 2009) noting that the increased absorption of Si promoted increases in the absorption of nutrients by Brachiaria brizantha, especially for N, increasing crop productivity.

In the ratoon cane, there was no effect of interaction N fertilization with corrective materials used. The yield obtained for the ratoon cane was 114.4 t ha-1.

CONCLUSIONS

Increasing N fertilization promoted a quadratic response in sugarcane plant productivity in the presence of silicon. However, there was no effect of the corrective material used or N rates in the ratoon cane yield.

ACKNOWLEDGEMENTS

To FAPESP (The State of Sao Paulo Research Foundation) for the financial aid and the Ph.D.-graduate scholarship award to the first author and the support provided by Sao Paulo State University.

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Keywords：*Saccharum spp., nitrogen fertilization, calcium silicate, lime, siderurgical residue*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Available, Surface Runoff and Leaching of Forms of Phosphorus in Soil With Addition of Organic And Mineral Sources of Nutrients

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The application of animal manure to soil can increase phosphorus (P) availability to plants and enhance transfer of the nutrient solution drained from the soil surface or leached into the soil profile. The aim of this study was to evaluate the effect of successive applications of organic and mineral sources of nutrients on the available content, surface runoff and leaching of forms of P in a Typic Hapludalf soil managed under no-tillage. Experiment 1 was set up in 2004 at the experimental area of UFSM, in Santa Maria (RS, Brazil. The treatments set up in the no-tillage system were: control (without application of nutrients), application of pig slurry (PS), deep-litter of pigs (LP), cattle slurry (CS) and mineral fertilizers (NPK). The rates from organic sources were determined to meet the N needs of crops. Throughout the cultivation of black oats and maize in the 2010/2011 crop year, the soil solution was collected after each event (rain + runoff or leaching) and the soluble, particulate and total P contents were measured, prepared and analyzed. In November 2008, soil was collected stratified 2 by 2 cm, to 20 cm layer, of 5 by 5 cm, to 40 cm layer, and 10 to 10 cm to 70 cm layer. The soil was dried and ground, and the P, extracted by anion exchange resin (AER), was analyzed. In experiment 2, in samples collected from the Typic Hapludalf soil near experiment 1, the following treatments were set up: soil, soil + PS, soil + LP, soil + CS and soil + NPK. After 20, 35, 58, 73 and 123 days of incubation of the soil and the treatments, soil samples were taken and prepared, and P was analyzed by AER. The applications of sources of nutrients over the years led to an increase in available P and its migration in the soil profile. This is reflected in P transfers through surface runoff and leaching, with the largest transfers being observed in treatments with the application of PS and LP, in which the greatest additions of P were made. The P available in the soil and P transfers through surface runoff correlated with the amounts applied, regardless of the P source. However, the transfer of P through percolation did not correlate with the amount of the nutrient applied, but rather with the amount of solution which leached in the soil profile.

Keywords：*Organic waste, nutrient release, environmental contamination, no-tillage system.*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Nitrogen Net Mineralization of Cauliflower Crop Residues after Incorporation to the Soil

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Nitrogen is an important nutrient in agricultural systems but suboptimal N management can result in environmental pollution. An excess of soil mineral N, either during a crop or in between crops, increases the risk of nitrate leaching in areas of intensive agriculture and can also result in higher losses of nitrous oxide to the atmosphere affecting negatively the environment. An important aspect to account for when fertilizing vegetable crop rotations is the N input due to the mineralization of crop residues. Vegetable crop residues in many cases consist of large amounts of biomass with high nitrogen content, and the mineralization of these residues in a few weeks after their incorporation to the soil can provide an important N input.

In the Valencia region nitrate pollution of groundwater is a worrying problem because the nitrate concentration is greater than 100 mg L-1 in some areas of the coastal plain where groundwater provides 40% of the drinking water. In this region there are approximately 17000 ha of vegetable crops, with lettuce, cabbage, cauliflower, onion and artichoke as the main crops. The cauliflower crop is grown in rotation with other vegetables crops such as squash, onion or fennel, during autumn and winter period, with furrow irrigation and high N fertilization rates. The aim of this work was to quantify the mineralization of nitrogen from cauliflower residues in a few months (ten to seventeen weeks) after their soil incorporation.

This experiment was conducted during the 2012-2013 period in two fields located in the Valencia area after harvesting a cauliflower crop and incorporating the crop residues. Soil textures were loamy and clay loam and the organic matter content of the first soil layer ranged from 1.8 and 3.5% OM. Dry matter yields of the above ground part were high, ranging from 11.0 to 16.6 t ha-1, and a with a N content varying from 360 to 494 kg N ha-1. In the first year, soil mineral content, soil moisture and soil chloride content was monitored during 120 days while in the second year the monitoring period was 70 days. Nitrogen net mineralization (mineralization minus gaseous losses) in top soil (30 cm) was obtained by a nitrogen balance, in which the inputs by rainfall and irrigation and the mineral nitrogen change were measured. In this N balance, nitrate leaching at a given depth and for a period was calculated as the product of the drainage for this period and the mean nitrate concentration of the soil solution to the depth considered. Drainage was calculated by a chloride balance method and also by water balance. In addition, N mineralization in laboratory was obtained from soil incubations at 70 -80% water-holding capacity and 25ºC.

The net mineralization in field ranged from 150 kg N ha-1 in a period of 105 days for the first year, and 155 kg N ha-1 in the second year for a period of 70 days. These values represent between 55-60% of the net mineralization obtained in the lab incubations. The results obtained show that the mineralization of cauliflower crop residues, is dependent on soil moisture conditions after incorporation into the soil, and represents an important contribution to the soil mineral nitrogen. This nitrogen is available for the next crop in the rotation and should be considered when planning crop fertilization to achieve an efficient nitrogen use.

Keywords：*nitrogen, mineralization, crop residues*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Sensitivity Analysis for Calibration of Two Simulation Models of the Soil Nitrogen Dynamics in a Cauliflower Crop

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Simulation models for soil water and nitrogen in crop systems are powerful tools for planning soil and crop management strategies that minimize environmental problems. These models tend to have a large number of parameters that need to be calibrated. It is known that calibration when there is a large number parameters produces overparameterization and overfitting. To calibrate a model with a large number of parameters a large quantity of measured data are required, and some of them may be difficult to obtain in field experiments, especially for data related with the soil nitrogen dynamics. To select the main parameters for the calibration process it is necessary to perform a previous sensitivity analysis of the simulation model.
In this work, data obtained from a cauliflower crop fertilization experiment have been used to analyze the sensitivity of two simulation models (LEACHN and EU-Rotate_N) with different approaches for water and nitrogen dynamics modeling. Particularly, soil water content, N-NO3- and N-NH4+ in soil profile (0-45 cm) were measured throughout the growing season. Additionally, climate and irrigation data were measured. Variables used in the sensitivity study were the soil water and the mineral nitrogen contents.
LEACHN is the nitrogen module of the LEACHM model. LEACHM (Leaching Estimation And Chemistry Model) is a process-based, one-dimensional model that simulates water and solute movement, and related chemical and biological processes, in the unsaturated soil. This model describes the one-dimensional water flow in the unsaturated zone using the Richards' equation. Solute transport is modeled by the convection-dispersion equation, and the main processes described in the nitrogen module are mineralization, nitrification, denitrification, volatilization and nitrate leaching.
The EU-Rotate_N model is a crop-based simulation model developed to optimize N use in horticultural crop rotations in a wide range of environments, from the cold North-European climates to the warm and dry conditions of Southern Europe. EU-Rotate_N simulates crop growth and the dynamics of N and water in the soil–plant system on a daily time step. The model includes a database with all the necessary parameters to run simulations for most vegetable crops, and these parameters can be modified by the user. These parameters include those related to crop development, N uptake, root growth and decomposition of crop residues.
Methods of global sensitivity analysis are very useful because they allow identifying the factors that must be measured or estimated accurately. Two different methods for the global sensitivity analysis were used, the Morri's method, based on a Latin Hypercube sampling and the first order Sobol's indices computed by the Monte Carlo simulations. The results obtained show that simulated variables of interest were sensitive to changes in a few parameters: the soil hydraulic parameters and those related to the mineralization of organic matter. These were the most important parameters in calibrating both models. These parameters should be included in an optimization process for the final calibration of the two studied models. Once the models are calibrated they can be used to make recommendations to the farmers for an efficient water and nitrogen efficient use in agricultural systems.

Keywords：*nitrogen, simulation models, cauliflower crop*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Influence of Vermicompost on Soil Physical Properties and Soil Microbial Activity in Cassava Field

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The aim of this study was to investigate the effects of vermicompost on soil physical and biological properties in cassava field. The experiment was arranged in a randomized complete block design was used with three replications with cassava Rayong 7 variety. Different amounts of vermicompost (0, 5, 10 t ha-1) and chemical fertilizer were incorporated into the top 15 cm of soil. The soil sampling and measurements carried out for 4 months after the application of vermicompost in soil and the soil samples were collected from depth of 15 cm. The results showed that addition of vermicompost at rate of 10 t ha-1 significantly ($P < 0.05$) increased contents of microbial biomass - N (62.66mg kg-1) and microbial biomass - C (278.28 mg kg-1) compared with chemical fertilizer (143.01(Bio-N), 48.20(Bio-C) mg kg-1) and control plots (143.70 (Bio-N), 47.83 (Bio-C) mg kg-1) respectively. And vermicompost at rate of 5 and 10 t ha-1 significantly ($P < 0.05$) increased contents of soil respiration (7.63, 7.55 μg CO2 Cg-1day-1) compared with chemical fertilizer(11.77 μg CO2 Cg-1day-1). The addition of vermicompost in soil resulted the physical properties such as bulk density, total porosity and moisture in soil amended with vermicompost were improved. The results of this experiment revealed that addition of vermicompost had significant ($P < 0.05$) positive effects on the soil physical and biological properties. The results from this study would be useful for the improvement of soil physical properties and soil microbial activity in sandy soils of Northeast Thailand.

Keywords：*Vermicompost, Organic amendments, Soil Physical Properties and Soil Biological Properties*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Sewage Sludge and Poultry Manure on Biomass Yield of Palak (beta Vulgaris L. Var. Bengalensis) and Heavy Metal Availability

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The experiment was laid out in completely randomized design consisting of 10 treatments with 4 levels of sewage sludge (2, 4, 6 and 8 t ha-1) and 4 levels of poultry manure (2, 4, 6 and 8 t ha-1) and 100 per cent RDF (10:10:20 kg ha-1 of N, P2O5 and K2O, respectively in a pot culture. The palak variety (All green) was used as a test crop.

The characteristics of sewage sludge generated at Amberpet municipal sewage treatment plant were catalogued. The sewage sludge was slightly acidic in nature with pH of 6.40, EC was 1.47 d Sm-1, CEC was 20.08 c mol (p+) kg-1 and OC was 36.75 per cent. Sewage sludge was a good source of major nutrients like total N (1.48 per cent), total P (0.95 per cent) and total K (0.70 per cent). The DTPA extractable micronutrients and heavy metal contents (mg kg-1) in sewage sludge followed the decreased order i.e., Fe > Zn > Cu > Mn > Ni > Pb > Cd > Cr. The physico-chemical and chemical characteristics of poultry manure collected at LRI, Rajendranagar were catalogued. The poultry manure had a pH of 7.40, EC was 1.85 d Sm-1, CEC was 22.48 c mol (p+) kg-1 and OC was 38.42 per cent. Poultry manure was a potential source of major nutrients like total N (1.78 per cent), total P (1.2 per cent) and total K (1.5 per cent). The DTPA extractable micronutrients and heavy metal contents (mg kg-1) in poultry manure followed the decreased order i.e., Fe > Mn > Cu > Zn > Ni > Pb > Cd > Cr.

The results indicated that the application of different levels of sewage sludge and poultry manure increased the composition and uptake of major nutrients, micronutrients and heavy metals by palak. The higher value of N, P, K, Fe, Mn, Cu and Zn in leaves was recorded in poultry manure treated pots. The maximum composition and uptake was observed at poultry manure @ 8 t ha-1, but the composition and uptake of heavy metals were recorded higher values with sewage sludge @ 8 t ha-1, however, the composition and uptake of major nutrients,

micronutrients and heavy metals was decreased significantly from I cutting to IV cutting in palak.

The experimental data showed that addition of sewage sludge and poultry manure did not show any significant influence on physical properties and pH of the soil after final cutting of palak. However poultry manure @ 8 t ha-1 increased the EC, CEC and organic carbon by 0.48 d Sm-1, 19.08 c mol (p+) kg-1 and 7.23 g kg -1 over control after final cutting of palak, respectively. Highest contents of soil available major nutrients and micronutrients after final cutting of palak was noticed in poultry manure treatments followed by sewage sludge. Highest available N (221.54 kg ha-1), P (14.45 kg ha-1) and K (355.70 kg ha-1) were recorded in poultry manure @ 8 t ha-1. The DTPA extractable micronutrients (Fe, Mn, Cu and Zn) of soil also showed same trend as that of major nutrients but the DTPA extractable heavy metals were noticed with application of sewage sludge @ 8 t ha-1.

The results indicated that there was an increase in dry matter yield (g
pot-1) with the application of sewage sludge and poultry manure. The highest dry matter yield was attained in poultry manure @ 8 t ha-1, however the dry matter yield was decreased significantly from 1st cutting to 4th cutting of palak crop.

In both organic manures, poultry manure showed significantly more nutrient uptake, nutrient concentration in leaves of palak. More available nutrient status, high dry matter yield and heavy metals were low in poultry manure than sewage sludge. Among all the treatments PM @ 8 t ha-1 was significantly superior over control in all the aspects and best treatment for the cultivation of palak.

Keywords：*sewage sludge,poultry mnure,yield,heavy metals,Palak (Beta vulgaris L)*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Impact of Crop Residues Decomposition on Soil Organic Matter in an Oxisol Under No-Till

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Plant residues are considered the primarily resource for soil organic carbon (SOC). The amounts and quality of plant residue are important controlling factors for the SOC sequestration. The SOC can be divided into two major pools based on particle size: particulate C pool (> 53 μm) (POC) and the C mineral-associated pools (< 53 μm) (MOC). The POC is composed mainly of plant, root and fungal hyphae residues at varying stages of decomposition. POC can respond rapidly to changes in soil C input due to soil and/or crop management. For this reason, POC pool has been considered an early indicator of the effects of cropping systems on soil quality. The MOC pool is a relative stable pool of SOC. It is formed predominantly by humic substances (humin, humic acid and fulvic acid). Those humic substances are partially resistant to microbial degradation, which preserve SOC depletion. Additionally, they have considerable contribution on SOC reactivity, which affect SOC quality. We performed a study to determine the impact of residues of 21 different crop sequences on POC and MOC pools, and on soil humic substance contents of an Oxisol under no-till. The study was conducted in Jaboticabal, SP, Brazil (21°14' S; 48°17' W; 550 m asl). The climate is classified as Koppen's Aw (a tropical climate with a dry winter and the average temperature of the coldest month above 18 °C). The average annual rainfall is 1,425 mm, with an annual distribution peaking in the period of October-March. The average annual temperature is 22 °C, and the relative humidity is 70%. The experiment was conducted using a split-block design. Two sets of treatments were composed of three summer crop sequences and seven winter crops, that is, comprising 21 different crop sequences. They were randomized across each other in strips in an otherwise randomized complete block design Three replications (blocks) were performed. The amount and quality of crop residue on the soil surface was evaluated after crop harvest. The different crop sequences did not influence the SOC content. However, crop sequence influenced differently the major soil C pools (POC and MOC). Summer crop sequence with soybean (Glycine max L. Merrill) on a continuous basis showed higher POC contents, while with maize (Zea mays L.) on a continuous basis showed higher humic acid and MOC contents. The lowest POC and MOC pools and humic substances contents were observed in the SM. Among winter crops, sunn hemp (Crotalaria juncea L.), pigeon pea (Cajanus cajan (L.) Millsp), oilseed radish (Raphanus sativus L.) and pearl millet (Pennisetum americanum (L.) Leeke) were associated with higher MOC content, while sunn hemp and pigeon pea also showed higher POC content. In addition, sunn hemp, pigeon pea, oilseed radish, and pearl millet favored the soil C humification process and increased humin and humic acid content in the soil. Our results suggest that 1) changes in soil C input due to soil and/or crop management not always can be detected by SOC analyses; 2) crop residues showing higher lignin concentration and higher C:N and lignin:N ratio (higher recalcitrance) enhance soil MOC pool and humic substances contents, which allows higher duration of the C retention in the soil and, consequently, allows soil C sequestration in an Oxisol under no-till management.

Keywords：*soil organic matter; soil organic carbon; particulate organic carbon; mineral-associated organic car*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Production and Biomass Quality of Different Elephant Grass Genotypes Grown in an Ultisol for Alternative Energy Use

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The elephant grass crop (Pennisetum purpureum Schum.) is extremely efficient in fixing carbon dioxide during photosynthesis to produce high plant biomass levels under tropical conditions. With low N fertiliser inputs the plant biomass has a very low protein content and thus a high potential to be used as an alternative energy source, against the traditional use as forage to feed animals. The objective of this study was to evaluate the biomass production and quality of different elephant grass genotypes grown in an Ultisol of medium texture, poor in available N and with low N fertilizer application. The experiment was carried out from June 2005 to May 2006 at the experimental area of Samarco Mineration in Anchieta – Espirito Santo state, Brazil. Five elephant grass genotypes (Cameroon, Gramafante, CNPGL F06-3, F79-2 and Bag 02) were evaluated without N fertiliser and with 50 kg N ha-1 as urea. Biomass production, nutrient content in plant tissue and its quality (fiber, cellulose, lignin and ashes) were evaluated. No significant statistical response of any variables studied to the application of 50 kg N ha-1 as urea. The biomass production during the growth period of 18 months was high (40 to 47 Mg ha-1 dry matter). The elephant grass genotypes most suitable for use for alternative energy production for combustion were found to be CNPGL F79-2, Cameroon and CNPGL F06-3.

Keywords：*Pennisetum purpureum, agroenergy, lignin, ultisol*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Responses of Wheat Yield and Soil Fertility to Long-Term Application of Farmyard Manure and Chemical Fertilizers in Semiarid Region of Northwestern China

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A 27-year field trial was conducted to evaluate the effects of fertilization on wheat yields, wheat yield change trends during the experiment conducted from 1981 to 2008, partial balance of N, P and K and Nitrate-N accumulation in soil and monitor long-term effects of fertilization on soil organic matter, N, P and K contents under of farmyard manure and inorganic fertilizers at a site of semiarid loess plateau, China. The results shown that long-term applications of farmyard manure increased wheat grain yield by 24% on average and nitrogen fertilizer either alone or in combination with phosphorus fertilizer application increased wheat grain yield by 29% and 46%, while K application had apparently influence on wheat yields. Analysis of variance of 23 years wheat grain yields indicated that fertilization and years significantly impacted wheat grain yield and also found that except for no-fertilizer treatment and only manure treatment, the other treatments wheat grain yields strongly correlated with growing season precipitation values. The accumulation of NO3-N in the soil profile was clearly affected by applications of mineral fertilizers and farmyard manure. In received farmyard manure plots or no farmyard manure plots, application of nitrogen fertilizer alone NO3-N accumulation amount is the highest in the soil profile among different fertilization treatments. Except for control(CK), the remaining treatments NO3-N accumulation major distribution in the 180–220 cm soil depth. The total of NO3-N recovered in the 0–400 cm soil depth were 163 kg N ha–1 for CK, 1156 kg N ha–1 for N, 736 kg N ha–1 for NP, 708kg N ha–1 for NPK, 873 kg N ha–1 for M, 1530 kg N ha–1 for MN, 1297 kg N ha–1 for MNP, and 1224 kg N ha–1 for MNPK treatment.

Keywords：*Long-term fertilization experiment; semiarid region, wheat yield, soil fertility, chemical fertilize*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Immediate and Residual Effect of Nitrogen from Green Manures and Urea for Rice and Corn Grown in Rotation in Cerrado (savannah) Oxisol

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The majority of nitrogen (N) derived from mineral fertilizers and green manures (GMs) is usually not much recovered by the very next crop, but can be utilized by follow-up crops. The grown GMs crops promote nutrient cycling and biological nitrogen fixation (BNF), when the legume species is used, and, also, is an alternative to supply the annual input of straw required to maintain the no-tillage system, mainly in the tropical region. Corn is one of the main no-tillage crops in Brazil, which is grown mainly in the savannah area in rotation or succession with upland rice, soybean and cotton crops. As N is required in large amounts for rice and corn growth, it is of great importance to know the capacity of GMs to supply N requirements for crop production. The objective of this research was to evaluate the utilization by the corn of residual N derived from urea and GMs species, labeled with 15N, applied to upland rice grown under no-tillage in the previous growing season (2009/2010); and estimate the balance of N of GMs and urea in the soil-rice-corn system, using the 15N isotope. Field experiments were carried out in Selviria, MS, Brazil (51º22'W and 20º22'S and altitude of 335 m), in an Oxisol (Rhodic Hapludox), cerrado (savannah), with historic of 19 years under conventional tillage and last 11 years in no-tillage systems. The experimental design was randomized blocks with 15 treatments and four replications, in a 5x3 factorial outline. The treatments were four GMs species: (1) sun hemp (Crotalaria juncea L.), (2) pigeon pea (Cajanus cajan L.), (3) green velvet bean (Mucuna prurens), and (4) millet (Pennisetum glaucum L.) + spontaneous vegetation (off-season fallow ground), combined with or without mineral N fertilizer application as urea to upland rice grown in succession to GMs (experiment 1). The GMs were grown during mid-winter/spring season, prior to rice crop and, at 70 days after sowing, the shoot dry matter productivity of GM crops, in Mg ha^{-1}, were: sun hemp (11.25) > millet (7.43) > pigeon pea (6.13) > green velvet bean (4.02) > spontaneous vegetation (3.05), with accumulated of N, respectively, of 196.8, 83.9, 142.8, 109.3 and 36 kg ha^{-1}. The contribution of BNF in the legume GMs was 41.2% for sun hemp, 54.4% for pigeon pea and 21.3% for green velvet bean, equivalent to 81.1, 77.6 and 23.2 kg N ha^{-1}, respectively. Nitrogen fertilizer was applied to rice crop at sowing (20 kg N ha^{-1}), or at sowing (20 kg N ha^{-1}) and plus topdressing (60 kg N ha^{-1}). After rice harvest, the same GMs were grown in the area and then followed by corn crop (2010/2011 growing season - experiment 2), using the same fertilizer rate for all plots, to distinguish the residual effect of N from the urea and GMs. The results from the study showed that: the utilization of N from urea by rice crop was, in average, 34.7%; the legume GMs provided higher utilization of N from urea (38.1%) by rice crop, compared to the millet (30%) or fallow soil during the off-season (30.4%). The utilization of N mineralized from three legume GMs species by rice were similar (7.6%), but higher than the N from millet (5.8%). The average utilization of residual N from the above ground part of GMs

residues and from urea by corn crop was less than 3.5% of the initial amount to previous rice cultivation. The GM specie did not affect the use by corn of residual N from urea, and vice-versa. The majority of N from mineral fertilizer and, mainly N from GMs residues, were not utilized until the second crop after their application to the soil. The soil provided the greatest portion of N absorbed by rice and by corn crop. The non-quantified N (losses) from GMs and urea in the soil-plant system were equivalent to a third of the amount initially applied. The results indicate that there is an opportunity to both reduce N fertilizer inputs and increase rice and corn yields by growing in succession with a legume GMs, which are both important considerations in Brazil where resources are limited and there is a need to improve both productivity and environmental sustainability. (Project financed by FAPESP and IAEA)

Keywords：*Grass, Legume, Isotopic Dilution, Nitrogen-15, Nitrogen Mineralization*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Targeted Yield Model as a Tool for Fertiliser Best Management Practice in a Maize Based Cropping Sequence of Tamil Nadu, Southern India

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In the era of increasing population pressure with shrinking cultivable area and its impact on food and nutritional security, adopting a sound and valid model as one of the Fertiliser Best Management Practices (FMBPs) for obtaining higher productivity, fertiliser use efficiency (FUE) with sustained soil health is utmost essential. In this regard, Soil Test Crop Response based Integrated Plant Nutrition System (STCR-IPNS) fertiliser recommendations were developed in the form of Fertiliser Prescription Equations (FPEs) for desired yield targets of crops in maize-tomato sequence and post-harvest soil test values were predicted by developing post - harvest soil test values prediction equations (PHSTVs) on Typic Rhodustalf (Coumaravel et al., 2013) following the Inductive cum targeted yield model of Ramamoorthy et al. (1967). This model is a unique field experimental approach (Inductive methodology) for soil test crop response correlation evolved through creating a macrocosm of soil fertility variability within a microcosm of an experimental field and provides a scientific basis for balanced fertilization not only between fertilizer nutrients but also with the soil available nutrients (Velayutham,1994). In order to validate and advocate the targeted yield model as one of the FMBPs, two field experiments were conducted at farmer's fields on Typic Rhodustalf (red non-calcareous) with hybrid maize-tomato sequence during 2012-13 in Tamil Nadu, Southern India. There were seven treatments for hybrid maize viz., control, general recommendation, STCR-NPK (through fertilisers alone) -10&11t ha-1, STCR-IPNS - 10&11t ha-1 and farmer's practice. After the harvest of maize at the respective locations, hybrid tomato was raised with seven treatments viz., control, general recommendation, STCR-NPK -80 & 90 t ha-1, STCR-IPNS - 80 & 90 t ha-1 and farmer's practice which were imposed on the respective plots.

Based on the initial soil test values of available N, P and K and yield targets aimed, fertilizer doses were calculated using the respective fertilizer prescription equations and applied for STCR treatments. For IPNS treatments, Farm Yard Manure (FYM) @12.5 t ha-1 was applied basally and Azospirillum @ 2 kg ha-1 was applied a week after fertilizer application; For tomato, initial soil test values of available N, P and K were predicted using the PHSTVs prediction equations. All the improved agronomic practices were carried out periodically and yields were recorded at maturity.In both the locations, the targeted yield was achieved within +/- 10 per cent variation proving the validity of the equations for maize and tomato. The mean grain yield of maize in STCR - IPNS -10 t ha-1 treatments was 10.49 t ha-1 and fertiliser use efficiency in terms of response ratio (RR) was 13.80 kg kg-1 while in blanket and farmer's practice, the mean grain yield was 7.65 and 6.71 t ha-1, respectively; RR was 10.8 and 10.1 kg kg-1, respectively proving the superiority of STCR-IPNS. STCR-IPNS-10 t ha-1 had recorded a mean yield increase of 37.1 and 56.3 per cent respectively over blanket and farmer's practice.

The mean fruit yield of tomato in STCR-IPNS-90 t ha-1 treatment was 89.15 t ha-1 while in blanket and farmer's practice, the mean fruit yield was 74.20 and 57.95 t ha-1, respectively. The highest mean RR was recorded in STCR-IPNS-80 t ha-1 (82.8 kg kg-1) followed by STCR-IPNS-90 t ha-1 (81.7 kg kg-1) while in blanket and farmer's practice, the RR was 68.9 and 66.6 kg kg-1,

respectively proving the superiority of STCR-IPNS. The mean yield increase in STCR - IPNS-90 t ha-1 over blanket and farmer's practice was 20.2 and 53.9 per cent, respectively.

Using the PHSTVs prediction equations developed for tomato, the post harvest soil test values were predicted at the end of the sequence (after tomato). The data clearly revealed that there was build up with respect to soil available N,P and K in all the STCR treatments; however, the magnitude of build up was higher with higher yield targets and with STCR-IPNS. Therefore, based on the results of the two sequential experiments, it could be inferred that targeting of 10 t ha-1 of hybrid maize in the first season and 90 t ha-1 of hybrid tomato in the second season would be ideal for maize-tomato sequence on Typic Rhodustalf in terms of higher productivity, fertiliser use efficiency and soil fertility.

Keywords：*Targeted yield model, Fertiliser Best Management Practice, Maize*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Animal Manure with and without Chemical Fertilizer on Dragon Fruit (hylocereus Undatus (haw.) Britton & Rose) Cultivation in the Low Country Intermediate Zone of Sri Lanka

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Soil fertility depletion and loss of plant nutrients in soil are the major constraints in crop production at present. Therefore, most of the farmers in Sri Lanka are using high doses of chemical fertilizer and other agro-chemicals in their fields resulting in various types of environmental and health hazards. Integrated Plant Nutrient Management System (IPNS) is one of the effective soil fertility management systems which can be used to develop overall soil fertility such as physical, chemical and biological properties in soil. It helps to create sustainable farming system by integrating natural and regenerative processes in the soil. Therefore, a long term experiment was carried out for eight consecutive seasons to find out the effect of different sources of animal manure with and without chemical fertilizer on the yield of dragon fruit Hylocereus undatus (Haw.) Britton and Rose in red yellow podsolic soils at the Regional Agricultural Research and Development Centre at Makandura which belongs to the Low Country Intermediate Zone (LCIZ) of Sri Lanka. In relation to the sustainability, soil chemical properties such as pH, EC, Exchangeable Potassium (K) content, available Phosphorous (P) content and organic matter percentage (OM%) were assessed. Brix value of the fruit flesh and severity of disease spreading were assessed as added information for the study.

Three sources of animal manure namely cattle manure, deep litter and broiler litter were tested with and without chemical fertilizers. They were added at the rate of 20 t ha-1 in every 6 months interval in dry weight basis. Rate of chemical fertilizer application was done as 100 kg ha-1of Nitrogen, 150 kg ha-1of Phosphorous as P2O5- and 300 kg ha-1 of Potassium as K2O in a split pattern as basal and every 3 months intervals as top dressing. The eight treatments including control were replicated three times in a Randomized Complete Block Design (RCBD) and plant spacing was 2.5 X 2.5 m2.

Significantly higher fruit yield was recorded by deep litter with chemical fertilizer treatment, which was 28.1 t ha-1 followed by the broiler litter with chemical fertilizer (18.8 t ha-1) and deep litter alone 15.3 t ha-1. The lowest yield (< 1 t ha-1) was recorded in the treatment that consists of only chemical fertilizers. The efficiency of three sources of animal manures has increased when they are combined with chemical fertilizers. The application of deep litter with and without chemical fertilizer has showed increase of pH, K, P and OM% in the soil more effectively when compared to other animal sources. A significant incidences of disease symptoms showed only in chemical fertilizer treated plants which was an important issue in disease management in dragon fruit cultivation.

Keywords：*Soil fertility, Integrated Nutrient Management, Animal manure, soil properties*

P4-447

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Electrical Conductivity, Ph and Potential Acidity in Soils Fertilized with Poultry Litter Compost

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The modern animal productive confined systems result on a increase in the scale oof production in the way to supply the animal origin food demand. Brazil produced in 2012, around 12.6 million tons of poultry meat, which generates 10.3 millions of tons of poultry litter. The practice of adding residues from poultry or manure residues to the soil demands a monitoring to realize the correct use on the treatment of the soil as a biofertilizer so it can prevent impact by excess of mineral elements into waters and soil itself. This work aimed to study the effects of poultry litter compost used in soil over the electric conductivity (EC), pH in $CaCl_2$ and soil potential acidity (H + Al). Treatments studied were five doses of poultry litter compost 0;20;40;60;and Mg ha^{-1}. Soil was classified as a haplorthox, sampled in 20 cm deep, dried, sieved and homogenized. Soil laboratorial analysis were performed according to methodology proposed by Raij e Quaggio (1983) and the electric conductivity according to Camargo et al., (2009). Soil present the following chemical initial composition: pH $CaCl_2$= 4,9; H+ Al^{3+}= 31.0 mmol dm^{-3}; electric conductivity = 36.4 µS cm^{-1} and granulometric analysis (g kg^{-1}): 180 for silt, 230 for clay and 590 for sand.
Organic compost was obtained by biodigestion in an aerobic fermentation during 60 days. Compost was then artificial dried at 55º C for 48 hours. Physico-chemical analyses of the compost were performed according to methodology described in Brazil (2007). Results from organic compost analysis (g kg^{-1}) were 29.4 of N, 39.3 of P, 25.5 of K, 92.4 of Ca and 11.8 of Mg. Organic fertilizers were homogenized and sieved in 3 mesh sieves, corresponding to a free opening of 0.67 cm and mixed to the soil. Experiment was carried out in a green house, in a randomized blocks design with five replications. The incubation and neutralization curves were determinate in dried samples of soil according to Ernani & Almeida (l986), evaluating pH data in solution of $CaCl_2$ 0.01 mol L^{-1} in a proportion of 1:2,5 (soil: solvent) related to the increasing doses applied of dolomitic calcarium (PRNT= 130 %, CaO= 44% e MgO= 20%), aiming to evaluate the effects of soil reactions and to compare with the application of poutltry litter compost. The application of poultry litter compost increased significantly the pH values, decrease the potential acidity. The incubation curve for this soil with increasing amounts of calcarium showed values of pH $_{CaCl2}$ increasing linearly and adjusting to the equation Y= 0.86X + 3.91 (R^2= 0.94**) where X= amount of calcarium (t ha^{-1}). Considering pH values obtained by addition of 20 t ha^{-1} of organic compost, it can be estimated though the equation that corrective values of this product is equivalent to application of 2.43 tons of calcarium per hectare, using poultry litter compost. The amount of changeable Al in the soil and Al saturation (m%) decreased with the compost application in comparison to the control treatment, and as a consequence, a decrease on the potential acidity values (H + Al), a decreasing on the changeable Al in the soil, which can be explained by the aluminum complexation, by the acids fractions fulvic and humic from organic matter, which are very reactive and increase significantly in the soil with addition of higher amounts of carbon.
The electric conductivity values (EC) from soil were altered by the bio fertilizer doses applied on the soil. Values of EC showed higher levels after poultry litter compost application (from 86,5 to 2.447,0 µS cm^{-1}). As results, this work shows that altering concentrations of Ca, Mg and K, besides the pH , responsible for the nutrients and micro nutrients availability also alters the EC in the soil. Higher amounts of poultry litter compost (2.842 mg kg^{-1}) explains the increase on the EC. Values superior to 400 µS cm^{-1}(4 dS m^{-1}) were obtained with doses above 20 t ha^{-1} of poultry litter.
The fertilizing potential of the poultry litter must be monitored and doses must be used inferior to 20 t $ha^{-1)}$ in the way to prevent negative impacts and environmental risks avoiding chemical and physical soil unbalances.

Keywords：*organic fertilizer, poultry litter, physical-chemical soil properties*

P4-448

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Combined Effect of Organic and Chemical Nitrogen Fertilizers on Growth and Nitrate Accumulation in Watercress Grown in the Glasshouse

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Glasshouse vegetable trial was conducted for two seasons using watercress, with the aim of evaluating the environmental risks and agronomic benefits of applying different combinations of organic and chemical N fertilizers to sandy soil. The results showed that, all fertilizer application rates had the capacity to stimulate vigorous growth, nutritional status of watercress plants, and to increase N recovery and concentration by watercress plants compared to control. Over both seasons of this study, all these improvements in growth quality parameters of watercress plants were in most cases not significantly different at the higher fertilizer application rates of 120 and 180 kg/feddan. This finding indicates that the plant response due to the increasing of fertilizer application rate is subject to diminishing returns. Where the diminished yield per unit of fertilizer N addition was clearly seen, beyond which further additions will not improve the yield.

Results of this work showed that, major considerations in applying of chemical N fertilizers alone on sandy soils cultivated with leafy vegetables are the increase in residual nitrate in soils, the increase in groundwater contamination potentials by nitrate, and the threat of nitrates build-up in plant tissues. Under conditions of this study, high application rates of chemical nitrogen fertilizer (180 kg/feddan) caused high levels of nitrate accumulation in watercress plants, and on being con¬sumed by living beings, pose serious health hazards. In general at the rate of 120 kg/feddan equal combined organic and chemical fertilizers, no health problems could be foreseen to humans or animals from food chain movement of nitrates. Under the conditions of this study, incorporation of combined organic and chemical fertilizers into sandy soil cultivated with leafy vegetables at the rate of 120 kg/feddan nitrogen using drip irrigation system was the best management strategy practice to reach optimum agronomic benefits while minimizing environmental impacts.

Keywords：*Nitrate pollution, Agronomic benefits, Environmental risks, Feddan (= 4200 m2 = 2.38 Hectare).*

P4-449

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Enhance of Nutrient Supply of Soil By Groundcovering in a Hungarian Peach Orchard

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A field trial has been conducted on 9-year-old Sweet Lady and Royal Glory peach cultivars on a sandy loam soil at Siofok, West Hungary, since 2009. Four in-row ground management systems (pine bark mulch, cow manure, black fabric cover, and no cover with herbicide applications) were evaluated in a plot design with three replicates to study their effects on soil parameters and nutrient contents of leaves.
Soil parameters (pH, available nutrient contents)affected by treatments significantly. Moreover, our plant analytical results suggest that leaf nutrient concentrations respond differentially to different mulches.

Keywords：*groundcover, fruit nutrition*

P4-450

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Enhance of Nutrient Supply of Soil by Groundcovering in a Hungarian Peach Orchard

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The importance of ground cover management is increasing continuously in fruit production in the past few decades. It is explained by its application in organic farming and as it is regarded as excellent water-saving method. These problems are very actual in Hungarian fruit growing sector. Therefore, a field trial has been conducted to investigate the effects of different ground cover materials on nutrient availability, uptake and fruit quality.

The study was conducted at the orchard of Gyumolcsert Ltd. (Fruit Research Experimental Site, University of Debrecen) at Siofok. Our trial was conducted in an integrated 9-year-old peach plantation with two cultivars: Sweet Lady and Royal Glory. The 10-ha orchard, grafted on GF 677 rootstock, was planted in 2004 at a spacing of 5 × 3 m.

Four in-row ground management systems (pine bark mulch, cow manure, black fabric cover, and no cover with herbicide applications) were evaluated in a randomized block design with three replicates to study their effects on soil parameters, nutrient supply of soil and nutrient contents of leaves.

The mulches were applied to the ground without incorporation. Materials were spread in a strip 0.75 m wide on either side of the trees. Each plot consisted of 50 trees, and the total covered area was 225 square metre.

It seems that soil parameters (pH, available nutrient contents) affected by treatments significantly.

Results of chemical analysis of leaves showed that the leaf N, K, and Ca concentrations increased but leaf Mg and Zn decreased as a result of the treatments. Leaf Mn and Cu contents were slightly affected by the treatments, and the change was not significant at some treatments.

Overall, our results suggest that leaf nutrient concentrations respond differentially to different mulch applications. Obtained results indicate that the groundcover treatments have effects on the nutrient uptake of trees because they influence the availability of nutrients in the soil.

Keywords：*groundcover, fruit nutrition*

P4-451

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Integrated Nutrient Management and Irrigation Practice on the Productivity of Crops and Soil Health

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Crop production is closely related to soil fertility. Field experiments were conducted in Old Brahmaputra Floodplain soil (AEZ 9) at farmer's field, Sutiakhali, Mymensingh, during 2012-2013 to study the effect of integrated nutrient management and irrigation practice on the yield of different crops and soil health. The soil was silt loam having 6.2 pH, 1.37% soil organic carbon (SOC), 0.11% total nitrogen, 9.20 mg kg-1 available phosphorus, and 0.131 meq% exchangeable potassium. There were five treatments consisting of T1: recommended chemical fertilizer, T2: soil test based chemical fertilizer, T3: soil test based chemical fertilizer + cowdung (integrated plant nutrition system), T4: Farmer's practice, T5: without fertilizer (control). N, P, K, and S were applied in the form of urea, triple super phosphate, muriate of potash and gypsum respectively. Cowdung was applied at the rate of 5 Mg ha-1. Rate of fertilizer was different depending on the crop, two cropping pattern was completed as winter vegetable (cabbage) - transplanted aus rice -transplanted aman rice (CP 1) and transplanted aman rice - fallow- irrigated rice (CP 2). Continuous flooding (CF) and alternate wetting and drying (AWD) used as water management practice for CP 2 in dry season.

Treatments had a significant positive effect on the yield and yield contributing characters as tillers hill-1, plant height, population m-2, panicle length, grains panicle-1 and 1000-grain weight of cabbage, transplanted aus rice, transplanted aman rice and irrigated boro rice. Highest yield of cabbage (89.2 Mg ha-1), T. aus rice (4.7 Mg ha-1), T. aman rice (6.7 Mg ha-1) and boro rice (5.6 Mg ha-1) was obtained from the soil test based chemical fertilizer + cowdung treatment with integrated plant nutrition system. SOC was also affected by the treatments. An increment of 0.15% and 0.13% SOC was recorded from CP 1 and CP 2 respectively due to use of 5 Mg ha-1 cowdung. AWD was found affective irrigation practice which can save 32% irrigation water compare to CF practice.

Keywords：*Nutrient, Irrigation, Crop yield, SOC*

P4-452

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Organic and Inorganic Fertilizers on the Growth and Yield of Physic NUT (Jatropha Curcas)

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The research was conducted in 2011 cropping season at the Teaching and Research farm of the Faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology, Enugu, Nigeria to study the effect of organic and inorganic fertilizers on the growth and yield of physic Nut (Jatropha curcas). There were five treatments namely, control, (no application of treatment), NPK 20:10:10, NPK 15:15;15, poultry droppings and goat dung. The treatments were laid out in a Randomized complete Block Design (RCBD) with five replications. The total land area used was 228m2 (19x12m) while the plot size was 3mx2 (6m2). The growth parameters measured were plant height, number of leaves, and leaf area, index (LAI).The results obtained showed that there were significant differences at P=0.05 among the different treatments in 30, to and 90 DAP.

Based on the results T4 (poultry droppings) had higher effect at P=0.05 at 30, 60, 90 DAP than the other treatments when compared and is hereby recommended as the best type of fertilizer for the optimum growth and production of physic Nut (Jatropha Curcas) in South Eastern Nigeria.

Keywords：*organic, Inorganic fertilizers, growth, yield, Jatropha curcas*

P4-453

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Biofertilizer, Vermicompost and Chemical Fertilizers on Bushbean

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A field experiment was conducted at BARI Central Farm, Joydebpur, Gazipur to evaluate the effect of Rhizobium biofertilizer, vermicompost and chemical fertilizers on bushbean during the rabi season of 2011-2012 and 2012-2013. The crop variety was BARI Zharseem-1 and Rhizobium strain was BARI RPv-701. There were nine treatments viz. T1: Control, T2: Vermicompost (VC) @ 2.5 t ha-1, T3: VC @ 5 t ha-1, T4: VC @ 2.5 t ha-1 + Integrated Plant Nutrient System (IPNS) based NPKSZnB, T5: VC @ 5 t ha-1 + IPNS based NPKSZnB, T6: VC @ 2.5 t ha-1 + Rhizobium + IPNS based PKSZnB, T7: VC @ 5 t ha-1 + Rhizobium + IPNS based PKSZnB, T8: 100%NPKSZnB, T9: Rhizobium + 100%PKSZnB which were replicated four times. Peat based rhizobial inoculum was used at the rate of 1.5 kg ha-1 as seed inoculant. The Rhizobium inoculated bushbean with VC 5 t ha-1 and IPNS based PKSZnB increased nodule number (12.91 plant-1 in 2012 and 12.81 plant-1 in 2013), nodule weight (19.30 mg plant-1 in 2012 and 19.35 mg plant-1 in 2013) and 1000-seed weight. It was observed that full doses of NPKSZnB fertilizers produced the highest green pod yield (11.24 t ha-1, 72.9% higher over control in 2012 and 11.54 t ha-1, 72.5% higher over control in 2013) and seed yield (1.37 t ha-1, 93.0% higher over control in 2012) of bushbean. This green pod yield was statistically identical with all other treatments except control treatment, VC @ 2.5 t ha-1 and VC @ 5.0 t ha-1 both in 2012 and 2013, and seed yield was identical with VC @ 2.5 t ha-1 + IPNS based NPKSZnB, VC @ 2.5 t ha-1 + Rhizobium + IPNS based PKSZnB, VC @ 5.0 t ha-1 + Rhizobium + IPNS based PKSZnB and Rhizobium + 100%PKSZnB fertilizers but differed from other treatments both in 2012 and 2013. This indicates that application of vermicompost @ 5.0 t ha-1 plus Rhizobium can reduce a considerable amount of chemical fertlilizers. Vermicompost exhibited better performance in bushbean. To improve soil health and to maintain it as well as to improve crop production, we have to reduce chemical fertilizer. Benefit cost ratio (BCR) revealed that the highest BCR (15.19 in 2012 and 16.08 in 2013) was found in T9 treatment followed by T8, T6 and T4 treatment. As the yield was higher in T8 and T9 treatment, poor farmer can adopt these treatments. From one year trial, it can be concluded that full doses of chemical fertilizers and Rhizobium along with IPNS based chemical fertilizers except N may be recommended for bushbean cultivation in Grey Terrace Soil of Joydebpur (AEZ-28). From economic point of view, full doses of chemical fertilizers along with rhizohial inoculum is the best treatment. Further trials at Joydebpur and different AEZs, and economic analysis are required for final recommendation.

P4-454

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Biofertilizer, Vermicompost and Chemical Fertilizers on Gardenpea

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A field experiment was conducted at BARI Central Farm, Joydebpur, Gazipur to evaluate the effect of Rhizobium biofertilizer, vermicompost and chemical fertilizers on gardenpea during the rabi season of 2011-2012. The crop variety was BARI Motorshuti-1 and Rhizobium (R) strain was BARI RPs-501. There were nine treatments viz. T1: Control, T2: Vermicompost (VC) @ 2.5 t ha-1, T3: VC @ 5 t ha-1, T4: VC @ 2.5 t ha-1 + Integrated Plant Nutrient System (IPNS) based NPKSZnB, T5: VC @ 5 t ha-1 + IPNS based NPKSZnB, T6: VC @ 2.5 t ha-1 + Rhizobium + IPNS based PKSZnB, T7: VC @ 5 t ha-1 + Rhizobium + IPNS based PKSZnB, T8: 100% NPKSZnB, T9: Rhizobium + 100% PKSZnB which were replicated four times. Peat based rhizobial inoculum was used at the rate of 1.5 kg ha-1 as seed inoculant. The Rhizobium inoculated gardenpea with VC 5 t ha-1 and IPNS based PKSZnB increased nodule number (13.80 plant-1), nodule weight (27.50 mg plant-1), root weight (0.28 g plant-1), pods plant-1 and stover yield. It was observed that VC @ 5 t ha-1 + Rhizobium + IPNS based PKSZnB fertilizers produced the highest green pod yield (10.77 t ha-1, 53.4% higher over control) and seed yield (1.56 t ha-1, 41.8% higher over control) of gardenpea. This green pod yield was statistically identical with all other treatments but different from control treatments and seed yield was identical with VC @ 5 t ha-1 + IPNS based NPKSZnB, VC @ 2.5 t ha-1 + Rhizobium + IPNS based PKSZnB, 100% NPKSZnB and Rhizobium + 100% PKSZnB fertilizers but different from other treatments. This indicates that application of vermicopost @ 5 t ha-1 plus Rhizobium can reduce a considerable amount of chemical fertlilizers. The lowest green pod yield and dry seed yield was found in control treatment. Vermicompost exhibited better performance in garenpea. To improve soil health and to maintain it as well as to improve crop production, we have to reduce chemical fertilizer. Benefit cost ratio (BCR) revealed that the highest BCR (16.99) was found in T9 treatment followed by T8, T6 and T4 treatment. Poor farmers can adopt this treatment. From current year trial, it can be concluded that vermicompost 5.0 t ha-1 plus Rhizobium along with IPNS based chemical fertilizer (except N) may be recommended for higher pod yield of gardenpea in Grey Terrace Soil of Joydebpur (AEZ-28). From economic point of view, full doses of chemical fertilizers along with rhizohial inoculum is the best treatment. Similar results were observed in previous years. Further trials at different AEZs and economic analysis are required for final recommendation.

P4-455

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Forgotten Soil Sulphur in Chilean Soils: A More Efficient Diagnosis of Soil Sulphate

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Soil sulphur (S) fertility has not received enough attention in Chile considering the environmental vertiginous global change in the last 30 years, not only in climatic change terms through the reduced S-emissions, but also regarding the introduction of technology for crop genetic improvement and agronomic management. Previous studies in the South of Chile have shown low values of sulphate in the soil (4 mg SO4-2 kg soil-1), the available form for plant up take. However, there is no recent information about the state of soil sulphur fertility along the agricultural extension of the country (roughly 29oS-53 oS). The aim of this ongoing research is to assess the sulphate mineralised from the organic matter in three contrasting agricultural systems in order to evaluate the state of soil sulphur fertility and further agronomic recommendations to improve the crop yield/quality. Particularly, we aim to implement the application of ion chromatography to quantify SO4-2 instead of the current turbidimetric method, that shows inaccurate results when applied to volcanic soils. The study is being carried out in two contrasting regions of Chile, differing in rainfall and temperature regimes, over volcanic and a non volcanic soils, respectively. This is to assess two scenarios where the intensity of mineralization and leaching will probably be different. The first experimental site is located in the central valley of Chile ('Palmilla' 34ºS 71ºW, 153 masl) and the soil at the study site is currently under agricultural crop rotation of wheat-maize-alfalfa. The climate is Mediterranean and the rainfall is below 600mm, concentrated in winter (three months). The second site is located in the Andes premountains ('Yungay', 37ºS 72ºW, 268 masl), where soil samples has been collected from an Andisol under oat-wheat rotation. The weather conditions of the area are governed by a longer winter season with 1000 to 1500 mm of rainfall and cooler temperatures too (16ºC annual average). To asses a more suitable procedure than turbidimetry to obtain a reliable soil sulphur sulphate fraction, a complete random sampling in both sites is being conducted in order to test the reliability of the soil sulphur extraction (n=40) on soil samples taken at 0-10cm depth. The samples are air dried for 48 hours and sieved at 2mm, and three different extractants will be tested: 0.1M LiCl, H2O, and 0.15%CaC2l (Ajwa and Tabatabai, 1993). Soil samples of 20g will be shaked with 100 mL of the extractant for 60 min using an reciprocal shaker. Soil-solutions will be left to settle and filtered if necessary using Whatman Nº42 and 0.45 μm membrane filter. Sulphate in the extract will be determined by ion chromatography (HPLC, column Shim-pack IC-SA2, 250mm L x 4.0mm I.D.for anion analyses, detector HIC-20ASuper 230V CE). Results will be analysed by ANOVA procedure.

Keywords：*ion chromatography, soil sulphur, volcanic soils*

P4-456

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Crop Residues on Soil Zinc Bioavailability and Grain Zinc content in Wheat

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Zinc (Zn) deficiency is considered one of the most widespread problems of human malnutrition. Zinc deficiency in human results from diets that are low in bioavailable Zn. Cereals and legume seeds are poor sources of Zn, because they are high in phytic acid, which strongly make poorly soluble Zn-phytate complexes. In arid and semi-arid regions like Iran, soils under cereal cultivation are high in total Zn concentration but readily plant available Zn is limited. Several approaches such as genetic biofortification and agronomic biofortification have been used for increasing Zn content of cereals. Agronomic biofortification increases Zn concentration in the edible parts of the plants through agronomic practices. Application of inorganic Zn fertilizers and organic amendments like crop residues is an important approach for agronomic biofortification. Thus, the present study was conducted with the aim of evaluating crop residues effects on plant Zn availability in soil and on Zn concentration in wheat grain. The experiment was conducted in a greenhouse at Isfahan University of Technology (IUT), Isfahan, Iran. The surface soil sample (0-20 cm) was collected from Rudasht agricultural research station in the southeast of Isfahan city in the central part of Iran. Residues of safflower (Carthamus tinctorius L.), sunflower (Heliantus annus L.), bean (Phaseolus vulgaris L.), clover (Trifolium pretense L.) and sorghum (Sorghum bicolor L.) were used as soil amendments at an application rate of 2.4 g dry matter kg-1. Two weeks after incorporating the residues into the soil, seeds of two wheat cultivars including Kavir as Zn-inefficient and Backcross Roshan as Zn-efficient cultivar were planted in the soils. Seven months after planting, wheat was harvested and grains were used for Zn analysis and soil N and Zn was measured. All crop residue treatments significantly increased total soil nitrogen contents relative to the control treatment. Legume residues added greater amounts of nitrogen to the soil than non-legume residues. Soil DTPA extractable Zn was significantly increased in all residue treatments relative to the controls, and they were generally higher after cultivation with the Zn-efficient 'Backcross Roshan' cultivar than with the Zn-inefficient 'Kavir' cultivar in a given treatment. Non-legume residues increased DTPA-extractable soil Zn concentrations by 60%, while this increase for the legume residues was only around 30%.

Incorporating the crop residues in to the soil increased the grain yield in both cultivars. The pattern of treatment effects was very similar to that on soil N content, as reflected also by a strong positive correlation ($R^2=0.79$, $P= 0.01$) between these two parameters. The greatest grain Zn uptake per pot was observed in the treatments with legume residues for both cultivars. In these treatments the increase in grain Zn uptake amounted to 16-22% of the Zn input with the residues, while it was only around half as much in the sunflower residue treatments and only one third or even less of it in the two other non-legume treatments.

Our results show incorporation of crop residues improved the grain wheat yield and increased the grain Zn uptake. The legume residue had greater effects on increasing the grain yield and Zn uptake.

P4-457

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Potassium Balance and Soil Exchangeable Potassium Accumulation in the Intensive Vegetable Fields of China

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China's vegetable production has experienced a rapid growth inrecent years. Potassium (K) is an important element to improve quality and stress resistance of vegetables. In addition of compost or manure, the compound fertilizer with high content of potassium is widely used in vegetable production. Excessive K input led to low use efficiency, and nutrient antagonism, i.e. K+ and Mg2+, which induced Mg deficiency in fruity vegetable due to excessive high exchangeable K level in greenhouse. In this study, potassium balance and soil exchangeable potassium accumulation in the intensive vegetable fields were evaluated based on the literatures and our recent experiments. The average seasonal K input recently increased in vegetable production, with 617 kg K ha-1 (before 2003) and 1221 kg K ha-1(after 2003) in greenhouse and 256 kg K ha-1 (before 2003) and 173 kg K ha-1(after 2003) in open-field, respectively. Although generally highest K removal in vegetable planting, excessive high K surplus led to soil K enrichment, which measured as NH4OAc-K in the 0-20 cm soil depth, averaging 206 mg K kg-1 (before 2003) and 380 mg K kg-1 (after 2003) in greenhouse, while 149 mg K kg-1 (before 2003) and 206 mg K kg-1 (after 2003)in open-field, respectively. In some cases K leaching easily occurred in sandy soil with flooding irrigation, as evidenced by increases in NH4OAc-K level at the 40-100 cm soil depth, especially in the greenhouses with longplanting history. Rootzone control, i.e. fertigation technique, is urgently needed to implement science-based nutrient management practices considering critical K supply for sustainable vegetable production.

Keywords：*Potassium balance; Available potassium; Soil potassium enrichment, Potassium leaching; Vegetable planting*

P4-458

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Camel-Horse Dung and Crop Variety on the Productivity of Cucumber in a Semi-Arid Land of Nigeria

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Two field experiments were conducted to investigate the influence of camel-horse dung and variety on the growth and yield of cucumber during the 2008/09 and 2009/10 dry season in the horticultural garden of the College of Education, Azare in Bauchi State, Nigeria. The treatments consisted of five levels of camel-horse dung (CHOD), 0 (without CHOD), 60, 120 kg ha-1 of camel droppings as well as 40 and 80 kg ha-1of horse dung with two varieties of cucumber (Ashley and Alpha beit). The treatments were laid out in a randomized complete bock design with four replications. Vine length and number of leaves were significantly increased in all the two dry seasons of this experiment with application of 120 and 80 kg ha-1 of camel-horse dung and Alpha beit variety giving the highest values. However, camel-horse dung applied at 120 and 40 kg ha-1 increased number of fruit yield per plot at all dry seasons, so also Alpha beit in 2009/10 dry season. Therefore, it was recommended that for higher production of cucumber in the area and related ecologies, application of camel-horse dung at 120 and 40 kg ha-1 using Alpha beit is necessary.

Keywords：*Camel-horse dung, variety and cucumber*

P4-459

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Rice Straw Application and Tillage Method on Rice Quality and Yield in Plain Paddy Field

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Nutrient availability and crop development is highly influenced by soil management practice. The objective of this study was to investigate the effect of tillage methods and rice straw application on nutrient absorption pattern and the quality of rice. The experiment was conducted at Jeonbuk series (fine silty, mixed, nonacid, Aeric Fluventic Haplaqepts) in Korea. The main treatment was 1) rotary tillage in two weeks before transplanting of rice, and 2) deep plowing in autumn. Sub-plots were treated with rice straw application and non-application. Soil physical properties including surface soil depth, bulk density, and porosity was improved by deep plowing. Soil organic matter and available phosphate content was the highest at the combination of deep plowing and rice straw application. Nitrogen absorption amounts by tillage method were greater in order of rotary tillage with rice straw, rotary tillage, deep plowing, deep plowing with rice straw. Translation rate(grain N-amount/Total N-amount) were higher in order of deep plowing, deep plowing with rice straw, rotary tillage, rotary tillage with rice straw. Rice yield was higher in order of rotary tillage with rice straw, rotary tillage, deep plowing, deep plowing with rice straw. Head rice ratio was the highest at rotary tillage with rice straw plot, however head rice yield was the highest at deep plow with rice straw. The results of this study showed that soil physical and chemical properties in plain paddy field can be improved by rice straw application and tillage method, indicating that rice cultivation in plain paddy field should consider the management practice of tillage and rice straw application for the best yield and quality of rice.

Keywords：*Tillage method, Rice straw, Yield, Quality, Rice*

P4-460

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Optimum Application Rates of Oil Cake, Rice Bran and Rice Straw for Effective Soil Management in Korea Lettuce Field

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To establish the optimum application rate of rice straw (RS), rice bran (RB) and oil cake (OC), they were applied at 5 Mg ha-1 to salt-accumulated greenhouse soil. The organic materials were 5 times successively applied to the same plots of greenhouse soils and the lettuce was 5 time cultivated. Also, the effects of organic materials application on soil physiochemical properties, microflora and lettuce yields were investigated. Soil pH was increased by the application of RS from 6.1 to 7.1, while decreased by OC. Soil EC and NO3-N showed a high content by OC treatment. Soil organic matter content was higher in all organic materials treatments compared with the control. With RB application, soil available P2O5 was slightly increased and exchangeable K exhibited declining tendency and maintained around 1 cmol kg-1. NO3-N mineralization rate of OC in soil was showed higher than that of RS and RB. From the NO3-N mineralization rate, the equation to recommend amount of OC could be made as follows; application rate of OC (kg 10a-1)=N fertilization rate by soil test (kg 10a-1)÷(22.1/100)÷(N content in OC/100). And available P2O5 mineralization rate in soil was showed higher in RB treatment compared with RS and OC application. From available P2O5 mineralization rate, the equation to recommend amount of RB could be made as follows; application rate of RB (kg 10a-1)=P2O5 fertilization rate by soil test(kg 10a-1)÷(16.6/100)÷(P2O5 content in RB/100).

Keywords：*Oil cake, Rice bran, Rice straw, Lettuce*

P4-461

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Relationship Fertilization with Growth of Fruit and Accumulation of Anthocyanin in Schizandrae Chinesis Baillon

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This study was conducted to investigate the effect of fertilization on characteristics of growth and anthocyanin accumulation in fruit of Schizandrae Chinensis Baillon using a response surface methodology. Schizandrae Chinensis Baillon was cultivated with sixteen treatments, which were composed of 2 by 3 factorial fertilization arrangement and fertilizer as a top dressing was applied periodically. Anthocyanin and anthocyanidin of fruits were analyzed using colorimeter and high performance liquid chromatography. Analysis of variance showed that fertilization of nitrogen and phosphorous influenced on the fruit yield and anthocyanin accumulation, but content of anthocyanidin in fruit was not affected. Two anthocyanidin was identified during maturing season, but cyanidin was dominantly present in fruit at harvesting period (20. Sep.) (data are not shown). Canonical analysis of response surface and contour plot interpretation revealed that 8 kg 10a-1 of nitrogen and 6 kg 10a-1 of phosphrous result in maximum yield and anthocyanin accumulation of fruit in the Schizandrae Chinensis Baillon.

Keywords：*Fertilization, Anthocyanin, Schizandrae Chinensis, Medicinal plant, Response surface methodology*

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[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Root Zone Temperature on Nutrient Uptake and Photoassimilates Accumulation of Tomato Plants

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Root zone temperature (RZT) is an important factor affecting plant growth and uptake of water and nutrient. Soil temperature may influence the physico-chemical and biological processes which affect nutrient availability in soils, affect nutrient uptake and carbohydrate biosynthesis of plants, and thus modify the shoot-root partitioning of nutrients and carbohydrates. The objectives of this study were: (1) whether root zone temperature affects nutrient uptake and carbohydrate production, (2) what is a main limiting factor on nutrient uptake, and (3) how nutrients and carbohydrates are partitioned between shoot and root. Four-weeks-old tomato plants transferred into an environment-controlled growth chamber were grown in a nutrient solution for 30 days at RZT conditions which are low (15/8℃) and high (40/30℃). Results showed that shoot dry weight under each RZT was significantly lower at 15/8℃-RZT (30%) and 40/30℃-RZT (15%) compared to the normal (30/20℃), respectively. The N and P concentrations were not influenced by RZT, whereas K was obviously reduced. Low-RZT caused a significant reduction in the uptake of N (45%), P (25%) and K (50%). On the contrast, the uptake of N and P at high-RZT did not differ with the normal, while K (40%) was strongly decreased. The accumulation of soluble sugars showed different responses with the RZT conditions, which represented a decrease in 10% at low-RZT and an increase in 15% at high-RZT. In addition, both temperature conditions resulted in the reduction in starch accumulation (10%). In conclusion, this study suggests that unfavorable temperature conditions in terms of nutrient uptake greatly influenced plant growth compared to nutrient concentration, and in turn accumulated starch in roots at low-RZT and soluble sugars in shoots at high-RZT.

Keywords：*Carbohydrates, Mineral uptake, Root zone temperature, Tomato*

P4-463

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Status and Change in Soil Chemical Properties of Upland in Korea from 2001 to 2013

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Soil chemical properties of agricultural soil in Korea have been investigated every four-year interval in order of paddy, polytunnel, upland, and orchard soils since 1999. In order to monitor the status and change in chemical properties, upland soils were investigated over the whole provinces in 2001, 2005, 2009, and 2013. Upland soils were taken from the surface (0-15 cm) and subsurface (15-30 cm) at 1,650, 1,650, 1,750 and 1,760 sites each year investigated, respectively. One hundred sampling sites located in more than 400 m altitude were additionally investigated in 2009 and 2013. Averages of soil chemical properties in 2013 except Jeju province were 6.3 for pH, 0.63 dS m-1 for EC, 24.4 g kg-1 for organic matter (OM), 626 mg kg-1 for available (Avail.) phosphate, 0.75 cmolc kg-1 for exchangeable (Exch.) K, 6.4 cmolc kg-1 for Exch. Ca, and 1.68 cmolc kg-1 for Exch. Mg. Average of Avail. phosphate, Exch. K and Ca were exceeded the upper limit of optimal range. The median of soil chemical property except pH showed a lower value than the averages. The pH and Exch. Ca have slightly increased from 5.9 to 6.3 and from 5.8 to 6.4 cmolc kg-1 between 2001 and 2013, respectively. Soil OM content has maintained about 24 g kg-1 level. The proportion of samples below the optimal range were Exch. Mg (46%) > OM and Exch. K (39%) > Exch. Ca (37%) > pH (36%) > Avail. P2O5 (29%) in 2013. The proportions of samples exceeded the optimal range were Avail. P2O5 and Exch. K (51%) > Exch. Ca > pH (41%) > OM (30%) > Exch. Mg (28%) in 2013. The excess ratios of pH, OM and Exch. Ca have slightly increased, on the other hand the low ratios of those have been decreased. Nutrient contents in upland soils showed wide ranges and high levels especially for Avail. P2O5 and Exch. K, therefore fertilizer recommendation based on soil testing or plant testing is needed for effective soil nutrient management.

Keywords：*Optimal range, Upland soil, Salt accumulation, Soil chemical property*

P4-464

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Nutrient Surpluses with Input Sources in Pig-Concentrated and Cattle-Concentrated County in Korea

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Livestock numbers in Korea have been increased rapidly by development of livestock industries. According to increase of a livestock density in unit area of arable lands, an utilization of livestock manure has been required. The a way of livestock manure utilization is different with kinds of livestock. A pig manure is used as a liquid manure and a compost through resource facilities, and a cattle manure is used as self-consumption of farm in Korea. In this study, nutrient surplus, the amount of output (fertilization amounts in cultivation areas) subtracted from input (livestock manures and chemical fertilizers), was estimated in a pig-concentrated county (PC) and a cattle-concentrated county (CC). PC and CC, each one county, were selected considering the density of pig and cattle in unit area(ha). Statistics data for 2010 was used, and it collected from towns administration statistics and Statistics Korea. Nutrient contents from livestock manures and nutrient requirements of crops were calculated using data from RDA, Korea. The area of arable lands in PC was 17,233 ha, and pig numbers were 397,116. The area of arable lands in CC was 12,297 ha, and cattle numbers were 50,197. In PC, nutrient contents from total livestock manures(sum of a cattle, a dairy, a pig, a chicken) were N 3,935 ton yr-1 and P2O5 3,358 ton yr-1, and the rates of pig manures in total livestock manures occupied N 49.4 % and P2O5 38.3 %. Also, in CC, nutrient contents from total livestock manure were N 1,512 ton yr-1 and P2O5 1,190 ton yr-1, and the rates of cattle manures in total livestock manures occupied N 57.3 % and P2O5 80.0 %. Total amounts of crop requirements were N 1,799 ton yr-1 and P2O5 874 ton yr-1 in PC, and N 1,741 ton yr-1 and P2O5 870 ton yr-1 in CC. When considered input sources (chemical fertilizer consumptions and livestock manures) and amounts of crop requirements in unit area (ha), nutrient surpluses were N 202 kg ha-1 and P2O5 172 kg ha-1 in PC, and N 133 kg ha-1 and P2O5 50 kg ha-1 in CC. Especially, nutrient contents from pig manures in PC were possible to cover the crop requirements. Therefore, the pig-concentrated county was necessary to reduce other livestock numbers and purchases amounts of fertilizers. In CC, an utilization of other livestock manures including cattle would be helpful to lower nutrient balance. And regional managements of livestock manures and the regulation of fertilizer consumptions were necessary for an improvement of nutrient surpluses in arable lands.

Keywords：*Nutrient surplus, Livestock manure, Pig, Cattle*

P4-465

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Change in Chemical Fertilizer Consumptions and Livestock Manure Production Rates from 1990 to 2011 in Korea

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The livestock manure is a good source of major plant nutrients, and it can replace significant amounts of chemical fertilizers such as a nitrogen, a phosphorus, a potassium and essential plant micronutrients. The increase of the livestock manure production each year is a big issue, and authorities have many interests in its resonable utilizations in Korea, recently. In this study, we evaluated about the potential input amounts of a nitrogen, a phosphrous and a potassium by livestock manures and chemical fertilizer consumptions in Korea from 1990 to 2011. Numbers of a Korean cow, a dairy, a pig and a chicken in statistics Korea were used to calculate the livestock manure production. Nutrient contents and nutrient production differences with livestock manures were calculated using data from RDA, Korea. The numbers of Korean cows(a beef cow contained), a pig and a chicken have been increased about 1.8~2.0 times each others in 2011 compared to 1990. Therefore, livestock manures increased about 56.7% from 26,350,000 ton to 41,280,000 ton as time passes. The nitrogen, phosphorous and potassium from livestock manures were calculated to 150,727, 127,010 and 146,891 ton in 2011. The potential inputs of a nitrogen, a phosphorus and a potassium to arable lands through livestock manures were increased to 2.2, 2.1 and 2.1 times for 20 years. On the other hand, chemical fertilizer consumption showed significantly decrease. The consumptions of a nitrogen, a phosphorus and a potassium per hectare of arable lands were decreased to 54.6, 66.0 and 63.2% in 2011 compared with 1990, respectively. As the result, decrese of chemical fertilizer consumption was related with increase of linestock manures directly. Recycling rates of the livestock manure as well as fertilization amounts of chemical fertilizers are very important sources for estimation and control of nutrient inputs in cropland. Thus, we need a reasonable strategy for nutrient managements such as a combination of livestock manures and chemical fertilizers.

Keywords：*Chemical fertilizer, Livestock manure, Nutrition*

P4-466

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Salicylic Acid Treatment on Soil Moisture Shortage Stress of Waxy Corn (zea Mays L.)

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Climate change may result in greater risk of yield reduction of waxy corn due to drought stress and maize is one of the sensitive crops to the soil moisture shortage. In 2012, maize conductivity in the United States was estimated to be 7.6 Mg/ha, which is 24% less than 30 year yield trend line due to water deficit stress. While irrigation is the most effective practice to reduce the drought damage, farmers are unable to apply water due to limited water resource and irrigating facilities. The study was conducted to investigate the application effect of salicylic acid on reducing drought stress of waxy corn (Zea mays L.). Drought stress was imposed by withholding irrigation from 9 days before anthesis to 14 days after anthesis. Salicylic acid was applied on 15 days before anthesis at concentration of 0.5 mM. Drought stress increased anthesis-silking interval (ASI) by 3.0~3.3 days and decreased plant height, ear length, ear diameter, number of rows of ear, and yield by 47~51 cm, 4.6~5.0 cm, 4.4~5.3 mm, 1.5~2.0, and 2.4~2.5 Mg/ha, respectively. Application of salicylic acid significantly reduced the drought injuries of waxy corn. The results may imply that soil moisture shortage stress can be alleviated by salicylic acid application without irrigation.

Keywords：*soil moisture, drought stres, salicylic acids, waxy corn*

P4-467

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Testing of Different Fertilizer Practice on Carrot in up Country Intermediate Zone (UCIZ) Sri Lanka

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Intensive cultivation of potato and vegetables throughout the year is a dominant practice in UP Country Intermediate Zone of Sri Lanka. Tomato, cabbage, carrot and bean are the main vegetables which occupy a major part of the cropping sequence. Many farmers in this area apply large amounts of cattle and poultry manure with high rates of chemical fertilizers. This resulted in the accumulation of phosphorus and potassium in the soils of the region (Wijewardana, 1993). Carrot is one of the leading vegetables growing, and highly fertilized crop in up country and therefore, this study was undertaken to determine the growth and yield parameters of carrot with different fertilizer practices.

Four treatments No Fertilizer (T1), soil test based DOA recommendation (T2), Korean fertilizer recommendation (T3) and farmer's practice (T4), each replicated three times and laid out in Randomized Complete Block Design. Carrot variety "New Curoda" were seeded at 25 x 05 cm spacing to plots in T1, T2 and T3. In T4, sowing was done as farmers practice and plant density maintained as farmer's condition. Applied total amounts of N, P, K chemical fertilizers were 457.5 kg/ha, 848 kg/ha, 1818 kg/ha in T2,T3,T4 respectively. Poultry manure applied as the organic fertilizer at the rate of 10 t/ha in T2,T4 and 15 t/ha in T3. DOA recommended cultural practices were fallowed; supplementary irrigation was practiced as sprinkler irrigation and when necessary. Plant height, tuber length, tuber weight, tuber diameter and plot yield were recorded and estimate the total yield.

Significantly higher tuber yield was recorded in fertilizer applied treatments without statistically different. However 33.6 t/ha tuber harvest recorded in T3, 32.0 t/ha in T2, 30.1 t/ha in T4 and 23.6 t/ha in T1. The results proved that significant yield increment of carrot can be obtained through application of organic and inorganic fertilizers. Fertilizer application rates were not significantly effect on yield. Considering cost of production and environment, finally soil test based DOA recommendation can be recommended as the best fertilizers practice for carrot grown in UCIZ, Sri Lanka.

Table 1. Yield comparison of carrot in different with fertilizer management

Trt.	Yield(kg/10m2)	Marketable Plot Yield(kg/33m2)	Estimated yield (t/ha)
T1	23.66b	44.88b	13.58
T2	32.00a	57.50a	17.40
T3	33.66a	58.00a	17.50
T4	30.10a	55.00a	16.60
CV	8.71	9.14	

Keywords：*Carrot, Fertilizer recommendation, Country intermediate zone, Sri Lanka*

P4-468

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Yield of Green Manure and Nitrogen of Cornflower (Centaurea Cyanus L.) in Different Upland Soils

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Experiments were conducted to find out the landscape effects and green manure production at the same time in farmland. Cornflower was grown in different soil texture with sand, sandy loam, loam, clay loam, and was sowing with autumn and spring respectively. The overwintering rate of cornflower was at 58.7% in average, and the treatment at sand soil showed 62.1% that was highest among other soils, which cornflower is possible

to winter landscape crop. After flowering of cornflower, the contents of total nitrogen(T-N) and total carbon(T-C) in plant were 15.0 and 409.2 g kg-1, respectively, and the carbon-nitrogen ratio (C/N) was 28.6. The yield of cornflower biomass, which will be returned to soil as green manure, recorded 1,210 ~ 3,920 kg ha-1 at the spring seeding higher than the autumn seeding as 1,540 ~ 3,170 kg ha-1, and the biomass treated by soil texture were showed that the treatments at the clay loam had been the largest yields both spring and

autumn seeding among at other treatment of soil. The heights of cornflower regardless of soil treatments were 52.8 to 73.6 cm at the autumn seeding and 35.5 to 79.2cm at the spring seeding although it was more significant variation at the soil textures than the seeding periods. The flowering periods of cornflower ranged from 17th to 20th in May at the autumn seeding and from 19th to 20th in June at the spring seeding, which was faster 30 days approximately at the autumn seeding than the spring seeding. In a view of the cornflower

application as green manure after flowering, the autumn seeding, when considered to combine with following crops, was more suitable and various than the spring seeding, even though the yield at spring seeding was higher than one at autumn seeding.

Keywords：*cover crop, Nitrogen yield, cornflower*

P4-469

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Standards of Proper Fertilizer Application for Double Cropping (rape+rice) in Paddy Fields

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F1 hybrid cultivar, 'Seonmang' was double-cropped with rice for two years in Yeong-gwang Gun, Jeonnam Province. The soil texture of the experimental site was loam and soils were classified as Jisan soil series. The fertilizer application reaction of inclusion and elimination of rape stalks and reduced fertilizer effect for each level of nitrogen fertilizer application were investigated. There were some differences in the absorbed amount of inorganic materials into the plant body during the rice harvest season.

The absorbed amounts of P2O5 and SiO2 were similar to that of T-N, but there was no clear tendency found during the process between those two years in absorbed amount of K2O. When rape stalks were put into rape-succeeding rice, the effect of reducing nitrogen for rice was 30 to 70%. Even when its stubbles were left with rape stalks removed, the effect of reducing nitrogen was up to 30%. In addition, the quantity and quality of rice were both satisfactory. When canola stalks were put into the rice land as organic materials after rape seeds were harvested (for soil reduction), it was found to be eco-friendly, further improving the soil fertility owing to the improvement of soil carbon storage.

Keywords：*Rape, Rice, Fertilizer, Fertilizer application, Nitrogen*

P4-470

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Characterization of Chemical Properties from Anthropogenic Paddy Fields in Korea

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Anthropogenic soils have unique properties than natural soils, since soils have been disturbed or affected by human activities. Characterization of anthropogenic soils on crop growth is very important for optimizing soil function or soil use. However, there have been little studies of anthropogenic soil characteristics. Last four years, large area of paddy fields was disturbed to bury sandy soils from river beds in Korea. This project was performed to purify major rivers and prevent flood/drought in Korea. As a result, great amount of sandy soils were buried in paddy fields and created large scale of anthropogenic paddy fields. Especially, this project created landfill type anthropogenic paddy fields and there has been no research on landfill type anthropogenic paddy fields. This study hypothesized that human impact on agricultural soils would induce changes in soil managements. The objective of this study was to characterize and compare distributions of chemical properties between anthropogenic and natural paddy soils. Soils were sampled from two anthropogenic paddy fields and one natural paddy field. An anthropogenic paddy field had silt loam as top soil texture (A1) and the other one had sandy loam (A2). A natural paddy filed had loam (N1) as top soil. Below 50 cm of the A1 was filled with silt loam from a river bed. The A2 consisted with sandy soils from a river bed below 50 cm. The N1 had silt loam below 40 cm. Soil samples were collected from surface at 10m interval in a grid form. Each sample was analyzed for pH, electronic conductivity (EC), organic matter (OM), available phosphate (Avail. P2O5) and cation exchange capacity (CEC). Each chemical properties were analyzed with variogram and fractal dimension for characterization of spatial distributions. A range is one of variables resulted from the variogram analysis and it represents optimum size or interval of sampling. The spatial distributions were calculated with GS+ (RockWare,USA). The statistical analyses were performed with SPSS.

The averages of chemical properties were compared among sites. Each measurement from the soils compared with f-test with 95% significance. There was no significant difference or trend across sites, however anthropogenic soils showed smaller OM than the natural soil.

The result of fractal dimension showed that fractal dimensions from N1 had smaller values across all chemical properties except CEC than A1 and A2. This indicates that anthropogenic paddy fields had more irregular or random distributions of chemicals than the natural paddy fields. This trend kept in results of variogram analysis. The range values had a similar pattern of the fractal dimension. Except CEC, the chemical properties from A1 and A2 had smaller range values than the natural one. In other words, anthropogenic soils had less stable or manageable chemical distributions than N2.

These results concluded that anthropogenic soils had much heterogeneous spatial distributions of chemical properties and imply that managements of anthropogenic soils should be different to natural soils. In addition, it is important for anthropogenic soils to raise organic matter content up to natural soils. This study would provide valuable information of anthropogenic paddy field managements.

Keywords：*Anthropogenic soil, Fractal, Variogram, Range*

P4-471

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Different Management Techniques in Rye and Hairy Vetch for Maximizing Green Manure Production in Orchard

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Many organic fruit growers adopt cover cropping in their orchards to improve soil properties. A field experiment was conducted to determine the effects of cutting frequency of cover crop and liquid manure application on green manure production and returnable nutrient content in pear orchard. The combined effects of cutting frequency and liquid manure application were tested at two levels, respectively: Liquid manure was applied in L1 plots, whereas L0 plots were not. After that, cover crops were cut one (C1) and three times (C3) in rye, two (C2) and four times (C4) in hairy vetch. The result showed that the main factor related to green manure production and returnable nutrient content in each cover crop was different depending on the species. In rye, liquid manure application was more effective in increasing the dry weight of cover crop and returnable nutrient content than cutting frequency. In contrast, the parameters related to green manure production were more affected by cutting frequency rather than liquid manure application in hairy vetch. Thus, it is suggested that different management techniques are needed depending on the cover crop species in order to maximize the green manure production in orchard.

Keywords：*cover crop, green manure, cutting frequency, liquid manure*

P4-472

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Monitoring on Chemical Properties Change of Arable Soils in Gangwon Province, Korea

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Monitoring on soil chemical properties in arable soils was conducted on 4 cropland types including rice paddy, upland, orchard and plastic film house from 2009 to 2012 in Gangwon province, Korea

Upland soil samples were taken from 170 sites in 2009. Chemical properties were pH 6.3, organic matter 20 g kg-1, available phosphate 699 mg kg-1 and exchangable K, Ca, Mg were 1.19, 4.4, 0.8 Cmolc kg-1, respectivelly. The content of pH, organic matter was within the optimal range. The content of exchangable Ca, Mg was lower than the optimal range. Available phosphate content was over the optimal range.

Orchard soil samples were taken from 80 sites in 2010. Chemical properties were pH 5.9, organic matter 25 g kg-1, available phosphate 791 mg kg-1 and exchangable K, Ca, Mg were 0.97, 4.9, 1.3 Cmolc kg-1, respectivelly. The content of organic matter tend to increase gradually since first investigated 2002. Available phosphate content was much high than the optimal range. the ratio of high-level sites was increased from 80% in 2002 to 90% in 2010.

Paddy soil samples were taken from 150 sites in 2011. Chemical properties were pH 5.8, organic matter 25 g kg-1, available phosphate 104 mg kg-1, available silicate 131mg kg-1 and exchangable K, Ca, Mg were 1.19, 4.4, 0.8 Cmolc kg-1, respectivelly. The content of available phosphate, available silicate, exchangable K, Ca, Mg was lower than the optimal range for plant cultivation. The low-level sites of available phosphate tend to increase since 1999, first invesigated. Especially, the optimal-level site of available silicate was only 5 ~ 9%, and low-level site of it was 63 ~ 80%.

Plastic film house soil samples were taken from 100 sites in 2012. Chemical properties were pH 6.2, organic matter 36 g kg-1, available phosphate 1358 mg kg-1 and exchangable K, Ca, Mg were 0.98, 12.2, 3.9 Cmolc kg-1, respectivelly. The content of organic matter tend to increase gradually. In that increased EC and exchangable K, Ca, Mg, there was severe salination.

Keywords：*chemical properties change , Upland soil , Orchard soil , Paddy soil , Plastic film house soil*

P4-473

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Different Application Intervals of Granular Organic Fertilizer for Improving Rice Productivity and Quality

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Korean farmers are relatively easy to purchase granular organic fertilizer (GOF), thus the GOF is excessively applied without considering fertilizer recommendation levels. Furthermore, the GOF application intervals have not been established. Therefore, this study was conducted to investigate different application intervals of GOF for cultivating rice plant in paddy field. Sindongjin rice variety was cultivated in a paddy field on an environmentally-friendly experimental farm of the Jeollabuk-Do Agricultural Research and Extension Services. The GOF was applied in different intervals: 3, 10, 20, 30 and 40 days before transplanting rice plant seedlings. The GOF contained 4% nitrogen, 2% phosphorus, and 1% potassium as N, P2O5 and K2O, respectively. Main sources of the GOF were 60% castor bean, 20% sesame oilseed cake, 15% rice bran, and 5% bone powder. Amounts of GOF treated were N-P2O5-K2O=9.0-4.5-5.7 kg 10a-1. Selected properties of soil before applying GOF are as follows: EC of 0.50 dS m-1, SOM of 29 g kg-1, available phosphorus (P2O5) of 86 mg kg-1, and available SiO2 of 161 mg kg-1. At the harvesting period, SOM, available P2O5, and available SiO2 contents of the soils were slightly reduced but EC value was declined. Rice plant heights and tiller numbers were relatively higher as the ROF treated at 20 days before transplanting rice seedlings than other treatment intervals. Rice productivity and its chlorophyll content due to the ROF treatment intervals were higher in order of 20 > 10 > 3 > 30 > 40 days before transplanting rice seedlings. The contents of amylose in rice were not different among the different intervals ranging between 18.1 and 18.5%. Protein contents in rice as one of palatability factor ranged from 6.1 to 6.5%, which were relatively better with 20 days interval.

Keywords：*Rice, granular organic fertilizer, application interval, soil properties, productivity*

P4-474

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Impacts of Green Manure Crop Applications on Soil Properties and Ginger Grown in Continuous Cropping System

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Ginger (Zingiber officinale Roscoe) is a rhizome plant that is cultivated around the world. If ginger grows up in continuous cultivation condition, root rot disease is usually occurred. Rotten ginger is a very serious problem in ginger cultivation. Therefore, this study was to investigate the changes in soil properties and ginger growth as influenced by application of green manure corps in a field with continuous ginger cropping system. Four different applications of manure crops were prepared as follows: Plot 1 (control), Plot 2 (barley treatment), Plot 3 (hairy vetch treatment), and Plot 4 (mixed barley and hairy vetch treatment). All the plots were treated with 1,000 kg 10a-1 of organic by-product fertilizer. The experimental field was distributed with different soil textures, sandy clay loam, clay loam, sandy clay, and clay. Selected chemical properties of soils in ginger plots were investigated at three different sampling times, before planting ginger, maturing stage of ginger plant, and after harvesting ginger: soil pHs were 6.9~7.6, 7.0~7.5, and 6.8~7.5; electrical conductivity(EC) values were 0.45~1.19, 0.40~0.62, 0.26~0.38 dS m-1; soil organic matter(SOM) contents were 12.1~36.6, 21.1~41.4, and 23.0~35.5 g kg-1, total N contents were 0.81~1.84, 0.91~1.61, and 1.11~1.76 g kg-1; available P contents as P2O5 were 354~551 mg kg-1, 378~627 mg kg-1, and 304~494 mg kg-1; exch. K+ contents were 0.99~2.15, 1.07~1.74, and 0.89~1.59 cmolc kg-1; exch. Ca2+ contents were 3.93~7.21, 5.54~8.13, and 5.78~8.25 cmolc kg-1; exch. Mg2+ contents were 1.09~2.11, 1.30~2.04, and 1.40~2.07 cmolc kg-1, respectively. Shoot weights of healthy ginger plants were ranged between 360 and 831 g plant-1 and root weights were distributed from 402 to 765 g plant-1 on fresh weight basis. Shoot weights of unhealthy ginger plants damaged by root rot disease were ranged between 91 and 174 g plant-1 and root weights were from 90 to 141 g plant-1. Disease incidence rates were 41.7, 38.9, 21.1, and 15.6% in Plot 1-a, Plot 2-b, Plot 3-a, and Plot 4-a, respectively, placed in high elevation and 93.3, 51.7, 86.7, and 100% on Plot 1-b, Plot 2-a, Plot 3-b, and Plot 4-b, respectively, located in low elevation. The results indicated that ginger root rot disease could be affected by topographical and soil textural properties with poor drainage condition, and also it might be influenced by the applications of manure crops that supplied nutrients and somewhat changed physical properties of soils.

Keywords：*ginger, root rot disease, green manure crop, soil properties*

P4-475

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Influences of Charcoal and Biochar Applications on Soil Chemical Properties and Ginger Growth in Short-Term Cultivation

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Ginger (Zingiber officinale Roscoe) is an herbaceous perennial plant and it is cultivated as a cash crop for farming family. However, rotten root disease of ginger is a serious problem in ginger planting field. The objectives of this study were conducted to investigate the changes in soil chemical properties and ginger growth as affected by applications of charcoal and biochar in short-term cultivation. Three different treatments were provided: Pot 1 (control), Pot 2 (charcoal application), and Pot 3 (biochar application) and this experiment was conducted in a plant growth room. Soil texture in the pots was sandy clay loam, and the chemical properties of soil before planting ginger were as follows: soil pH of 6.9, electric conductivity(EC) of 0.50 dS m-1, soil organic matter (SOM) contents of 12.1 g kg-1, total N contents of 0.79 g kg-1, available P content of 564 mg kg-1 as P2O5, exch. K content of 0.67 cmolc kg-1, exch. Ca2+ content of 4.96 cmolc kg-1, and exch. Mg2+ content of 1.21 comlc kg-1. After harvesting ginger plants, soil pH and exch. Mg2+ content increased to 7.1 and 6.05 cmolc kg-1, respectively, with applying charcoal (Pot 2). Soils in Pot 3 increased in EC (0.75 dS m-1), SOM (15.4 g kg-1), total N content (0.85 g kg-1), and exch. K+ (1.22 cmolc kg-1) and Mg2+ (1.46 cmolc kg-1) contents but decreased in available phosphorus content with applying biochar as compared with those of the untreated control pot (Pot 1). Transport index (TrI) of selected nutrients in ginger plant was varied with applying charcoal and biochar. TrIs of Ca, Mg, Ni, and Zn were increased with applying charcoal (Pot 2) but Mn and Fe TrIs was decreased. With applying biochar (Pot 3), K TrI was increased but Fe was decreased. These results indicated that applications of charcoal and biochar influenced nutrient absorption and transport in ginger plant with the changes of in soil chemical properties.

Keywords：*ginger, charcoal, biochar, nutrient transport index, soil chemical property*

P4-476

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects Of Phosphate-Solubilizing Bacteria Applications on Pepper Growth

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After applying phosphate fertilizers in soils, orthophosphate forms are increasingly made unavailable because of adsorption, fixation and complexation mainly with/by aluminum, iron, and calcium ions depending on soil pH. Therefore, this study was conducted to investigate the improvement of phosphorus availability in paddy soils using applications of phosphate-solubilizing bacteria (PSB), Pseudomonas sp. CL1 (KACC 91282) and Kluyvera sp. CL2 (KACC 91283) to cultivate pepper plants. Cultivars of pepper plants used were Cheon-Ha-Dae-Se (CHDS) and NW-BiGaLim (NW-BGL). Fifty (50) mL of each PSB (107 cells mL-1) per a pepper plant was inoculated twice in every 30 days. Control plot was not inoculated with the PSBs. At sixty days after inoculating PSBs, plant heights of both cultivars were higher than those in the control plot. Stem diameter of the plants was different due to the different cultivars and PSB inoculation. The stem diameter of CHDS cultivar was larger in the plot of KACC 91282 inoculation and in the control plot, whereas that of NW-BGL cultivar was greater in the KACC 91283 inoculation plot than others. CHDS cultivar produced the highest amount of red pepper yield in the control plot, but NW-BGL cultivar made 12.3% increase of red pepper yield in the plot of KACC 91283 inoculation as comparing with other plots. The content of available phosphorus increased from 25.3% (avail. P vs. total P contents as P2O5) measured before transplanting the pepper plants to 31.6~48.1% at 30 days after transplanting the plants. Increase of available phosphorus content due to the inoculation of PSBs was in order of KACC 91283 > KACC 91282 > Control (no-PSB inoculation).

Keywords：*phosphorus availability, phosphate-solubilizing bacteria, red pepper, soil property*

P4-477

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Influences of Side-Dressing N and K Application Intervals on Red Pepper Productivity and Soil Properties in Plastic Film House

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Pepper is one of heavy nutrient feeders that need large amounts of nutrients to produce high quality crops. When farmers cultivate peppers in plastic film house, soils in the specific field may have salt accumulation under heavy applications of various fertilizers, which cause several problems associated with consecutive pepper cultivation. Therefore, this study was to investigate red pepper productivity and soil properties as affected by different intervals of side-dress N and K applications. All plots were applied with compost of 2 Mg 10a-1 and phosphorus of 8.3 kg 10a-1 as P2O5 for basal dressing. Nitrogen and Potassium fertilizers were treated for side-dressing at different intervals, 22 times in every 10 days (Plot 1), 15 times in every 15 days (Plot 2), and 11 times in every 20 days (Plot 3). The total amounts of fertilizers applied as N-K2O were 24.6-13.1 kg 10a-1. In control plot (Plot 4), 60% of total amount of N fertilizer (24.6 kg 10a-1) and 50% of total K amount (13.1 kg 10a-1) were applied for basal-dressing, the rest amounts of both fertilizers were applied for side-dressing in three separate times. When selected soil properties at pepper harvesting time were compared with those before transplanting peppers, electrical conductivity (EC) decreased in all the plots, but decrease rate of EC values was lowest in the Plot 4 (control). The contents of available phosphorus and exchangeable K+ increased whereas exchangeable Ca2+ content decreased in all the plots. However, amount of pepper harvested was the highest in the Plot 2 and amount of red pepper yield was 3,764 FW kg 10a-1 in the Plot. Low quality red pepper in the Plot 2 was 5.35% of total yields, which was the lowest amount among the plots. In addition, red pepper productivity (dry-weight basis) increased by 29.1% in the Plot 2 as compared to that in the control Plot 4.

Keywords：*Red pepper, side-dressing, fertilizer application interval, soil property, pepper productivity*

P4-478

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

The Effect of Different Nutrient Sources on Soil Properties and Corn Yield at Newly Reclaimed Land

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Soil health, that is plant productivity, has been a key issue of agriculture since early agricultural settlements. For these reasons, many agricultural scientists have focused on an understanding of soil properties including soil physical, chemical and biological properties because it provides basis for soil use and management. Unfortunately, not only many researches were carried out on cultivated land but also systemic approaches under long-term management were rarely in Korea. This paper report a major change of chemical properties, an amount of microbial and corn yield on newly reclaimed land with different nutrient sources in the first year as a part of long-term plan. There were five treatments with randomized block design; No-treatment (Con), manure compost (MC), oil cake (OC), and chemical fertilizers (NPK) with manure compost and lime (NPK+MC+L). Dry matters of corn plants were significantly affected the organic matter: NPK+MC+L 〉 MC 〉 OC 〉 NPK 〉 Con. This trend coincided with the order of an amount of phosphate remained in soil at harvest period. Meanwhile, microbial population was not significant difference except the treatment with compost such as NPK+MC+L and MC. The results demonstrate that treatment of organic matter and phosphate had a significant impact on the soil chemical and biological properties as well as plant productivity in newly reclaimed land in Korea.

Keywords：*Newly reclaimed land, Plant productivity , Soil health, Long-term management*

P4-479

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Mixed Treatment with Urea Fertilizer and Zeolite on Growth of Hot Pepper (Capsicum Annuum)

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Nitrogen is essential element for plant growth and living cell. Urea is the cheapest form of granular nitrogen, widely used for crops and occupied more than 50% of the world's nitrogenous fertilizers. However, one of the great disadvantages of urea among nitrogenous fertilizer is its volatile property which causes large losses of urea to the environment. This study was conducted to evaluate the growth of hot pepper(Capsicum annuum) and N efficiency by mixed treatment with urea and zeolite. Urea-zeolite mixture treatment was increased growth and yield of hot pepper compared to urea alone. N utilization efficiency of hot pepper plant was 36.8% at urea-zeolite mixture treatment, while 26.0% at urea application. Urea-zeolite mixture treatment was reduced 30% NH3-N volatilization amounts compared to urea alone. These Results showed that application of mixture of urea and zeolite had positive influence on efficiency of nitrogen useage and increase of red pepper yield.

Keywords：*hot pepper, zeolite, urea, ammonia*

P4-480

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Metabolite Profiling of Potassium Deficiency in Tomato

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The goal of the study was to determine the metabolomic effects of potassium deficiency. Plants were grown hydroponically in Hoagland nutrient medium with and without potassium sources. Leaf and root tissues were harvested at 5 and 15 days post treatment. The role of potassium in plant metabolism is not clear. In general, potassium has been reported to be required for membrane transport and many enzymatic reactions are dependent on cellular potassium levels. Potassium deficiency causes a decrease in the levels of intermediate biochemicals of glycolysis and TCA cycle, downstream of glucose-6-phosphate and fructose-6-phosphate in leaf tissue. In addition most the amino acid levels are also lower than controls at the 5 day and the 15 day stage. These observations in leaf tissue were consistent with the well documented reduction in pyruvate kinase activity with decreased content of potassium, causing a drop and glycolysis, the TCA cycle and amino acid biosynthesis. By contrast, in roots levels of glycolytic intermediates, dihydroxyacetone, glycerate and pyruvate, were slightly higher in K-deficient root than in control roots. However, all TCA cycle intermediates were lower in K deficient than in control roots. Most amino acid levels were higher in K deficient roots compared to controls, particularly at day 15. This may imply that that either the potassium levels in roots is not as low as in the leaf tissue or that alternative controls operate in the root. In both leaf and root tissue, glucose -6-phosphate appears to be channeled to the pentose phosphate pathway as evidenced by the higher level of sedoheptulose-6-phosphate and ribulose relative to controls.

One of the most significant observations in K-deficient roots was the high level of putrescine present in both day 5 and day15 samples, compared to controls. In addition spermidine also increased from day 5 to day 15 in K deficient plants but not in control plants. Arginine, the precursor of putrescine and N acetyl putrescine, γ aminobutyric acid (GABA) and β-alanine levels although higher than control levels decreased from day 5 to day 15. The polyamines, putrescine, spermidine and spermine, are a group of positively charged organic polycations that are involved in many biological processes, including binding to nucleic acids, stabilizing membranes, and stimulating several enzymes. In plants, polyamines have been implicated to play a key role in stress tolerance, senescence and morphogenesis.

Keywords：*Tomato, Metabolite, Potassium deficiency*

P4-481

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Metabolite Profiling of Phosphorus Nutrient Deficiency in Tomato

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The goal of the study was to determine the metabolomic effects of phosphorus nutritional deficiency. Plants were grown hydroponically in Hoagland nutrient medium with and without phosphorus sources. Leaf and root tissues were harvested at 5 and 15 days post treatment.

Phosphorus (P) plays a major role in the structure of cellular components and in the regulation of metabolism and signal transduction.

In leaf tissue, the levels of all phosphorylated biochemicals such as glucose-6-phosphate, fructose-6-phosphate, glycerol-3-phosphate, choline phosphate etc. were either unchanged or slightly lower than controls at day 5 and then fell by Day 15. In roots, all phosphorylated molecules were dramatically reduced at day 5 and remained low at day 15.

All intermediates of glycolysis downstream of glucose-6-phosphate were lower in leaf and root tissue. Citrate levels were higher in all tissues and the other intermediates of the TCA cycle elevated, relative to controls in 15 day root samples indicate that the TCA ycle is probably replenished by catabolism of amino acids.

Further, an increase in nucleic acid turnover was indicated by the higher levels of allantoin and β-alanine, degradation products of purines and pyrimidines respectively, as well as the increase in nucleic acid bases and nucleosides including modified basis derived from the breakdown of DNA and RNA, indicating cellular phosphorus was being reallocated to important cellular processes from nucleic acids.

Keywords：*Tomato, Metabolite, Phosphorus Deficiency*

P4-482

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Fresh Cattle Manure on Yield and Feed Value of Forage Crop in Hwaong Reclaimed Land

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The effect of application of gypsum and fresh cattle manure in Hwaong reclaimed land in Korea was investigated for 3 years from 2011 to 2013 with forage crop. In this study, experiments were conducted to develop the practical method of livestock manure which is applied for fertilization source and physicochemical improvement of soil for cultivation of forage crop in newly reclaimed tidal land soil. Treatments with six applications were established with three replications; chemical fertilizer(CF), gypsum(G) 20 ton ha-1, G+fresh cattle manure(FCM) 100%, G+FCM 200%, G+FCM 300%, FCM 100%. Livestock manure was applied in amount of phosphate recommendation rate. The forage crop used in this experiment was Sorghum×Sudangrass hybrid which is used as summer forage crop in Korea.

The dry matter yield of Sorghum×Sudangrass hybrid was significantly increased in proportion to the application rate of FCM but phosphate use efficiency was hightest in the application level of G+FCM 100%. This result was considered that excessive use of fresh animal manure was reduced nutrient use efficiency by nutrient immobilization. Total digestible nutrients(TDN) and crude protein(CP), relative feed value(RFV) of Sorghum×Sudangrass hybrid which were cultivated by applying of FCM were no significant difference compared with CF treatment.

Figure 1. The dry matter yield of Sorghum×Sudangrass hybrid and phosphate use efficiency on using with gymsum and fresh cattle manure in Hwaong reclaimed land.

Figure 2. Feed value of Sorghum×Sudangrass hybrid by the application of gymsum and fresh cattle manure.

Keywords：*Hwaong reclaimed land, Sorghum×Sudangrass hybrid, Gypsum, Fresh cattle manure*

P4-483

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of application of Oil Cake on Rice Yield In Hairy Vetch-Rice Cropping System

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When the yield of hairy vetch is insufficient for rice cultivation, oil cake is usually used as a alternative fertilizer in eco-friendly rice cultivation area. This experiment was conducted to identify the proper amount of oil cake application as affected by hairy vetch yields in hairy vetch-rice cropping system. The biomass amounts of hairy vetch applied to experimental plots were 500, 1,000, 1,500kg/10a and in each plot oil cake was applied at the level of total N of hairy vetch and oil cake 1.0N(N amount by soil analysis), 1.2N(increased N by 20%) and 1.4N(increased N by 40%) respectively. Also there were experimental plot fertilized with N, P, K by soil analysis and the plot where no fertilizer was added. The results of this experiment showed that there were no significant difference among rice yields as affected by total N fertilization level of hairy vetch and oil cake in all experimental plots. Also there were no significant difference of rice yield between experimental plot fertilized by soil analysis and the experimental plots incorporated with green manure and oil cake. So, we could conclude that when the yield of hairy vetch is insufficient for rice cultivation, the proper application amount of oil cake is the amount that the total N of hairy vetch and oil cake is between 1.0N and 1.2N.

Keywords：*oil cake, hairy vetch, rice*

P4-484

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Developing a Soil Quality Index to Assess Soil Fitness in Onion Cultivated Upland

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In this study, the soil quality index (SQI) was determined from soil chemical and physical parameters in onion cultivated upland. Our objective was to compare, in functional terms, soil quality assessments meaningful information for land management. Soil quality of southern coastal Korea, a typical ,onion growing area, was evaluated using SQI methods. Each SQI was computed using principal component analysis (PCA) and them a minimum data set (MDS) was selected.

PCA indicated that organic matter, available phosphorus, surface soil property, deep soil property, soil drainage class, soil pH, xchangeable potassium, exchangeable magnesium and soil electric conductivity were the main factors limiting onion cultivation. The method used to select a MDS could not only appropriately assess soil quality but also be used as a powerful tool for soil nutrient diagnosis at the regional level.

Keywords：*soil quality index, onion, soil chemical, soil physical*

P4-485

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Deep Planting and Excess Soil Cover on Rootstock Promote Scion Root Outbreak in 'shiranuhi' Mandarin

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Trifoliate orange is used widely as rootstock for 'Shiranuhi' mandarin in Korea for its dwarfing, cold hardiness and stable flowering properties. However, many 'Shiranuhi' mandarin growers are facing problem of scion roots in their orchard these days. Problem severely appears when rootstock of the graft is deeply planted, and soil or plant debris is added to the base of the tree. In our survey, it was found that thirty three percents of 'Shiranuhi' cultivation area that are deeply planted have a scion root problems. Trees having scion roots have low flowering with strong growth property. Weight of fruit and soluble solid contents in them were found significantly decreased. Yields were severely dropped in scion rooted plants with compare to the normal.

Keywords：*soil, rootstock, scion root, shiranuhi mandarin*

P4-486

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Improvement of Soil Water Condition for Soybean (glycine Max L.) by Inter-Row Stripe Tillage

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Changes of soil water content at inter-row strip tillage (IST), which involves conducting tillage between rows and sowing on no-tillage soil, were investigated compared with conventional tillage in upland field and paddy field converted to upland field during soybean cultivation in Suwon city of Korea, 2013. No-tillage soil in IST alleviated the fluctuation of the soil water content and showed larger water content in both upland and paddy field, particularly at the condition of drought which can affect uniform seedling emergence, nodulation, the maintenance of nodule activity and later soybean growth negatively. Growth of soybean plant in IST was higher showing longer stem with more nodes and larger dry weight at the flowering stage than those in conventional tillage. Continuous yearly experiments were needed to know soybean yield increase by inter-row strip tillage (IST).

Keywords：*inter-row stripe tillage, soil water content, soybean*

P4-487

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Cover Crops and Fertilization on Corn Productivity under No-Tillage System

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The use of cover crops in no-tillage corn(Zea mays L.) production has several benefits, such as reducing erosion and leaching, suppressing weed growth, and improving soil fertility. Especially, leguminous cover crop has the potential of replacing N fertilizer because legumes may provide substantial amounts of biologically fixed N to subsequent crops. A field experiment was conducted at the test site of National Institute of Crop Science, Suwon, from fall 2012 through summer 2013 to determine nitrogen contribution of two green manure crops of hairy vetch(Vicia Villosa Roth) and crimson clover(Trifolium incarnuturn L.) under different fertilizer levels in a no-tillage corn production system. The experimental site was established in 2009 and maintained over 5 years. For each cover crop treatment, mineral fertilizer was applied at four different rates: 0-0-0, 0-30-60, 72.5-30-60, 145-30-60 NPK kg ha-1. The conventional plots were amended with 145-30-60 NPK kg ha-1 without cover crops. The control plots received neither cover crop inputs nor NPK fertilizer. Crimson clover and hairy vetch produced 4,250 and 3,650 kg ha-1 of dry matter, which is equivalent to 85 and 133 kg N ha-1, respectively. Corn grain yield with crimson clover cover crop was ranged from 1,300 to 9,920 kg ha-1, while that with hairy vetch ranged from 8,810 to 11,600 kg ha-1. Control and the conventional treatments produced mean grain yields of 830 and 8,000 kg ha-1, respectively. Fertilization resulted in significant yield increases in the crimson clover cover plots, possibly due to insufficient nitrogen supply by the cover crop. On the other hands, the effect of fertilization was not significant in the hairy vetch cover plots, which indicates that the cover crop can provide most of the nitrogen requirement of the corn in no-tillage system. The grain yield was positively correlated with increase in plant N uptake. Soil total nitrogen after harvest was slightly higher in crimson clover cover treatments than in other treatments, but the difference was small. Plant residues on the soil surface in all cover crop plots have substantial amounts of nitrogen even after harvest, ranging from 56 to 116 kg N ha-1. The C/N ratio of surface residue was low(C/N=16.77), which indicates organic residues on soil surface can be easily mineralized and contribute to soil nitrogen accumulation.

Keywords：*corn, no-tillage, hairy vetch, crimson clover*

P4-488

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Coal Combustion Products (ccps)- Amended in Paddy Soil for Improvement Soil Fertility and Rice Productivity

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Coal Combustion Products (CCPs) generated a resultant of combustion of coal at thermal power plant, has been regarded as a problematic solid waste in globally. CCPs is a beneficial ameliorant that may improve the physical, chemical and biological properties of problem soil and is a source of freely available plant and micronutrients. However, application of CCPs in agricultural fields is minimal despite the fact that properties of CCPs are close to soil. Therefore, in this research was to evaluate the feasibility of CCPs in agricultural fields as a soil amendment and rice (Oryza sativa L.) productivity in paddy fields. Collected CCPs was mixed with bentonite and chemical fertilizer (urea for N source; superphosphate for P source; potassium sulfate for K source) at the ratio of 9:0.5:0.5(w/w) and manufactured as granule type at the size of 10 mm. Field experiments were conducted to evaluate the effects of CCPs fertilizer on the soil quality and crop growth compare to the control (no fertilizer) and, - traditional fertilizer, - were applied based on recommend application rate in Korea. During the experiment, soil chemical properties and rice growth were monitored periodically. Results showed that soil pH1:5 and organic matter contents in paddy soils after applying the manufactured CCPs fertilizer were not increased compared to the control and traditional fertilizer. However, the concentration of available phosphate and silicate in paddy soils after CCPs fertilizer treatment were higher than those of the control and traditional fertilization; were CCPs fertilizer (142 and 27 mg kg-1) > traditional fertilizer (141 and 25 mg kg-1) > control (130 and 24 mg kg-1) for available phosphate and silicate. With regard to rice productivity, no significant difference was observed between three different treatments. However, the content of protein in the rice grain cultivated with the CCPs fertilizer was higher than in the rice cultivated by other two treatments. Overall, CCPs fertilizer could increase the concentration of silicate and available phosphorus in soils and improve the rice quality. In conclusion, CCPs can be utilized in agricultural fields as soil amendments especially in paddy fields.

Keywords：*amendment, coal combustion products, fertilizer, paddy soil, rice*

P4-489

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effects of Seeding Time of Green Manure Crops with Liquid Pig Manure on Rice Growth and Yield

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Green manure crops (GMCs) are well known to substitute chemical fertilizers. By incorporating these GMCs into rice field, GMCs could be effective fertilizers for increasing rice yield. In some studies, to increase biomass of GMCs, liquid pig manure (LPM) is treated in GMC fields and GMCs are seeded under different time. This study was conducted to evaluate the effects of seeding time of GMCs with liquid pig manure on rice growth and yield. The GMCs used in this study were Hordeum vulgare L. (green barley) and Astragalus sinicus L. (hairy vetch). These GMCs were cultivated by two treatment conditions, application of LPM (+LPM) and absence of LPM (-LPM). Seeding time of GMCs were autumn (Oct 20, 2012) and spring (Apr 3, 2013). Biomass of GMCs in +LPM treatment were generally higher than those in -LPM treatment. In +LPM and -LPM treatments, biomass of green barley was generally higher than that of hairy vetch. In + LPM treatment, biomass of green barley in autumn seeding (2,416 kg 10a-1) was higher than that in spring seeding (2,571 kg 10a-1). In + LPM treatment, biomass of hairy vetch in autumn seeding (1,988 kg 10a-1) was higher than that in spring seeding (1,881 kg 10a-1). In soil incorporated with GMCs, rice yields in +LPM treatment were generally higher than those in -LPM treatment. In +LPM and -LPM treatments, rice yield in soil incorporated with green barley was generally higher than that of hairy vetch. In + LPM treatment, rice yield in soil incorporated with green barley in autumn seeding (560 kg 10a-1) was higher than that in spring seeding (542 kg 10a-1). In + LPM treatment, rice yield in soil incorporated with hairy vetch in autumn seeding (568 kg 10a-1) was slightly higher than that in spring seeding (528 kg 10a-1). Therefore, seeding of green manure crops in autumn was more effective than that in spring for increasing rice yield.

Keywords：*Biomass, Green manure crops, Liquid pig manure, Rice yield, Seeding time*

P4-490

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Effect of Carrot-Green Manure Crop Rotation for Improving Carrot Quality and Yield

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In order to improve the carrot quality and yield in carrot-green manure crop rotation system, green manure crop (GMC)s such as crotararia and sudangrass were applied, which GMC was sowed in latter-June and returned to soil in latter-October. Nutrient contributions of N, P2O5, K2O, CaO, and MgO in crotalaria were 9.2, 9.8, 7.4, 12.9 and 2.5 kg 10a-1, respectively. Nutrient contributions of N, P2O5, K2O, CaO, and MgO in sudangrass were 8.7, 8.9, 45.7, 5.2 and 2.8 kg 10a-1, respectively. After incorporation of GMCs into soil, growth characteristics of carrots were much better as compared to control. The O.M, T-N, and avail. P2O5 contents in soil with GMCs were higher than those in soil without GMCs. The highest yield(3,530 kg 10a-1) was observed in a mixture of crotararia and sudangrass treatment. In single cropping condition, the chlorophyll content of crotararia was 5.37 ㎍ g-1, which was higher than those in other treatments. In case of sugar contents, there were no significant differences among the treatments except control plot. The β-carotenoid content of carrot in a mixture of crotararia and sudangrass treatment was higher than other treatments. These findings indicate that the optimum cultivation method of green manure crops in carrot-green manure crop rotation system was a mixture of crotararia and sudangrass treatments for improving carrot quality and yield.

Keywords：*Carrot, green manure crop, chlorophyll, β-carotenoid, yield.*

P4-491

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Self-Diffusible Silicate Fertilizer Development for Paddy Field in Korea

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Application of silicate fertilizers is typically practiced with several years' interval to amend soil quality and improve rice productivity at the paddy field in Korea. Most of silicate fertilizers applied in Korea is slag-originated silicate fertilizer. Some water soluble silicate fertilizers have been manufactured and commercially marketed in Korea. However, these fertilizers are manufactured mostly for upland use. The objective of this study was to develop water soluble silicate fertilizer for paddy field. A 'tablet type' soluble silicon fertilizer, which was designed to be adaptable to rice paddy farming, was developed, and field trials in the farms were attempted. Optimal combination with citric acid and potassium carbonate for self-diffusion was designed, and Hewton 102 was chosen as the bider for making 'tablet shape'. Water-soluble silicate content of 12.5% was most appropriate. In practical farming test, optimum application timing was 15-55 days after rice transplanting. As a results of field test, application 20kg/ha of 'tablet type' showed lower lodging index (106) compared to control plot (188), higher yield compared with control (without treatment), non-soluble silicate fertilizer (granule type). In the evaluation of the labor burden for application water soluble silicate fertilizer significantly reduced labor time compared to the silicate fertilizer (granule type). According to the survey in 20 different counties, 96% of farmers replied more convenient to application, 86% those surveyed replied that it was more effective than other silicate fertilizers. The economic analysis of 'tablet type' silicate fertilizer indicated that it was more labor saving and effective.

Keywords：*silicate fertilizer, slag-originated silicate fertilizer, water soluble silicate fertilizer, paddy filed*

P4-492

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Silicon Mediated Different Roles in Alleviation of Cadmium Toxicity in Two Cypress Varieties

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The interaction of silicon (si) and root exudates on cadmium (cd) bioavailability in rhizosphere remain poorly understood. in this respect, pot experiments with two cypress varieties, j. chinensis and p. orientalis, subjecting each to 100 mg kg-1 cd and/or 400 mg kg-1 si for 220 days were investigated. the results showed that adding si increased cd tolerance for both varieties, but the mechanisms involved are species specific. for j. chinensis, si significantly increased soil ph and cd sorption capacity in the rhizosphere, and enhanced cd retention of roots by strengthening the epidermis plus endodermis tissues. for p. orientalis, si failed to restrain cd trans from roots to shoots, significantly enhancing the cd accumulation, but without aggravating growth inhibition. moreover, si mobilized cd from the rhizosphere soil by stimulating the phenolics exudation from roots, suggesting that cd-chelating with the si-induced phenolics is involved in the cd detoxification in this plant.

Keywords：*Cd, Si, Stabilazation; Phenolics*

P4-493

[C3.3-4] Soil Management Strategy for Enhancing Crop Yields

Chlorophyll Content Estimation from Spad, Chlorophyll Fluorescence and Leaf Reflectance Properties

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An experiment was conducted under pot-culture conditions to determine chlorophyll content of barley by SPAD, leaf chlorophyll fluorescence and reflectance properties. Three barley cultivars, Zhexiu 12, Hua 30 and Zhepi 33 were planted in 36 twelve-liter pots filled with sand-loam soil. Each had four nitrogen rates of 0, 50, 100, and 150 kg N ha-1 with three replicates. Fertilization in base and added form was carried out when planting and elonging period (35 DAS, days after planted), respectively. The measuring day was 50 DAS and leaf SPAD reading, reflectance, chlorophyll fluorescence and total chlorophyll content CH(a+b), chlorophyll a content CH(a), chlorophyll b content CH(b), of the uppermost, fully expanded leaves were determined. The result showed that SPAD, spectral reflectance indices R550 (Reflectance at 550 nm), REP (Red edge position), chlorophyll fluorescence parameters Fm (maximum fluorescence), Fv (variable fluorescence) were well linear correlated with CH(a+b), CH(a), CH(b). Chlorophyll fluorescence, reflectance and SPAD methods all can estimate the CH content. And good relation existed between them. In some way, interaction transformation of three methods data could be done by amount calculation. Chlorophyll fluorescence had the greatest sensitivity to chlorophyll status, reflectance was the second, whereas CH(b) can not be predicted from REP. Species difference of CH(a+b) was smaller than CH(a) and CH(b). As a conclusion, chlorophyll content can be estimation from SPAD, chlorophyll fluorescence and leaf reflectance properties.

Keywords：*SPAD; REP; Chlorophyll fluorescence; Rice; REP; Fv/Fm*

P4-494

[C3.4-1] Design and Performance of Cover Systems for Landfills and Contaminated Sites

Reinforcement and Ductility Effect of Plant Fine Roots on the Soil

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In the prevention of soil erosion, vegetation is an economical and environmentally friendly control methods, the most basic indicators of the plant protection design is solid soil function of plant roots. From the perspective of composite the fine rooted soil as a kind of special composite materials, the fine roots as the reinforcement material, using composite mechanics theory the paper analyzes the enhancements and toughening effect of roots on the soil in order to illustrate the mechanism of solid soil and protection slope of plant roots. At different stages of loading the bridging effect of root has different manifestations, during the micro-crack propagation the bridging effect of root as follows: an equivalent closure role imposed on the expansion of micro-cracks, the stress concentration of micro-cracks cutting-edge can be passivated, the stress distribution more uniform, increasing the shear capacity of the soil; during the macro-crack propagation the bridging effect of root as follows: the roots across crack gradually pulled out to prevent cracking or crack propagation, crack propagation must consume a large amount of energy, thereby increasing the strength and toughness of the composite soil. Due to matrix cracking the load transferred to roots, by stress proliferation the load is passed to the soil surrounding roots. while its stress reached peak, soil had strain strengthening characteristics with the strength, toughness and plastic of composite soil having been greatly improved. Finally, it was verified by numerical simulation and laboratory test of the direct shear tests.

Keywords：*root reinforcement; slope stability; root-soil complex; shear strength; toughness; plasticity*

P4-495

[C3.4-1] Design and Performance of Cover Systems for Landfills and Contaminated Sites

Impact of Pesticide Mixture on Ryegrass (lolium Perenne) Cover in a Biopurification System with Andisol of Southern Chile

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The biobed is a simple biopurification system which retains and degrades pesticides, through the composition and properties of a biomixture composed by straw, topsoil and peat (2:1:1 v v-1) and a grass layer covering the surface. The aim of this study was evaluate the effect of atrazine (ATZ), chlorpyrifos (CHL) and iprodione (IPR) mixture on Lolium perenne cover and biological activities of biomixture with (Andisol) topsoil. A greenhouse experiment was conducted to evaluate the behavior of grass layer using glass columns (30 x 5 cm) containing the biomixture. The biomixture was prepared by mixing an allophanic top soil (Andisol) (37.1% sand, 34.2% silt, 28.7% clay, 7.3% organic carbon, pH 5.4), commercial peat (organic carbon 43.7%) and winter wheat straw (organic carbon 34.3%) in the volumetric proportion of 1:1:2, respectively. The constituents were mixed to obtain a homogeneous biomixture (organic carbon 30.8%, pH 6.05, C/N 57) and composed for 15 days at 20 ± 1°C in a polypropylene bag before use. Columns were packed with the biomixture (357 g) and L. perenne seeds were grown for 30 days on the top of biomixture. The hydraulic load condition was calculated in order to stimulate rainwater of 2500 mm per year adding 14 mL of distillated water to each column during 40 days. A water solution containing a mix of formulated atrazine, iprodione and chlorpyrifos was prepared and added to the column surface (2 mg kg-1 each). The non-planted and non-contaminated columns were used as controls. During the experiment samples were taken on day 5, 10, 20 and 40, shoot and root length and organic acid released by L. perenne in planted treatments were measured. After 40 days of incubation, columns were cut in three sections and fluorescein diacetate (FDA) hydrolysis, urease, peroxidase and acid phosphatase activity were measured in the biomixture in the columns at different depths (0-10, 10-20 and 20-30 cm). Results indicate that with addition of pesticides mixture, shoot and root of ryegrass was affected. In fact, length shoot and roots diminished about 20% and 40% compared with control and this was accompanied with a decrease of oxalic, citric and succinic acid during the assay. Moreover, malic acid was lower in control treatments without pesticides. Enzymatic urease and FDA activities were higher at five day and then decreased for all treatments. In addition, lower activity of peroxidase was detected on day 40 without plants and pesticides. Besides, acid phosphatase activity shown higher values in contaminated columns with and without plants on day 10 being affected on days 20 and 40, the controls without pesticides were stable. These results allow concluding that the pesticide mixture could affect grown tissue and organic acids exudation of L. perenne. However, biological activities in the biomixture were similar and better in planted columns with pesticides.

Financed by Chilean FONDECYT project 1120963

Keywords：*Pesticides, Lolium perenne, biobed system*

P4-496

[C3.4-1] Design and Performance of Cover Systems for Landfills and Contaminated Sites

Pesticide Degradation in a Full Scale Biopurification System in the South of Chile

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The widespread contamination of soil by pesticide spills every year is a concern because the can potentially impact in the environment and human health as well as the quality of soil and water. Inadequate practice on farms mainly related to the handling of pesticides appears as an important source of soil and water contamination. Due to the environmental concerns associated with the accumulation of pesticide in food products and water supplies there is need to develop safe and economical methods for pesticide degradation. The biopurification system is a low cost technology that provides a biomixture composed of wheat straw, peat and soil that increase the biodegradation of pesticide by microorganisms. The aim of this study was to evaluate biodegradation of pesticides in a full scale biopurification system including a layer of grass.

The biomixture of biopurification system (0.6 m3) was prepared by mixing allophonic top soil (Andisol), peat, wheat straw in a volumetric proportion of 1:1:2. A layer of grass (1 m2) was germinated (80% Festuca arundinacea and 20% Lolium perenne) and irrigated with 8 L d-1 of water. The control was a biomixture without a layer of grass. The biomixture and control were contaminated with 40 mg Kg-1 of pesticides (iprodione, chlorpyrifos and atrazine) at the beginning of the experiment. The concentration of pesticides was measured by high-performance liquid chromatography (HPLC). After 60 days of incubation at 20 ºC, different parameters were evaluated: pesticide degradation, phenoloxidase activity and organic acids from the rhizosphere of grass.

The result showed that all pesticide were degraded (100%) after 60 days and the half life of pesticide were faster in the biomixture with a layer of grass than the control. During the experiment the phenoloxidase activities were between (2- 3 U kg-1) and the organic acid were correlated with the pesticide degradation. In conclusion, the full scale biopurification system including a layer of grass can be used a novel system for biodegradation of pesticides in the South of Chile.

Acknowledge: Financed by Chilean FONDECYT project 1120963.

Keywords：*Biopurification; pesticides; biobed; full scale*

P4-497

[C4.5-2] Cultural Perspectives on Soils and Soil Science

Observations on the Relationship of Soil And Land Utilization in Settlement of Eastern United States along the Fall Line

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Active soil survey in urban areas of the United States in the last 25 years have given a platform for the National Cooperative Soil Partnership to observe soil relationships to land use, particularly along the fall line of the eastern United States. A fall line (or fall zone) is the geomorphologic break between an upland region of relatively hard crystalline basement rock and a coastal plain of softer sedimentary rock. Rapid and waterfalls are prominent where a fall line is crossed by a river. Typically this is the point where river transport stops and commerce continues overland. It is also where the drop in elevation increases water velocity making the fall line a good location for water powered industry of the 18th century when most of the eastern US commercial cities were established. Because of the need for a river port leading to the ocean, and a ready supply of water power, most of the 18 and 19th century eastern US settlements developed where rivers cross a fall line. Study of these cities for native and anthropogenic soil characteristics creates a fertile ground for principles to apply modern land management and community planning. In addition to fall line amenities of water transport and energy, soils also exhibit particular characteristics in this region that control selective land uses, farming practices, crops and housing settlement. These concepts could be applied to most parts of the US. The historical interrelationships between farmland and population settlement patterns are well developed in this area and analysis shows land quality characteristics and historical technology availability controlling site selection for land utilization. A modern example is that prime farmland is selectively preferred for urban expansion for the same soil characteristic reasons that it was selected originally for development for farmland. In a historical context, as new farmlands (cropland and grasslands) were being created at the population frontier, certain other areas were being bypassed to be farmed only later when technology provided drainage and/or irrigation as an option. Commercial and housing land development has followed the same principles. Other areas characterized by poor climate, steep slopes, and soils unable to support cropland, pastureland, or grassland uses were unsustainably farmed or never farmed at all. Forcing nonfarm and housing development in these areas through policy has been a county and regional planning option but is complicated by issues of watershed sustainability for water quality and sediment controls. Land quality with defining soil characteristics can be sorted and interpreted through soil survey to support policies for sustainable land uses with competing resources.

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Keywords : *fall line; soil characteristics; land use; settlement patterns*

P4-498

[C4.5-2] Cultural Perspectives on Soils and Soil Science

The Restructure and Reorganization of the USDA Natural Resources Conservation Service Soil Science Division

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The U.S. Department of Agriculture, Natural Resources Conservation Service, Soil Science Division, has undergone a restructuring process to streamline operations and meet the goals of the Secretary of Agriculture's 'Blueprint for Stronger Services. Difficult cost-cutting choices were required in the face a challenging fiscal environment. The end result is a plan that creates optimal use of NRCS's Soil Science Division employees, gains efficiencies for American taxpayers, and ensures that vital services are not cut. The restructuring closed 6 Soil Survey Regional Offices and18 Soil Survey Project Offices. Soil survey program responsibilities for the closed offices were consolidated to adjoining offices. The Soil Science Division was then realigned to centralize soil survey technical and administrative leadership under a "direct line of supervision" from the Division Director through the Associate Director for Soil Survey Operations to 12 Regional Directors to 124 local Soil Survey Offices. This is a significant departure from the previous arrangement, which had existed since 1953, whereby Soil Survey Offices in each of the 50 States in the U.S.A. were supervised by an official from within that State. This realignment fully implements regionalized geographic boundaries for office service areas that are based on Major Land Resource Areas (MLRA) rather than geopolitical State boundaries as from before. This organizational structure offers an efficient means of managing the more than 630 soil survey program employees who are housed in national, regional, and local MLRA soil survey offices, as well as at the National Soil Survey Center in Lincoln, Nebraska. The NRCS's Soil Science Division is now more agile and able to respond to changing priorities and budgets, technological advancements, and insuring that data development follows geographical and geomorphic boundaries.

Under this structure there are five entities that provide leadership, guidance and production for the soil survey program. The National Headquarters provides the overall leadership for the National Cooperative Soil Survey (NCSS) program. The National Soil Survey Center is responsible for the development of technical standards, policy and procedures that guide soil survey in six functional areas. The Soil Survey Regional Offices provide leadership in the production and quality assurance of soil survey information and ecological site description work. The MLRA Soil Survey Offices are responsible for planning and leading mapping, related field data collection, needed investigations to complete initial and update soil survey work and ecological site descriptions along with providing quality control of all soil survey and ecological site activities. A State Soil Scientist also remains housed within each of the 50 States. Their responsibilities have been re-focused on strengthening the NCSS partnership with universities and other cooperators within each state, leading the delivery of soil technical services, developing soil interpretations, insuring that soils information is properly used in Farm Bill programs, and working with various special projects developed within the individual States.

The Soil Science Division Program priorities include continuing the work on the Soil Data Join Recorrelation Project, the completion of the remaining initial Soil Surveys, the acceleration of Ecological Site Inventory Program, continuing to build a strong National Cooperative Soil Survey Program, and continue the development of the Web Soil Survey, tools for data capture, new products and support of NRCS initiatives.

The Soil Survey Program is the foundation for NRCS conservation activities. Over the past 4 years NRCS has enrolled more than 115 million acres into conservation programs and has applied over 4 million practices which equates to $9.7 billion in assistance. Protecting U.S. natural resources at this level could not be accomplished without the soil survey information.

Keywords：*National Cooperative Soil Survey, Blueprint for Stronger Services, direct line of supervision*

P4-499

[C4.5-2] Cultural Perspectives on Soils and Soil Science

Soil-Landscape as a Tool in Planning and Management of the City

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Ignoring the soil in the city is not only highly cost-inefficient; it also means missing chances for a more resilient and more meaningful cityscape. Cities are more and more at the frontline of a fight against degradation of humanity and its dealings with the environment, therefore a more integrated management and planning of the city is urgently required. That it should depart from a city's soil-landscape is proposed in this paper.

The soil map is a clue to define a landscape that is in movement and in process. In a functional hierarchy of layers that defines landscape – i.e. climate, geology, geomorphology, hydrology, soil, vegetation, fauna, land-use, and landscape patterns or settlement – the soil layer is the turning point where the abiotic and the anthropogenic start influencing each other: soil is a continuous record of this process. The soil map directly correlates to the geological, biological and ecological processes that constitute our world, as well as the land use that we as humans pose upon it. These two sides address natural-scientific issues, and processes of settlement that reflect in historicity. It is exactly the Gestalt-like approach of the field soil scientist and his soil map that guarantees this two-sided approach. On the one hand soil science and the soil map correlate directly with other geo-related sciences like agriculture, landscape ecology (faunistic, floristic, microbiologic), environmental control, forestry, geography, geochemistry, geostatistics, geology, hydrogeology, or hydrology. On the other hand, as soil mapping fundamentally derives from a field observation, it recognizes uniform characteristic pieces that constitute a coherent perceptual (emotional or visual) structure of the landscape. This coherency is a structural characteristic of landscape and relates directly to identity of place. In environmental psychology coherency in our perceived environment provides recognizable structure that enables orientation, positioning, spatial cognition, even things like attachment to place, and personal or communal identity. If the soil-landscape of a city can be 'read' it supports the 'recognize-ability' of an urban environment, also called readability, which contributes to identity and a sense of place. This is fundamental to feelings of home and communality and therefore to well-being and health – in short the sustainability – of individuals and communities.

Several cases of successful introduction of soil-landscape paradigms in urban planning and management will be shown to make the method clear. As a more general applicable practice map overlay is proposed.

It presupposes that maps provide pertinent information and data on the city for its natural-scientific component as well as its historic component; on this condition the layering of information shows the systematic soil-landscape with its geo-scientific aspects in their relation to historical or cultural aspects. Map overlay of geo-data and history is a simple and effective way to make the systematic of the urban soil-landscape visible and approachable for management and planning purposes. Maps might be as advanced as in geographic information systems, but can also be historic and hand drawn. Map overlay, therefore can be applied to any urban situation, rich or poor.

The Gestalt-like approach of the soil-landscape map is a clue to understand the systematic of the urban landscape. More in particular map overlay as a tool to investigate it, will always increase the awareness of problems that are relevant when planning or managing the urban. At the same time it leaves room for cultural, artistic, political or any other interpretation when implementing planning or design. As such it poses a universally applicable, urgently needed tool for more integrated urban planning and management.

Keywords: *geo-sciences, history, identity, resilience,*

P4-500

[C4.5-2] Cultural Perspectives on Soils and Soil Science

The Final Straw: The Merging of Soil and Society through the Arts

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A few hundred years ago in what is now North America, a style of 'agriculture' which had quietly pervaded for around 4,000 years was about to come to and end. This indigenous style of food production, which was akin to tending semi-wild gardens, quickly fell prey to the Western idea of intensive industries for maximized capitalization and production.

We might have completely lost these concepts, if it weren't for a modern day re-invention of similar practices in the 1930s by Masanobu Fukuoka and Mokichi Okada. These two Japanese farmers came to the realization, independently of each other, that there was something terribly wrong with the way the modern world was growing food, and specifically, in the way they were treating the soil. These farmers, above all, emphasized 'connection' with the plants and the land.

This concept of 'connection' is important, because at the root of today's system of mass consumption is a social condition where farmers have lost connection with the individual plants which they raise, and where consumers have lost connection with the sources of their food. In a system which still behaves along the economically-inspired lines of supply and demand, the re-connection of consumers and farmers alike to the natural world, then, is essential to drive change for rebuilding the health of our farmlands.

But how do we begin to rebuild this connection between consumer, producer, and nature- The answer lies necessarily at the intersection of soil and society.

Since November 2011, ecological research-based artists Patrick Lydon (United States) and Suhee Kang (South Korea) have been working at this intersection, having conducted dozens of interviews in East Asia and the United States with farmers who were inspired by the late Masanobu Fukuoka. These farmers work on the simple premise of respecting nature as a first priority in everything they do, and as a result they don't till their soil, nor do they input any kind of nutrients (chemical or organic) into their fields from outside their immediate area. Yet it's about far more than just their farming methods.

Although a part of the issue is necessarily a logical one requiring methodological answers, perhaps the larger part is that of reversing the human being's gradual separation from nature, something which is more of a metaphysical process than a methodological one. Lydon and Kang have since dedicated themselves to increasing human-nature interaction and awareness through field work, a documentary film, and arts-based interventions.

For Lydon and Kang, this rather simple way of looking at our soil, isn't primarily concerned with how farmers farm, but with how

producers and consumers alike, think. It is concerned with how we think about food production, about nature, and our responsibility as human beings.

At the root of saving our soil, then, might be a process which seemingly has little to do with soil itself.

This way of thinking requires a radical recalibration of the way we create, distribute, purchase, and consume in every category, from food to fashion. Though it sounds like a tall order, this recalibration is already happening in Korea, the United States, India, and most noticeably, in several hundred communities throughout Japan. In these communities, natural farmers are not only re-educating themselves, but also re-educating their consumers about the benefits going 'back' to an emphasis on regional, in-season foods as staples of the modern diet.

The goal of our documentary film, and of the art projects we produce, is to put the issue of human and nature connection into the public realm, installing it as a centerpiece of our lives, and reminding individuals of the necessity for connection between world, human, plant, and soil.
In the end, this re-connection, if approached with care and thought, offers itself as a key to repairing our very deepest issues, both ecologically and socially.

Keywords：*natural farming, art, social, human connection, metaphysics, community, Japan, Korea*

P4-501

[C4.5-2] Cultural Perspectives on Soils and Soil Science

Pathways Towards an Integral-Informed Soil Homeostasis

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In the Anthropocene, processes and response feedbacks to soil-ecosystems have accelerated, jeopardizing the sustainability and resilience of the soil resource at local, regional, and global scales. Over the past decades, exponential population growth with more than 7 billion people on Earth, projected to reach 9 billion in 2050, global climate change, economic imbalances, and drastic land use shifts have imposed profound imprints onto soil-ecosystems impacting global soil-, food-, and biosecurity. Although research on pedogenesis, micromorphology, digital soil mapping, soil-plant-atmosphere interactions, and others have been pivotal to improve our understanding of soils as part of ecosystems it has not translated seamlessly into actions protecting soil natural capital and its soil ecosystem services, improving soil health and quality, and minimizing the decline in soil resources for food production. Dichotomies between soil science and policy actions, social behavior (e.g., management and use of soil resources), and cultural awareness of the importance of soils to sustain life on Earth are evident.

In this essay the assertion is made that a new paradigm is needed that facilitates to better synthesize data, knowledge, understanding, interpretations, beliefs, values, and actions considering multiple perspective-dimensions across multiple domains, including those prevalent in soil science. Integral Methodological Pluralism (IMP) is juxtaposed to facilitate such synthesis and fosters trans- and postdisciplinary thinking and enactment aiming to address soil security and vulnerability of soils in context of a complexifying and changing global world. In this approach soils are viewed from the inside, i.e., manifested as a functional, independent soil system composed of parts that provide services (e.g., food production, act as carbon sink); and viewed holistically from the outside, i.e., manifested as interdependent soil system that continuously interacts with other socio-cultural, political, economic, ecological, and other systems where humans and other autopoietic forces are acting as agents co-creating soil evolution in space and time. These multiple perspective-dimensions disclose a ‘multiple soil object’ that is revealed through different perspectives/philosophical worldviews including axiology [values] (the Why), motivations, needs, and purposes (for What/Whom), ontology (the What) and hermeneutics (interpretation), epistemology (the Who), and methodology (the How).

This paper will awaken the audience to pathways towards an integral-informed soil homeostasis that is robust and resilient enough to respond to the amplitude of major changes that are projected for the globe. It will advocate (i) synthesis pathways from abstract, philosophical/ethical soil constructs towards sustainable soils applications using IMP, (ii) an integral approach that links soil science and other disciplines into an integrated framework of Meta conjectures based on the ‘multiple soil object’, and (iii) to conflate the notion of an integral approach within and beyond the soil science discipline. The promulgation of integral pathways aims to foster a more carbon neutral world, balanced and sensitive use of soil resources to sustain a growing world population, and espouse strategies that reduce the dissonance between action/land use management, policy and knowledge in soil science.

Harmony depends on how we align ourselves with nature to avoid environmental and human catastrophe and what relationship we form with the very thing - soils - that sustains and feeds us. The values we attach to soils vs. other things (e.g., economic security and wealth) and how much we distance ourselves from soils (e.g., soils viewed as capital and resource vs. soils viewed as dirt) determines how we use it and how cognizant we are of sustaining it.

[Note: This abstract would also fit into the Symposium 'Soil Security']

Keywords：*Soil security, integral pathways, soil sustainability, resilience, transdisciplinary, synthesis*

P4-502

[C4.5-2] Cultural Perspectives on Soils and Soil Science

Vulnerability Assessment to Soil Contamination Considering Socio-Economic Response Capability

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To be able to predict and manage the site vulnerability, the receptor sensitivity and socio-economic status must be understood. However, vulnerability assessment only has focused on contaminants and not considered socio-economic response capability. The vulnerability to soil contamination means that the sensitivity of the receptors which were exposed to pollution influences the potential impact, and the response capability to the potential impact determines the degree of vulnerability.

In this study, vulnerability assessment to soil contamination was assessed using environmental impact factors and socio-economic factors. Environmental impact factors can be classified in three properties, including contamination source characteristics, local environments and risk receptors. Source characteristics were evaluated by scoring relative risk of contamination sources. Local environments were evaluated by scoring annual rainfall, soil organic matter, soil texture, and land-cover condition. Risk receptors were evaluated by scoring local population, map of natural ecology.

Socio-economic factors were divided into two sections, sensitivity and response capability. As the socio-economic indicators for vulnerability assessment we identified the major parameters: older population, children population, farm population, agricultural area, livestock number, urban area, forest area, gross regional domestic product, self-reliance ratio of finance, civil service administrative officer, educational attainment, emergency medical service, farming and fishing villages special tax, conservation area for endangered species, water supply source protection area, wetland protected area, environmental budget, water supply ratio, capacity of water storage tank, and management service of soil and groundwater contamination sources. And each parameter was evaluated by scoring.

Scores and weights of each parameter were allocated by analytic hierarchy process (AHP) that was the opinions expressed by many experts. This concept was applied to Goyang-si, Gyeonggi-do, Korea. It will help the authorities in prioritizing their environmental management plan, and can also help in allocating the budget available for efficient contamination management.

Keywords：*Vulnerability, Soil contamination, Socio-economic, Response Capability, Sensitivity*

P4-503

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

System of Rice Intensification (sri) in Japan Needs More Careful Water Management Practices

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System of rice intensification (SRI) has been popular in asian and african countries. Some workers claimed yield increase although others reported yield reduction with SRI practices. Intermittent irrigation in temperate climatic regions usually decreases rice yield by 8-25% comparing with that under a conventional water management practice. We conducted various water management practices for SRI using japonica and indica rice varieties for three years. Soil water content was continuously measured with time domain reflectometry. Brown rice yields varied year and year, but relative yields to that under the conventional water management practice indicated that vary careful water management practices were required in the first three weeks after transplanting. We found that a flooded condition for the first three wk made Kinuhikari, a japonica rice variety, increase yield by 9% comparing with that under the conventional water management practice. This water management practice as well decreased the emissions of greenhouse gases, CH4 and N2O, by approximately 50%.

Keywords：*rice varieties, greenhouse gases, methane, nitrous oxide, soil chemistry*

P4-504

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Decreasing Global Greenhouse Effects by Biochar Amendment in a Double Rice Field of South China

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Static chamber-gas chromatography method was employed to study the derease effect of biochar addition on greenhouse gas (GHG, methane and nitrous oxide) emissions from a double rice field in Huizhou, Guangdong province, south China. Four field practices were designed with 3 replications, i.e., local traditiondal management (CK, 180 kg N ha^{-1}), biochar amendment BC1, BC2, BC3 (180 kg N ha^{-1} plus 5 t ha^{-1},10 t ha^{-1}, and 20 t ha^{-1} biochar incorporation, respectively). The biochar was made of winter wheat straw in 300-500 celsius degree by Sanli new energy Co. Ltd., Henan province, central China. All the fertilizers were applied just one day before the rice transplant, and the water regime is followed by local farmer, i.e., intermittent irrigation + mid season drainage + moisture. Additionaly, the rice cultivar tested is Hemeizhan, a populations with high grain quality and excellent yield performance identified by Guangdong governent in 2008. Greenhouse gas intensity (GHGI) and rice grain yield from each treatment was analysed. Our results showed that compared to CK (GHGI 1.65 kg CO_2-eq kg^{-1} and rice yield 6941.46 kg ha^{-1}), the treatments with biochar incorporation inhibited the GHGI significantly ($p<0.05$). The amendement of biochar reduced the total amount of GHGs emission while also mitigate the peak value of its seasonal variation. BC3 induced the lowest comprehensive GHGI among all the treatments (0.98 kg CO_2-eq kg^{-1}) with the highest rice yield output (7152.58 kg ha^{-1}) and the last methane (22.11mg m^{-2} h^{-1}) and nitrous oxide (60.60 μg m^{-2} h^{-1}) emission. Furthermore, biochar reduced the bulk density of the rice field and enhanced the nitrogen adsorption of rice plant with the middle and large amount addition (BC2 and BC3) than CK treatment significantly ($p<0.05$). Comprehensive analysis indicated that, biochar incorporation mitigated the global greenhouse effects and promoted the rice production, this just showed an idea on how to use the organic matter residue from agricultural crop land in an environment friendly way.

Keywords：*Biochar; Methane and Nitrous oxide emissions; Greenhouse gas intensity; Rice paddy*

P4-505

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Rice Community Base Production and Ghg Reduction in the Mekong Delta, Viet Nam: a Case Study in an Giang, Kien Giang Provinces

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Small intensive rice production or rice household production is one of the main constraints of the strategy of commodity rice production in the Mekong Delta, Vietnam. Community rice production or rice production cooperation in the large area with a thousand farmers, using the uniform agronomy techniques as fertilizer applied, pest management, land preparation and water management, harvesting, were the main tasks of the local authorities, agricultural scientists and the participation of farmers. Two surveys have been conducted in An Giang and Kien Giang provinces from the November 2011 to November 2012 to obtain the current rice production system. The research objectives will be presented the current intensive rice production system related to recommend the solutions how to mitigate GHG emission on the large area of rice field based on community production. The individual rice production was mainly system of two research places. Intensive triple rice crops with many rice cultivars were an important livelihood of local farmers. The average of rice field area was lower 0,5 ha/household. The current fertilizer use was very high in both research places. The highest net nitrogen application was used by farmers in An Giang because of intensive sticky rice production (more than 160 kg N/ha). The number of pesticide spraying was 10 times/crop. The amount of seed was very high density more than 220 kg/ha. The average of water irrigation/crop was fluctuated five - seven time/crop in different crop/year (triple rice crop/year). The highest water irrigation was 10 times/crop. The water level after water pumping into rice field was fluctuated 5-7 cm upper rice field surface. The water management of farmer was mainly based on their experiences. The water supply was surpassed the need of rice in different vegetation periods. There was so misspend the water irrigation as the farmer's traditional practices. The series of activities has been designed at two study places after the identification of current agronomy techniques of farmers such as the uniform of agronomy techniques (fertilizer use, water management, seed sowing, pest management), the separation of farmer's group according to the same water supply, field conditions, field topography or the leveling of soil surface has been done at two research places during November 2012 to April 2014 to conducted (1) the on-farm trial experiments with 9 core-farmers who used the uniform of the same seed amount and varieties, fertilizer formula and water management in different rice crop, (2) the establishment of farmer's groups who applied the results of on-farm field trial by the supports of agricultural local authorities, local governments, scientists, (3) monitoring the GHG emissions (CH4 and N2O concentration) on 9 core-farmers fields based on the advance water management method and nitrogen application. The primary results after the establishment of farmer's groups showed the decreasing of all input matter (fertilizer, seed, and pesticide spraying). The most important was water management methodology between the farmer's groups. The numbers of water pump out and to dry out the rice field surface has been accepted by farmers (both core-farmers and adopters or each member of farmer's groups). The concentrations of GHG emission have positive regression with the amount of nitrogen decreasing and water management methods in different crops/year. In the field condition, when soil factor was homogeneous, water management and nitrogen fertilizer application were two factors affected to GHG emission increasing in the rice field. The area of rice field and farmer's participation who applied the new advance techniques were increasing continuously from the first crop (November 2012) of the on-farm field trial to the fourth crop (November 2013) at 2 research places. Individual rice cultivation is one of constraints for reducing GHG emission. Community rice cultivation, as the good practice, will be appropriated rice farming to reduce GHG emission in the large scale areas, good quality product because of the same agro-techniques farming.

Keywords：*triple rice crop, intensive rice cultivation, water management, community base rice production*

P4-506

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Rice Straw and Nitrate Content Control Nitrous Oxide Emission in a Flooded Paddy Soil

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Carbon dioxide, methane, and nitrous oxide have been considered the main greenhouse gases (GHC) and the negative environmental impact of GHG motivated scientists to search for mitigation strategies. In rice fields, due to the anaerobic conditions are created after flooding, nitrate and organic carbon compounds are reduced to nitrous oxide and methane, respectively, by anaerobic microorganisms. Nitrate is the first compound used as electron acceptors when molecular oxygen is not available and nitrous oxide is 296 times more powerful greenhouse gas than carbon oxide. After nitrate consumption, other compounds can be used as electron accepter, such as manganese and iron oxides, sulfate or organic carbon compounds. Soil solution nitrate content is affected by nitrogen fertilization and soil organic carbon decomposition. Thus, nitrous oxide emission from soil into the atmosphere depending on soil solution nitrate content and the efflux peaks are concentrated in a short time after flooding. The objective of this study was to evaluate the influence of rice straw and nitrate content on nitrous oxide emission in a flooded paddy soil. The experiment was conducted in a translucent plastic-covered greenhouse at the Department of Soil Science at the Federal University of Santa Maria (UFSM), Brazil. Environmental conditions of the greenhouse included a steady temperature of 25°C ± 5°C by using a fan-driven cooling system. Light and humidity were not controlled in this macrocosm. The experiment consisted of plastic (PVC) pots with a 0.25 m diameter, 0.25 m height, and containing 7 kg of a paddy soil (Planosol). The treatments were addition of 0, 50 and 100 mg de $N\text{-}NO_3^-$ kg^{-1} of soil (as sodium nitrate) combined with addition of 0, 5 and 10 Mg ha^{-1} of rice straw equivalent, in a completely randomized design and three replications. To evaluate nitrous oxide emission rate, initial air samples were taken between one and twelve days after flooding. For each sample, a static closed chamber was placed on top of the pot. Air samples were extracted from each chamber at time equal to 5, 10, and 15 minutes after covering the pot with the chamber. Air samples were directly injected into a gas chromatograph (Shimadzu GC-2014) for the analysis of nitrous oxide and its efflux was calculated. The soil solution was sampled along with nitrous oxide efflux. To enable soil solution sampling, a PVC pipe (20 cm long and 2.5 cm diameter) covered with 80 μm pore polyamide screen was buried 5 cm deep inside the chamber base before flooding. A second plastic pipe (50 cm long and 0.3 cm diameter) was linked to it allowing a plastic syringe (60 mL) to be connected during soil solution sampling. Soil solution nitrate and soluble organic carbon were determined.The nitrous oxide emission peaks occurred in the first 12 days after flooding for all treatments.Without rice straw, total nitrous oxide emissions during first 12 days after flooding were 0.51; 61.82; and 173.64 mg of N_20 pot^{-1} for 0, 50, and 100 mg de $N\text{-}NO_3^-$ kg^{-1} of soil added, respectively. Using the same nitrate addition, but combined with 10 Mg ha^{-1} of rice straw equivalent, the nitrous oxide emission were 0.128; 18.13; and 109.97 mg of N_20 pot^{-1}, representing 25; 29; and 63% less nitrous oxide emission respectively than without rice straw addition. Soil solution nitrate content was affected by rice straw addition, probably because of nitrogen immobilization. Nitrous oxide emission was strongly related with soil solution nitrate availability after flooding and the crop straw helps to reduce nitrous oxide emissions in paddy soils cultivated with flooded rice.

Keywords : *flooded rice, greenhouse gas, redox potential*

P4-507

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Comparison on the Methane Emission from Different Cropping Seasons of Paddy Rice in Central Taiwan

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The methane emitted from paddy is one source of greenhouse gases. The methane flux from paddy was measured continuously by Eddy Covariance Method in central Taiwan and the comparison of methane emission has been analyzed between the first and second crop of paddy rice in 2012 in this study. The results reveal the methane emitted mostly from transplanting to the end of vegetative stage. The methane emission start to decrease gradually from the beginning of drainage after flooding management during the ending of vegetative stage and maintain low emission during the stage of intermittent irrigation until harvest. The high emission did not occur even flooded again by irrigation. This phenomenon might be caused due to most of dissolved organic carbon (DOC) has decomposed after vegetative stage. The methane emission from fertilized paddy were estimated about 1.57 μg m-2s-1 (range -1 ~ 16.3 μg m-2s-1) and 1.07 μg m-2s-1, (range -2~17 μg m-2s-1) in the first and second crop respectively. The percentage of missing data was up to 19 % due to the limitation of open path instrument affected by the weather condition. These results were higher than those measured by chamber method before. However, the former one is similar to the default value 1.5 μg m-2s- of IPCC (Intergovernmental Panel on Climate Change) guideline, but the latter one is lower than 1.63 μg m-2s-1. The total emissions of first and second crop were around 143 and 90 kg-CH4/ha respectively. The lower emission of the second crop was due to the shorten duration of vegetative stage under high temperature in summer. The first, second crop and annual emission simulated by DNDC are about 116, 96 and 292 kg-CH4/ha respectively. The simulated results by DNDC model are similar to measured data. It is reveals that the emission mechanism of DNDC model can fit the emission pattern in central Taiwan, although the simulated data are not yet as same as the measured ones.

Keywords：*Methane, Rice, Eddy covariance method, Cropping season*

P4-508

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Fluxes of Methane and Nitrous Oxide in Water-Saving Rice Production from Eastern India

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Water is the most important input for rice growing and in the era of acute water scarcity under changing climate, water-saving rice cultivation receives considerable attention for saving irrigation water without sacrificing grain yield. Low level of soil moisture in aerobic rice fields (as opposed to submerged paddy) may significantly reduce methane (CH4) emissions. However, this benefit may be offset by increased nitrous oxide (N2O) emissions, which has much higher ability to absorb radiation. In the present study, emissions of CH4 and N2O, their global warming potential (GWP), carbon efficiency ratio (CER), water productivity and yield attributes under aerobic vis-à-vis flooded conditions were compared in a field experiment conducted in the dry season with two rice cultivars [cv. Naveen (inbred) and PHB 71 (hybrid)]. Cumulative CH4 emissions from aerobic rice fields (21.94 kg ha-1 for cv. Naveen and 21.61 kg ha-1 for cv. PHB 71) was approximately half of that from continuously flooded rice fields (68.39 kg ha-1 for cv. Naveen and 57.53 kg ha-1 for cv. PHB 71) while cumulative N2O emissions were marginally higher in the aerobic fields (0.43 kg ha-1 for cv. Naveen and 0.38 kg ha-1g for cv. PHB 71). Average CH4 emissions from flooded rice fields planted with cv. Naveen and PHB 71 were 52.05 and 44.38 mg m-2 h-1 respectively, as compared to 17.31 and 16.83 mg m-2 h-1from the sane varieties grown under aerobic conditions. Average N2O emissions from flooded fields planted with cv. Naveen and PHB 71 were 251.59 and 261.68 μg m-2 h-1 respectively and in case of aerobic fields the values were 332.39 and 316.50 μg m-2 h-1, from the same rice varieties. However, the GWP of aerobic rice fields during the entire crop growth period was significantly lower (676 kg h-1 for cv. Naveen and 653 kg h-1 for cv. PHB 71) as compared to the continuously flooded rice fields (1778 kg h-1 for cv. Naveen and 1501 kg h-1 for cv. PHB 71). The GWP decreased by about 62.00 and 56.50% for cv. Naveen and cv. PHB 71 respectively, cultivated under aerobic condition as compared to flooded condition. The greenhouse gas intensity (GHGI) (kg CO2 equivalent kg-1 grain yield) from flooded rice fields planted with cv. Naveen and PHB 71 were 0.48 and 0.27 respectively, as compared to 0.13 and 0.10 from the same varieties grown under aerobic condition resulting in a decrease of about 72.9 and 63.0% for cv. Naveen and cv. PHB 71, respectively. The CER (kg C grain yield kg-1 C-equivalent) from flooded fields planted with rice cv. Naveen and PHB 71 were 3.97 and 6.80 respectively and 14.31 and 17.90 from the same varieties grown under aerobic conditions. The CER thus increased by about 260 and 123% for cv. Naveen and cv. PHB 71 respectively, under aerobic condition as compared to flooded condition. The water productivity for cv. Naveen grown under flooded and aerobic conditions was 0.84 and 0.85 kh m-3 respectively whereas it was 1.03 and 1.24 kg m-3 for cv. PHB 71 grown under flooded and aerobic conditions. Hence, an increase in water productivity by 1.2% for cv. Naveen and 20.4% for cv. PHB 71 grown under aerobic condition as compared to flooded condition was recorded. Although aerobic rice cultivation resulted in a total savings of 55.8% water, mean grain yield was marginally reduced (9.34%) as compared to submerged rice cultivation. Results thus revealed that growing rice under aerobic as opposed to flooded condition yielded lower GWP, lower GHGI, higher CER and noticeable increase in water productivity signified as effective alternative option for reducing CH4 and N2O emission while saving substantial amount of water in rice production. However, global implementation of this practice requires a critical assessment of global warming potential, C-sequestration and C-footprint analysis via-avis water savings accrued under diverse geographic locale.

Keywords：*Water saving rice production, Methane and nitrous oxide flux, Global warming potential*

P4-509
[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

A Combined Net Economic and Environmental Benefit with Greenhouse Gas Intensity Evaluation of Three Rice-Cropping Systems in the Taihu Lake Region of China

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Ensuring food security and preventing dangerous climate change are two of the greatest challenges for humanity by the mid-21st century. Proposing sustainable management practices in agriculture is critical for tackling these challenges. However, the impacts of many greenhouse gas mitigation managements on food security and environmental and economic costs failed to be comprehensively assessed. A field experiment has been established in the Taihu Lake region of China since 2012 to overall appraise net economic and environmental benefit (NEEB) and greenhouse gas intensity (GHGI) of certain agricultural managements. Three typical rice-cropping systems were chosen including rice-wheat (RW) rotation, rice-broad bean (RB) rotation, rice-fallow (RF) rotation. Crop straw in RW rotation system was in situ ploughed into the soil, while broad bean straw in RW rotation system was composted and then incorporated. Four N application rates (0, 120, 180 and 240 kg N ha−1) were designed under RB and RF rotation systems, while five levels (0, 120,180, 240 and 300 kg N ha−1) were under RW rotation system, for a total of thirteen treatments. The crop straw and N fertilizer application induced emissions of CH4 and N2O plus CO2 emissions through processes of N fertilizer production and consumption using life cycle analysis were expressed as global warming potential (GWP) in CO2-equivalent (CO2-eq). The NEEB was qualified by combining the economic income of crop grain yield with the environmental and economic cost of GWP calculated by specific international carbon price. Rice grain yields in all rotation systems showed nearly consistent response to N fertilizer application. N fertilizer application significantly increased grain yields, but once the application rate reached 180 kg N ha−1, extra increasing dose of N failed to further statistically improve grain yields. Fertilizer treatments in all rotation systems got comparable NEEB, being 21971 to 26328 yuan ha-1 in RW rotation system, 23286 to 25767 yuan ha-1 in RB rotation system and 23730 to 24820 yuan ha-1 in RF rotation system, respectively. Compared with directly incorporation, straw application after composting significantly decreased the GWP and GHGI. At a same level of N fertilizer application, GHGI and GWP in all rotation systems followed the series: RW > RF > RB. The results of this study suggest that for the sake of ensuring food security, RW rotation system is an optimal cropping pattern, but in the cause of greenhouse gas mitigation and maintaining soil fertility, the pattern of cultivating single-season food crop is more sustainable, and RB rotation system can further reduce greenhouse gas emissions. However, the comparable NEEB in all cropping systems resulted from the current lower international carbon price is not much of an incentive for famers to change the traditional cropping pattern of rice-wheat rotation to an economical and environmental friendly one of rice-board bean rotation. Therefore, further greenhouse gas mitigation in the Taihu Lake region requires direct policy support from Chinese governmental agencies.

Keywords：*rice-cropping system, net economic and environmental benefit , greenhouse gas intensity, international carbon price, greenhouse gas mitigation*

P4-510

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Mitigating Greenhouse Gas Emission from Vietnam Rice Paddy Soils

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In last 50 years (1960-2010), rice production in Vietnam was increased in both crop yield (2.5 times), cultivated area (1.5 times). Today more than 36 million ton of rice per year in total of 46 million ton of grain food was produced in Vietnam. This provided enough food more than 90 million Vietnamese and contributed to world food security. Vietnam is now the second world rice exporter with a total about 4-5 million tons of rice annually. But with respect to environment, rice fields are among the major sources of atmospheric CH4, the second important greenhouse gas (GHGs) contributing to global warming. GHGs emission from Vietnamese agriculture sectors was estimated for 2000 data as great as 43.1% of the total emission from Vietnam (about 65.1 million tones of CO2e). In which, rice cultivation contributes 57.5% , livestock contribute about 5.3%, enteric fermentation accounts for 11.9% of total GHGs emission from agriculture. Total GHG emissions were also projected for 2010, 2020 and 2030. Emissions from Agriculture sectors will be relatively great as 169.2 M; 300.4 M and 515.8 M tones of CO2 e. (MONRE, 2010).

In agriculture, there are several techniques/practices options can be developed and implemented to respond for both adaptation and mitigation of climate change.

Monitoring on soil and fertilizers uses for different soils types with different cropping were conducted by Viet Nam Soil Monitoring Station since 1998 for better fertilizer use efficiency as well as for better soil organic carbon management. Estimation of the CH4 emission from rice field were conducted under different condition of water regimes and fertilizers treatments for different soil types to understand the behavior of methane emission as well as to find out an understanding water uses in paddy fields. DNDC model was also adapted to estimate GHG emission from different cases in agriculture sectors. A global review of possible mitigation options in Vietnamese agriculture together with three cases study such as the bottle-neck study on system rice intensification (SRI); Bio-digester/biogas technologies (Bio-gas) and the development study on mix-cropping and minimum tillage were conducted. Results showed that high peak of CH4 emission rate appeared at 30 – 60 days after transplanting. It may reach more than 70 mg C/m2/hr for Spring rice in Fluvisol since 6 weeks after transplanting and 87 mg C/kg/hr in Acrisol since 8 weeks after transplanting and than decrease. For Summer rice, figure are different, the maximum absolute rate may reach since 4 weeks after transplanting in Fluvisol, but the maximum absolute value was only 27 mg C/m2/hr and the maximum value found in Acrisols was 37 C/m2/hr in 6 week after transplanting. CH4 emission rate from rice soil applied Fe-containing fertilizer trended lower than that from rice soil without Fe-containing fertilizer. Cumulative CH4 emission rate both two rice seasons from fluvisols and acrisol was decreased by more than 20 % ($p < 0.05$) in comparison with no application of Fe-containing fertilizer.

In rice based cropping systems, it seems that non-continuous flooding reduces significantly CH4 emission in rice production and he exact values are depend not only on the soil parameter such as soil types; soil carbon and clay content, soil pH, soil Eh, but also rice variety and cropping season.

As part of solution to adaptation and mitigation response to climate change, there are a list of promising options we may consider in crops productions such as integrated crop management (ICM); System Rice Intensification (SRI); minimum tillage; upland soil erosion control; re-use crop residues; mix cropping in crop production and livestock sectors such as biogas and animal food and breeding. These promising options not only sustain agricultural productivity but also contribute to mitigate climate change; the extension capacity depends on each local condition.

Keywords：*Vietnam, Rice, Mitigation, GHG, Paddy Soils*

P4-511

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Soil Controlling Factors of Ch4 Gas Production from Flooded Paddy Soils of Central Java

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Methane (CH4) production and oxidation in the flooded rice soils are regulated by various microorganisms, which controlled by biological, chemical and physical factors of the soil environment. Atmospheric methane is recognized as one of the most important greenhouse gases. Methane, with some 15-30 times greater infrared-absorbing capability than CO2 on a mass basis, may account for 20% of anticipated global warming. Soils are one of the key factors, which play an important role in CH4 production and emission. However data on CH4 emission from different soil types and soil characteristics affecting CH4 production are lacking. Therefore this study was conducted to investigate the potential of CH4 production of selected soils in Java, and determine the limiting factors of CH4 production. In this study, addition of 1% glucose to the soils led to an increase in CH4 production by more than twelve folds compared to no glucose addition. The CH4 production potential ranged between 3.21-112.3 mg CH4/kg soil. The lowest CH4 production potential occurred in brown grayish Grumosol while the highest was in dark gray Grumosol. Chemical and physical properties of the soils have great influence on CH4 production. Regression and correlation analysis of CH4 production and soil characteristic showed that pH and the contents of Fe2O3, MnO2, SO4, and silt in the soil strongly influenced CH4 production. Results of this study can further be used for the development of a model on CH4 emission from rice fields.

Keywords：*methane, emission, production potential*

P4-512

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Methanogenesis Affected by the Co-Occurrence of Iron(iii) Oxides and Humic Substances

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Due to their redox reactivity and ubiquitous presence, iron oxides and humic substances (humics) have substantial influences on biochemical processes, such as methanogenesis. This study aimed to investigate methanogenesis affected by the common occurrence of these compounds, which has not been previously considered. The experiment was conducted with anoxic paddy soil microcosms receiving a humics surrogate compound (anthraquinone-2,6-disulfonate, AQDS) and three iron(III) oxides (ferrihydrite, hematite, and magnetite) differing in crystallinity and conductivity. Ferrihydrite suppressed methanogenesis, whereas AQDS, hematite and magnetite facilitated methanogenesis. In the case of the co-occurrence, CH4 production in the ferrihydrite+AQDS, hematite+AQDS, and magnetite+AQDS cultures was 4.1, 1.3, and 0.9 times that in the corresponding cultures without AQDS. Syntrophic cooperation between Geobacter and Methanosarcina occurred in the facilitated-methanogenesis cultures. Experimental results suggested that the conductive characteristics of iron(III) oxides was an important factor determining the methanogenic response to the co-occurrence of iron(III) oxides and humics in the anaerobic paddy soil. This work indicated that the type of iron(III) oxides may significantly affect the carbon cycling under anoxic conditions in natural wetlands.

Keywords：*Methanogenesis; Humic substances, Iron(III) oxides; Syntrophy; Geobacter species*

P4-513

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Greenhouses Gas Production from Different Soil Types and Water Managements under Defined Laboratory Condition

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Recently, special attention has been given to the increasing of greenhouse gases concentration in atmospheric regarding the contribution to global warming. Rice paddy fields have been recognized as one of the sources of greenhouse gases such as methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O). Management practices used in agriculture will influence not only crop production but also environment. Many technologies could reduce GHG emission and enhance grain yield from paddy field. One of the most effective mitigation technologies to reduce GHG emission from rice field is water management. Nowadays, rice paddy field meets challenge in using water efficiently and effectively while improving food production. On the other hand, soil properties is one factor that responsible on emitting greenhouse gas especially CH_4 in rice field due to water movement through larger pore space. The objective of this study is to investigate the effects of AWD on GHG production potential in different soil types under defined laboratory conditions. Soil incubation experiment with a factorial arrangement (5 x 2 x 3) of two water management treatments and five soil types were used. The fifth soil types are Inceptisol, Latosol, Histosol, Acrisol and Fluvisol which was collected from Indonesia and Philipines. The water management treatments are as follows: continuous flooded and alternate water drainage (AWD), keeping continuous flood and another day keeping water soil wet with no water layer above the soil surface. The soil saturation was conducted twice. There were three replication of each treatment. Samples of CH_4, CO_2 and N_2O were analyzed using GC which is equipped with Flame Ionization Detector (FID), Thermal Capture Detector (TCD) and Electron Capture Detector (ECD), respectively. The result of this study shown that CH_4 production is around 0.004-2.29 μg/g soil with the soil orders as Latosol>Inceptisol>Acrisol>Fluvisol>Histosol. AWD can decrease CH_4 production around 4%-54%. AWD was significantly lower than those from continuous flooded. While CO_2 production with soil orders as Latosol>Fluvisol> Histosol>Inceptisol> Acrisol is around 87-947 μg/g soil. N_2O production from different soil with soil orders Fluvisol>Inceptisol>Histosol>Latosol>Acrisol is around 0.03-3.14 μg/g soil. Given a trade-off between CH_4 and CO_2-N_4O production, Most of the soil was increase of CO_2 and N_2O production with AWD except at Inceptisol. GHG production potential varied significantly in different soil types with a positive relationship with NH_4-N and a negative relationship with NO_3-N.

Keywords：*soil types, methane, carbon dioxide, nitrous oxide production, water management*

P4-514

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Effect of Bacterial Material on Straw Decomposition and Greenhouse Gas Emission from Paddy Soil

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The greenhouse gases, such as methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) are released from the paddy field. These greenhouse gases are mainly derived from soil microbial activity and there is a relationship between the dynamics of fertilizer components and soil organic matter. In particular, during the flooding period, a large amount of CH_4 is generated by immature organic matter application such as rice straw. This CH_4 generation not only promotes global warming but also induces growth failure of rice. Harmful effects such as more CH_4 emission caused by immature organic matter application to the paddy field are more common in cold climatic area because these cannot be plowed into soil before winter. Promoting maturity of organic matter can be effective to suppress CH_4 emission where bacterial materials are applied. The dynamics of greenhouse gases on paddy field affected with the application of such materials is not yet clear. Therefore, in this study, we investigated the effect of a bacterial material including spores of Clostridium acetobutylicum and Bacillus subtilis on the rice growth and greenhouse gas emissions (both CH_4 and CO_2) in paddy field and pot experiment before and after flooding and rice cultivation.

Three paddy soils were collected around Sanmu, Chiba Prefecture, Japan. The field experiment was conducted at Matsuo paddy field from April to August, 2013. In parallel, pot experiment was conducted from May to September, 2013 using soil samples collected from three paddy fields. Pot experiment was conducted using 0.02 m2 or 0.001 m2 wagner pot. Rice (Oryza sativa var. Japonica) was cultivated with the three treatments: 1) no amendment (control), 2) straw applied (3cm cut straws) at 0.5kg/m2, 3) straw applied as treatment no. 2 with bacterial material at 0.02kg/m2. Gases emissions were measured using a closed-chamber technique both in the aerobic period and anaerobic period. We collected gas samples at every 2-3 days before flooding, and every 2 weeks after flooding. Additionally, we analyzed soil chemical and biological properties. Furthermore, we investigated rice growth (plant height, number of tillers and SPAD value) and soil Eh before each gas sampling.

We found that CO_2 emission was increased significantly by the application of the bacterial material in both field and pot experiments under the aerobic period. On the other hands, the CH_4 emission in the fields was decreased significantly by the application of the bacterial material, much less than CO_2 increase on global warming potential basis. It was probably due to enhanced decomposition of straw with bacterial material application under aerobic condition. No significant difference was observed in the rice growth among the treatments. However, yield was increased significantly by the application of the bacterial material. In addition, the CH_4 emission per yield and carbon conversion of total greenhouse gas emission on the treatment applied bacterial material were less than only straw applied.

Our results indicated that the application of bacterial material could be a good option to reduce CH_4 emission and to increase yield in the paddy fields.

Keywords：*greenhouse gas, methane flux, paddy soil, bacterial material*

P4-515

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

The Effects of Dolomite Addition on N_2O Emission from Acidic Soil

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Nitrous oxide (N2O) is one of the most important greenhouse gases and its reported dominant source is agricultural soils. The emission of N2O from soil mainly depends on soil pH, organic carbon, nitrogen fertilization, moisture and temperature. In recent years, the acidification of Chinese agricultural soils is becoming even severe due to heavy N fertilization. In order to counteract the deterioration, farmers have adopted the practices of lime and dolomite application. However, the effect of dolomite application on soil nitrogen turnover and N2O emission is very considerable. Therefore, we conducted an incubation study to examine the effects of dolomite addition on N2O emission from acidic soil under different moisture levels. The treatments were arranged as follows: 3 dolomite levels (CK: no dolomite, L: 1g kg-1 soil, H: 2g kg-1 soil), 2 moisture levels (55% and 90% water filled pore space), 2 N fertilizer levels (no N fertilizer [(NH4)2SO4], and 200 mg N fertilizer kg-1 soil). N2O were collected and analyzed by a gas chromatograph during entire study over 52 days. Soil dissolved organic carbon (DOC), microbial biomass carbon (MBC), NH4+-N, NO3--N and soil pH were also analyzed. The results showed that dolomite addition significantly ($p \leq 0.05$) reduced N2O emission. The H treatment was more effective for the reduction of N2O emission compared to L treatment. Higher N2O emission was observed from 90%WFPS compared to 55%WFPS, and a maximum of 0.37 μg N2O-N kg-1 h-1 in 90%WFPS. The H dolomite treatment reduced 67.65% cumulative N2O emission from 90%WFPS compared to CK. These results show that high moisture condition increased N2O emission but dolomite addition reduced N2O emission from high moistures. N fertilizer enhanced the N2O emission and the maximum fluxes were up to 0.59 μg N2O-N kg-1 h-1 in 90%WFPS. However, the H treatment reduced 40.35% cumulative N2O emission for N fertilizer in 90%WFPS compared to CK. These results show that high soil moisture and N fertilization increased soil N2O emissions. However, increasing the soil pH by dolomite addition decreased N2O emissions. The addition of dolomite significantly ($p \leq 0.05$) increased the soil pH from 5.52 to 6.57 and 7.21 in L and H treatment of 90%WFPS with N fertilizer, respectively. The increase in soil pH triggered the DOC and MBC, which reached their maximum contents of 99.92 mg kg-1 and 449.72 mg kg-1, respectively in H treatments of 90%WFPS with N fertilizer. Increasing the soil pH increased the concentrations of bio-available carbon via desorption and solubilization of soil organic matter. Sufficient availability of C stimulated the microbial activities which were responsible for the N2O reduction and, hence, low N2O emission from dolomite treated soils. In addition, the NO3--N concentration kept increase during the incubation, which implied that nitrification was the main microbial process responsible for N2O production in the current study. The mechanism by which increasing the soil pH decreased the amount of N2O emission from high moisture and N fertilization, through the nitrification process, may be related to the specific organisms responsible for N2O reduction. We conclude that the addition of dolomite is a potential mitigation strategy for decreasing N2O emission from acidic soils. Therefore, the results suggest that dolomite not only counteracts the acidification but also has the potential to mitigate N2O emission from acidic soils.

Keywords：*Dolomite, N2O emission, Nitrification, N fertilization, water filled pore space*

P4-516

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Effect of Nitrification Inhibitors on Yield and Green House Gas Emissions in Rice

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Agriculture accounts for approximately 10–12 per cent of total global anthropogenic emissions of greenhouse gases (GHG), which amounts to 60 and 50 per cent of global nitrous oxide (N_2O) and methane (CH_4) emissions, respectively. GHG emissions from rice (*Oryza sativa* L.) systems are roughly four times higher than either wheat (*Triticum aestivum*) or maize (*Zea mays*). On average, rice systems emit 100 kg CH_4-C ha^{-1} $season^{-1}$, which accounts for 89 per cent of the GWP. Therefore, efforts to reduce the over all GWP of rice systems should focus on reducing CH_4 emissions; however, both CH_4 and N_2O need to be considered as many strategies that reduce CH_4 emissions tend to increase N_2O emissions. Methane is an end product of organic matter decomposition under anaerobic soil conditions. Therefore, the two strategies often proposed to reduce CH_4 emissions are to limit the period of soil submergence and reduce carbon inputs (*e.g*. residue management). Nitrous oxide has important effects both on the climate system and on stratospheric ozone. It is a potent greenhouse gas (GHG) produced in the soil predominantly by the microbial processes of nitrification (ammonia oxidation) and denitrification (nitrate reduction). Different types of coated urea fertilizers are coming in to the market apart from commonly used prilled urea. The difference in release of N from these fertilizers is of major concern to improve the NUE. The advantages of coated urea fertilizers are minimization of leaching and volatilization losses of N and longer-lasting N supply. With this background a field experiment was carried out during *Kharif*, 2013 at college farm, college of Agriculture, Rajendranagar, ANGRAU, Hyderabad in India to study the effect of nitrification inhibitors on methane and nitrous oxide emissions in puddle as well as aerobically grown rice crop. The experiment was laid out in split plot design under two types of rice management *i.e*., puddled and aerobic with five treatments viz., T_1 - control i.e., without addition any fertiliiser ; T_2- nitrogen @ 120 kg ha^{-1}(Prilled Urea) ;T_3- Neem coated urea (NCU) ;T_4- *Karanja* i.e., *Pongamia pinnata* cake coated Urea (KCU);T_5- Vitex negundo leaf extract coated urea replicated thrice. Rice variety MTU1010 was raised and recommended management practices were followed. The phosphorous and potassium were applied @ 60Kg ha^{-1} each for all treatments. The green house gas emissions were collected throughout the crop growth period at regular intervals by using closed static chamber (Hutchison and Moiser model). The gas samples were analysed through GC equipped with TCD, FID and ECD (Varien 450GC) and the data was interpolated for getting daily values and were summed up over crop growth season. The results revealed that drastic reduction (about 50%) in methane gas emission was observed with aerobic rice compared with puddled rice. Within the each ecosystem the highest nitrous oxide emission was observed in prilled urea applied plots followed by control and coated urea applied plots. The total nitrous oxide emission during entire crop growth period in prilled urea applied plots was 45% more than that of coated urea plots. Among the nitrification inhibitors *Karanja* coated urea produced more methane followed by *neem* coated urea and *Vitex nigunda* coated urea. The grain yield of rice in puddle plots was more (around 1t ha^{-1}) than in aerobic plots in all treatments. The nitrification inhibitors significantly influenced grain yield of rice in both aerobic and puddle rice. The highest grain yield was recorded in *Karanja* coated urea applied plots (5.5 t ha^{-1}) followed by *Vitex nigunda* coated urea plots (5.15 t ha^{-1}) followed by neem coated urea plots(5.09 t ha^{-1}) in puddle rice. In aerobic rice highest grain yield was recorded in *Karanja* coated urea applied plots (4.64 t ha^{-1}) and lowest grain yield was recorded in plots where no fertiliser was applied (2.74 t ha^{-1}).The results reveal that 50 % reduction in methane emission can be achieved by growing aerobic rice instead of puddle rice. Within each ecosystem the coated urea applied plots recorded more methane emission than prilled urea applied plots.

Keywords：*puddled rice,GHG emission,aerobic rice, nitrification inhibitors*

P4-517

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Potential of Chelating Compounds Like Edta to Mitigate Methane Emission from Rice Paddy Soils

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Methane (CH4) is the second most potent greenhouse gases after carbon dioxide. More than 90% of world rice is cultivated under submerged condition, which facilitates CH4 production in soil. Methanogens utilize simple carbon compounds to produce methane (CH4) under strictly anaerobic condition. During methanogenesis, methyl coenzyme M (MeCoM) is reduced by MeCo M reductase enzyme to CH4 involving a nickel-containing cofactor F430. In this experiment, strong chelating agent like ethylenediaminetetraacetic acid (EDTA) was applied in soil to study its feasibility for suppressing methanogen activity and CH4 production in soil. Application of EDTA significantly ($P < 0.05$) reduced CH4 production in soil. Application of 60 ppm EDTA (soil weight basis) was the most effective among all treatments. Applied EDTA forms complex compounds with heavy metals like nickel (Ni) and increases Ni concentration in soil solution. Since methanogenesis is intracellular process, it is necessary for methanogens to assimilate those Ni-EDTA complexes inside cell to utilize Ni in EDTA treated soils. Results indicated that methanogens cannot utilize Ni in the presence of EDTA and that significantly ($P < 0.05$) reduced mcrA gene (coding MeCoM reductase enzyme) copy number and Co-M concentration in soil. Due to high correlation ($r = 0.901^*$) between Co-M concentration and mcrA gene copy numbers, Co-M concentration could be used as an alternative biomarker for methanogens. Therefore, it could be propose that 60 ppm EDTA could be an optimum dose to suppress CH4 emission from soil by restricting Ni availability to methanogens.

In a pot experiment, different doses of EDTA were applied in rice paddy soils to evaluate their effects on CH4 emission and plant growth during rice cultivation. Application of EDTA at small doses (up to 5.0 ppm) significantly ($P < 0.05$) suppressed CH4 emission without compromising rice grain yield. Higher doses (10.0 ppm) of EDTA application extended vegetative growth stage of rice plants, which not only reduced ripening percent of rice grains but also increased CH4 emission (even more than control). Therefore, based on this pot experiment data it could be concluded that EDTA application at 5.0 ppm was probably the most rational treatment to mitigate CH4 emission from rice paddy soils.

Keywords：*Rice paddy soils; Methane emission; Mitigation strategy; EDTA application.*

P4-518

[WG5] Mitigating Greenhouse Gas Emissions from Rice Paddy Soils

Effects of Liquid Pig Manure Application on the Emission of Ch4 in a Paddy Soil

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This study was carried out to monitoring the greenhouse gas 'CH4' from paddy soil in Gangwon Province. So we could obtain the possible options for mitigating greenhouse gases by application of liquid pig manure.

In paddy soil corporated with rice strawes the emissions in CH4 increased 89~125%.
Organic material application was more important to the emission of CH4 compared with nitrogen fertilization. In paddy soil under flooding the applying liquid pig manure right before transplanting brought results as follows. In paddy soil the applying by-product compost brought about increasing 4~5% of CH4. In case of Liquid manure 50% and 150% treatments CH4 decreased 9% and 4% respectly.

Keywords：*paddy soil, greenhouse gas, liqiud manure, methane, CH4*

P4-519

[WG8] Proximal Soil Sensing

Soil Information System of Infrared Mid-Infrared Photoacoustic Spectroscopy

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The stable crop production as well as protection and enhancement of the global environment require the development of innovative new methodologies to assess the spatial and temporal variability of soil fertility and soil properties. In particular, spectroscopic techniques like infrared photoacoustic spectroscopy offer the potential to quickly and inexpensively characterize soils relative to standard laboratory techniques. In the FTIR-PAS based soil analysis, the calibration set is the most important aspect, and the analyzed results will strongly depend on the selected soil number and soil type. Given the compositional diversity of soils, enough independent samples would be required to construct a complete global, empirical soil library for calibration purposes. At present, with a relatively limited soil spectral library, expanding the soil spectral library is necessary by scanning previously characterized state and national soil archives, and it is important to consider the number of samples that are needed to adequately describe the soil variability in the region in which the library is to be used; a soil information system based on soil FTIR-PAS spectra library has initially composed in this study, which provided an alternative platform for soil analysis combining soil identification based model; soil spectra library is one of the most important base in this software, however, the soil spectra data is far from enough in general application. It is proposed that global or national libraries should be used in conjunction with local calibration samples and with easy to measure auxiliary predictors like clay content, organic matter and pH. Developments in theoretical soil spectroscopy and spectral processing techniques should also improve predictions while reducing calibration requirements. We anticipate that the future development of soil infrared spectroscopy and the expansion of soil spectral libraries will support the assessment of soil fertility at a scale and resolution not previously possible.

Keywords：*soil fertility; infrared photoacoustic spectroscopy; soil identification, spectral library; model*

P4-520

[WG8] Proximal Soil Sensing

Adequacy of a Lower Cost Spectrometer for Prediction of Soil Particle Size Distribution

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Through Proximal Soil Sensing (PPS) a large amount of samples can be processed and facilitate the collection of soil spatial data using cheaper and less laborious techniques. Diffuse reflectance spectroscopy (DRS) operating in the visible and near-infrared (VNIR) spectra region has gained attention as a PPS technique that could deliver soil data with required speed and accuracy even for the development of on-the-go sensors. What has been hindering a wider application of this approach is the price of the DRS equipment. Spectrometers working in the range of VNIR (400-2500 nm) might cost as much as 60,000.00 USD. Research has to be carried out to increase PPS accuracy as to be comparable to conventional soil analysis techniques which are time-consuming, laborious and expensive. Attention also has to be given towards more affordable PSS equipment. The objective of this work was to verify the capacity of a 15,000.00 USD spectrometer, with limited spectra range acquisition (325-1075 nm), in determining the soil particle-size distribution. We described 10 Ferralsol profiles in Rio Marombas watershed located near the center of the state of Santa Catarina, in the south of Brazil. In each profile two soil sampling methodologies were carried out. We used the Brazilian System of Soil Classification method and sampled soil horizons in each profile. A total of 45 soil samples were collected (45_SiBCS). The sampling methodology according to the consortium GlobalSoilMap.net was also applied to each profile. This methodology requires six samples with predetermined depth. In total, 60 samples were collected for this methodology (60_GSM). Chemical and physical properties were determined in the 105 soil samples after air-dried, ground and sieved through 2 mm mesh. All analyses were conducted following the official Brazilian Society of Soil Science methods. The DRS of the samples was collected with an ASD FieldSpec HandHeld II. Spectral sampling was done inside a black painted box to avoid outsight light interference. Before scanning, the spectrophotometer was calibrated with a Spectralon® reference. The remaining collected spectra were smoothed by a Savitzky-Golay third-order polynomial across a moving window of nine bands; after that, an average across a 5 nm window was applied. In this study, two groups of spectral data were used to determine their suitability for modeling soil particle size distribution: the first one with reflectance data, and the second one with a pre-processing transformation of reflectance spectra to absorbance through Log(reflectance). Savitzky-Golay second derivatives were calculated on the resulting soil spectra (reflectance and absorbance) using a second-order polynomial across a six-band window. The 105 soil sample granulometric analyses and second derivatives were used for partial least-squares regression (PLSR) modeling in The Unscrambler X 10.3 software. Soil samples were portioned in two groups: 60 for model development (60_GSM) and for 45 for model testing (45_SiBCS). The 45_SiBCS sample group had an average of 50.35, 696.65 and 253.02 (g kg) of sand, clay and silt, respectively. The 60_GSM sample group had an average of 67.15, 654.78 and 278.07 (g/kg) of sand, clay and silt, respectively. Both groups had normal distributed data. Generally, second derivatives PLSR with reflectance data performed better than second derivatives PLSR with absorbance spectra. The R^2 value for sand, clay and silt were 0.61, 0.61 and 0.60, respectively. The Root Mean Square Error of Prediction (RMSEP) reached 29.84, 38,96 and 30,07 (g/kg) for sand, clay and silt, respectively. The latter are compatible with literature findings. Absorbance PLSR results showed values of R^2 0.51, 0.60 and 0.44 for sand, clay and silt, respectively. The RMSEP reached 32.44, 38.59 and 37.89 (g/kg) for sand, clay and silt, respectively. Full range VNIR spectrometers (400-2500 nm) have shown better results than those demonstrated here possibly due to the added variables in the 1000-2500 nm range of this more expensive equipment. However, these results have to be considered if there are bugged constraints and lower cost equipment is the only option available. Further research has to be conducted searching towards the adequacy of cheaper spectrometers for soil property prediction, and possible pre-processing transformation options which could improve the prediction capability.

Keywords：*Diffuse reflectance spectroscopy, Low cost spectrometers, Soil granulometry prediction*

P4-521
[WG8] Proximal Soil Sensing

Synchronization Prediction Model of Soil Water-Salt Based on Hyperspectral Reflectance Characteristics

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Taking farmland of oasis in Xinjiang Manas, as the example, in order to timely, accurately and dynamically monitor water and salinity of saline soils. Application of hyperspectral analysis technique, using correlation analysis and regression method to fit the soil spectral reflectance value relation with moisture, salt content, we established synchronization prediction model of water-salt content and performed calibrations. The results show that the models of using a continuum removal is built that has high precision, the determination coefficient R2 of prediction models of soil water and salt content were0.9414, 0.9531 respectively, the veracity of models was estimated by the determination coefficients (Rcv2) and the root mean square errors (RMSECV) of cross validation, the determination coefficients (Rv2) and the root mean square errors (RMSEP) of external validation. The Rcv2 of soil water and salt content models were 0.9204 and 0.9049, the RMSECV 0.2152 and 0.2977, the Rv2 were 0.9345 and 0.9084, the RMSECV 0.2011 and 0.3028. From the above results, we concluded that the synchronization prediction model of water-salt content can provide a new method for rapid determination of soil water and salinity in lab, theoretical basis for remote sensing monitoring of saline soils.

Keywords：*hyperspectral; soil; water; salinity; synchronization prediction model*

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[WG8] Proximal Soil Sensing

Mobile Multisensor Platform for Field Scale Soil Properties Mapping

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Visible near infrared spectroscopy (vis-NIR) is considered a cost-effective method for the analysis of soil properties due to labour savings and acceptable accuracy. Moreover, rapid real-time NIR measurements in the field can generate a high number of data necessary for a detail spatial coverage of soil properties variability.

The objective of this study was to predict and map field scale variability of soil organic carbon (SOC) and texture using Veris mobile sensor platform (MSP).

Two agricultural fields in Denmark were mapped with the MSP which collected simultaneous measurements from vis-NIR sensors (350-2200nm), coulter electrodes for shallow and deep electrical conductivity (EC) and a temperature sensor. Fuzzy k-means clustering was applied to select 15 calibration samples at each field from the obtained spectra. In order to predict soil properties, partial least square regression models were developed for each field separately using the calibration samples. To account for different physical factors (soil structure, moisture, temperature, and particle size) which can affect field spectra, relatively inexpensive supplementary auxiliary data (EC and temperature) were incorporated as covariates in spectral model development. The final models were used to predict soil properties from the remaining field spectra. Maps of predicted soil properties were generated with ordinary kriging and validated using 20% of each data set.

Improved predictive ability of the spectroscopic models with auxiliary data was reported.

The results from this study indicate that robust calibration models can be developed on the basis of the MSP and high resolution field maps of soil properties can be compiled.

Keywords：*mobile multisensor, NIRS, EC, PLS, SOC, texture*

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[WG8] Proximal Soil Sensing

Soil Pit Descriptions for the Contemporary Field Soil Scientist: Harnessing the New Soil Analytical Technologies

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The mainstay of field soil science is the soil pit, a roadside cutting, or any type of excavation into which the soil scientist can peer, and began to unravel the mysteries of the soil underfoot. The 'pit face' is where the soil scientist can begin to interpret then understand the soil and the soil-landscape interactions that are active in situ and to some degree- ex situ. This interpretation is aided by the observation, measurement and rudimentary analysis of a number of key soil physical and chemical characteristics. More detailed characterization of the soils is usually performed in the laboratory often long after visitation to the 'pit face'. It is likely that in the last 50 years, the tools, instruments, and chemical reagents for in situ characterization of soil have largely remained unchanged.

Proximal soil sensing instruments particularly mid- and visible-near infrared spectrometers, and x-ray fluorescent analyzers have demonstrated their utility for fast, accurate, and low cost analysis of both traditionally easy and difficult to measure soil characteristics. While they are said to be proximal soil sensors, their use has primarily been confined to the laboratory however. With developments in the portability of these instruments, we contend that their use will and should be the norm in the characterization of soils in situ. The potential information content that is retrievable from these instruments will enhance soil descriptions and interpretations in the field.

We trialed the use of a portable vis-NIR instrument in a number of soil pits in southern and central western, New South Wales, Australia. Prior to taking the instrument into the field a 'soil spectral inference engine' (SSIE) was constructed. The SSIE was composed of three extensive yet different spectral libraries collected from separate soil surveys within NSW. Calibration functions using the individual and a composition of these libraries were fitted using Cubist modelling to determine statistical relationships between soil spectra and measured soil characteristics. Soil characteristics to which calibrations were constructed included total soil organic carbon concentration, cation exchange capacity, and exchangeable cations: sodium, magnesium, calcium, exchangeable sodium percentage, soil pH and electrical conductivity, plus percentages of sand, silt and clay. The calibration functions were fitted with and without external parameter orthogonalisation (EPO) of the soil spectra, to ensure soil moisture effects could be accounted for and removed when making predictions in the field. Spectral pre-processing algorithms were built into SSIE, together with a principal component-based algorithm for measuring the reliability of a spectral library for making prediction of the given soil characteristics. Independent of the calibration functions were further algorithms for measuring soil color ? and assigning nearest Munsell color chips, and predicting the presence and abundances of soil minerals, specifically abundances of kaolinite, smectite and illite.

In the field, spectra were collected in replicates within genetic soil horizons. The soil spectra were then fed into the SSIE where they were pre-processed, then passed through the calibrated models and other algorithms. Predictions of the aforementioned soil characteristics were generated on the spot. In the field, we found this extra information enhanced our interpretations of the soil in situ and aided in their classification.

In this paper we also report on the validation of our SSIE, whereby field predictions were later compared to laboratory measured predictions. Validation could only be performed on a subset of the soil profiles, but soil characteristics such as total carbon, soil textures and CEC were generally well predicted. Surprisingly also were the presence/absence of soil minerals. This paper also discusses further work that is occurring to improvement and efficiency of the SSIE. More general discussion of other possible applications of using portable proximal soil sensors in the field is also detailed.

Keywords：*Soil spectral inference engine*

P4-524
[WG8] Proximal Soil Sensing

Predicting Soil Organic Carbon Contents in Archived Soils Using Mid-Infrared Spectroscopy

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Diffuse reflectance spectroscopy combined with chemometric analysis techniques has enabled the rapid and cost effective prediction of soil organic carbon. In this research, an attempt was made to predict soil organic carbon in archived legacy soil data. For this work the mid-infrared region of the spectra was utilized and statistical models were developed using partial least squares regression. In this study different calibration models were developed with the aim of predicting soil organic carbon in archived soil data. The first two calibration models were developed based on (i) only newly collected year-2010 data (Model 1), (ii) archived data itself (year-2000) (Model 2). In development of other calibration models, representative samples (n = 24) were selected from archived data (year-2000) and then incorporated (spiked) into the newly collected year-2010 dataset. In order to select the spiked samples the following sampling strategies were compared; linear (Model 3), random (Model 4), Kennard Stone algorithm on principal components of year-2000 data (Model 5), Kennard Stone algorithm on partial least squares regression analysis of year-2000 data (Model 6), conditional latin hypercube sampling on principal components of year-2000 data (Model 7) and finally conditional latin hypercube sampling on partial least squares regression analysis of year-2000 data (Model 8). The results revealed that all the calibration models performed adequately based on random cross validation. An independent validation was carried out on all models except for Model 2. Results revealed that a model based on the newly collected data (Model 1) resulted in the lowest performing model while samples selected based on the Kennard Stone algorithm (Model 5 and 6) were the best performing models.

Keywords：*carbon; spectroscopy; partial least squares regression*

P4-525

[WG8] Proximal Soil Sensing

Transfer Functions for Visnir Spectra: Application of Air-Dry Spectral Libraries to Moist and Intact Soils

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High-resolution digital soil mapping requires the integration of multiple data sources collected at variable scales and spatial resolutions. Commonly, researchers employ proximal sensing methods such as electromagnetic induction and passive gamma to provide rapid coverage of large areas with spatially dense data. When coupled with measurements of soil properties taken from soil samples, these sensors can yield valuable information on within-field variation of soil properties. A major limitation of this approach is that direct soil measurements require laboratory analysis which can be costly and time consuming. Additionally, reliance on laboratory analysis precludes the use of such methods for on-the-go sensing. Visible near-infrared spectroscopy (VisNIR) has been shown to accurately predict soil properties on dry –ground samples and offers a low-cost alternative to traditional laboratory analysis. If used on soils in the field, VisNIR can provide accurate, real-time measurements of soil properties and could be implemented into on-the-go sensor platforms. A major barrier to the implementation of VisNIR for in-situ measurement is that, unlike laboratory samples that have been dried and homogenized, in-situ soils are typically moist and heterogeneous. When dry and ground spectral libraries are applied to in-situ VisNIR spectra, model predictions are unreliable due to the effects of moisture and heterogeneity. To account for these effects researchers must either collect new spectral libraries containing data from in-situ soils or develop transfer functions that relate air-dry and ground spectra to in-situ spectra. Developing new spectral libraries can be costly and considering that many researchers have made large investments in developing dry-ground libraries, the latter approach seems most reasonable. An ideal VisNIR transfer function could reliably account for the effects of water content and heterogeneity over wide range of soils with minimal need to collect new spectral and laboratory data. Additionally, optimum transfer functions would be universal and could be applied to spectral libraries collected in different regions. In this paper we will discuss the use of transfer functions for predicting soil properties on moist and intact soils using dry-ground spectral libraries. We will demonstrate that transfer functions can remove for the effects of soil moisture and heterogeneity from in-situ VisNIR spectra.

Keywords：*VisNIR Spectroscopy, pedometrics, proximal sensing*

P4-526

[WG8] Proximal Soil Sensing

How Does Soil Moisture Effect the In-Field Prediction of Soil Properties from X-Ray Fluorescence (XRF) Spectra?

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Recently, handheld portable X-Ray Fluorescence (PXRF) devices have become available to be used directly in the field. They offer the opportunity to enrich the in-situ description of soil profiles by rapidly detecting the elemental concentration of unprocessed soil materials and can therefore become a highly valuable asset in pedology related field studies. Traditionally, XRF devices have been laboratory based, with time-consuming and labour intense sample preparations. One of the greatest benefits of employing PXRF devices is therefore that soil materials can be scanned non-destructively and rapidly. However, the soil medium is very complex and there are many factors that influence the XRF spectrum and in turn the prediction of soil properties in the field. One of these factors is the moisture content of the soil. The presence of moisture alters PXRF predictions because of two reasons; first, water molecules act like a barrier which absorbs the characteristic X-rays and thus may dampen the characteristic energy peaks of the XRF spectrum and secondly additional water molecules also cause increased scatter of the primary radiation during excitation of the soil sample which may result in an increase of the characteristic energy peaks.

Our aim in this study was therefore to investigate the influence of soil moisture on the XRF spectrum and to potentially remove this effect to increase the accuracy of in-field predictions of soil properties using a PXRF device. To do this, we evenly wetted 11 soil samples which were sampled from three different soil profiles with varying texture content. The samples were wetted to the point where the soil reached a slightly sticky consistency (about 30% of soil moisture). We then let the soil samples equilibrate for 1 day, followed by scanning the soil material through plastic bags in the PXRF field operating mode. Subsequently, soil samples were air-dried for 1 day under controlled laboratory conditions (about 23°C). Before and after each scan, soil samples were weighed to document the loss in water between the 7 treatments (air-dry plus 6 soil moisture conditions). We then used elemental peak heights as well as the total peak area to investigate the response of the XRF spectrum to different moisture conditions. Initial results show that (as expected) in general the highest peak as well as largest peak area corresponds to air-dry soil conditions.

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[WG8] Proximal Soil Sensing

Transferability of a Visible and Near-Infrared Model for Soil Organic Matter Estimation in Riparian Landscapes

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Visible and near-infrared (VNIR) spectroscopy has proven to be a rapid and efficient technique for estimating soil organic matter (SOM) content. With 108 soil samples collected from the Honghu City area (Hubei Province, China), we aim to explore the transferability of a VNIR model for SOM estimation in riparian landscapes. More specifically, with statistical analyses and different divisions of the total sample set, we address the following research questions: (1) whether the partial least-squares regression (PLSR) model calibrated from samples in one location can be applied in other locations with different land-use types and different ranges of SOM content; and (2) what is the relationship between the spectra of soil samples with different pretreatments (with or without air-drying, grinding, and 2 mm sieving pretreatment) at each single wavelength? The results indicate that for the soil samples with pretreatment, the model calibrated from the soil sample set with mixed land-use types can be applied in the SOM prediction of cropland soil samples (r2Pre = 0.66, RMSE = 2.78 g kg−1, RPD = 1.45). The models calibrated from cropland soil samples, however, cannot be transferred to the SOM prediction of soil samples with diverse land-use types. Wavelengths in the region 350–800 nm and around 1900 nm are important for SOM estimation. The correlation analysis reveals that the spectral wavelengths from the soil samples with and without the air-drying, grinding, and 2 mm sieving pretreatment are not linearly correlated at each wavelength in the region 350–1000 nm, which is an important spectral region for SOM estimation in riparian landscapes. This result explains why the models calibrated from samples without pretreatment fail in the SOM estimation. Our study also demonstrates that a widely applicable SOM prediction model for riparian landscapes should be based on a wide range of SOM content and soils with different land-use types.

Keywords：*VNIR spectroscopy; soil organic matter; model transferability; riparian landscape;*

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[WG8] Proximal Soil Sensing

Prediction of Soil Nitrogen at the Chinese Scale by Visible and near Infrared Reflectance Spectroscopy

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Soil nitrogen is an important nutrient for maintaining the earth's ecosystems. For the past few years, the visible-near infrared diffuse reflectance spectroscopy (vis-NIR DRS) has become an important area of research in the fields of remote and proximal soil sensing. This technique which can provide cheap and high-density soil data is considered to be particularly useful for acquiring data for soil digital mapping, precision agriculture and soil survey. Existing vis-NIR DRS research on estimating soil nitrogen lack of large-scale application due to large soil diversity and high cost. In this study, a Chinese scale soil survey of 1661 soil samples were collected from 13 provinces in China, including Tibet, Xinjiang, Heilongjiang, and Hainan. The samples represent 17 soil groups of the Genetic Soil Classification of China. After air-drying and sieving, the DRS of the samples scanning were carried out under laboratory conditions using a portable vis-NIR spectrometer (LabSpec®Pro Near Infrared Analyzer, Analytical Spectral Devices, Inc., USA) with a measurement range of 350-2500 nm. Then, calibration model developed using partial least squares regression (PLSR) and locally weighted regression (LWR) methods between the first derivative of DRS and total nitrogen (TN) content. 104 soil samples were collected from Zhejiang province as validation data sets.

Both the leave-one-out cross-validation and prediction for the two models. The results showed that LWR which calibration data sets were classified into 5 clusters (R2=0.764; RMSEP=0.032; RPD=2.066; RPIQ=2.675) was outperformed PLSR model (R2=0.635; RMSEP =0.037; RPD=1.656; RPIQ=1.794). In addition, the variable importance projection (VIP) showed that 880 nm, 1000 nm, 1430 nm, 1830 nm and 1900 nm are characteristic bands for the calibration model which should be considered in future. Therefore, such estimates could be used for assessing the mean TN content of large geographical entities or countries.

Keywords：*diffuse reflectance spectroscopy; vis-NIR; soil nitrogen; Chinese scale; PLSR; LWR*

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[WG8] Proximal Soil Sensing

Using Visible-Near Infrared Spectroscopy to Predict Some Soil Properties in a Semi-Arid Region of Iran

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Summary

Direct measurements of soil properties typically are, in particular at large scales, costly, time consuming, invasive, user and method dependent. Characterization of the inherent spatial variability of soil properties requires collecting a large number of soil samples or in-situ measurements. Recently, several studies have addressed the potential of soil spectroscopy, which typically used in laboratory scale, to provide predictors to estimate a large number of soil properties. So far, however no literature exists on predicting soil properties using soil spectroscopy in Iran. Additionally, it still remains questionable whether soil attributes are predicted with a similar accuracy at various locations. Thus, the objective of this study was to explore the feasibility to estimate some soil properties including clay, sand, silt, organic carbon (OC) content, geometric mean diameter (GMD) of soil particles, bulk density (Bd), gravimetric soil moisture at filed capacity (θfc) and permanent wilting point (θpwp), using diffuse spectral reflectance data in visible, near-infrared and short-wave infra-red (Vis-NIR-SWIR) range. The study area is located in Zanjanrood sub-watershed, northwest of Iran. This area, having an area of approximately 250 km2, was chosen so as to provide variety in terrain, land use characteristics, soil type and soil distribution patterns. Basic properties of 174 soil samples include particle size distribution (i.e. clay, silt and sand content) and organic carbon content were measured by sedimentation and Walkley and Black (1934) procedures, respectively. The geometric mean diameters of the soil particles were determined using Shirzi and Boersma (1984) procedure. Gravimetric soil water content was measured at field capacity and permanent wilting points using a pressure plate extractor apparatus. Prior to spectral reflectance analysis, each soil sample was air dried and sieved through 2 mm sieve. Spectra of soil samples were recorded in the visible, near-infrared and shortwave-infrared (350 to 2500 nm) regions in a dark room using a portable spectroradiometer. An average spectrum for each soil sample was generated by arithmetic averaging of 20 iterations for each soil sample. A spectral library was then generated for all the soils in the study area. Spectral preprocessing techniques have been checked using cross validation method. We used finally the continuum removed spectra transformation after applying a Savitsky–Golay smoothing with a second order polynomial in segments 3 points. Prior performing spectral analyses, because of excessive noise over 350 to 399 nm and 2451 to 2500 nm, these ranges were excluded from the spectral analyses. Since raw spectral data provide rich information with a high degree of correlation between many neighboring wavelengths, every 5 contiguous 1 nm wavelength were averaged, resulting in 410 data points from 400 to 2450 nm for calibration development. The dataset was randomly divided into two subsets of calibration (n=130) and test (n=44) sets. Stepwise multiple linear regression statistics was used to relate the soil properties with spectral reflectance values. The 'Variance inflation factor', VIF, and 'Durbin-Watson statistic' were also used to assess the degree of multico-linearity in each regression equation and the presence of autocorrelation among the residuals, respectively. We derived different sets of spectral functions to estimate these soil properties.

The most important spectral wavelengths in predicting each soil attribute were also determined. According to the obtained results, the soil properties indicated positive, negative and significant correlations with spectral reflectance values especially at SWIR region. Strongest correlations were observed by clay (r=0.674**), sand (r=-0.675**), OC (r=0.505**) and soil θpwp (r=0.673**). The accuracy of the estimations in each derived function differed considerably between properties. The coefficient of determination (R2) and root mean square residual (RMSR) for the calibration and validation sets were as follows: R2cal.=0.65 and R2val.=0.51, RMSRcal.=0.039 and RMSRval.=0.045 % for clay content; R2cal.=0.70 and R2val.=0.63, RMSRcal.=0.056 and RMSRval.=0.057 % for sand content; R2cal.=0.69 and R2val.=0.55, RMSRcal.=0.139 and RMSRval.=0.235 % for organic carbon content; R2cal.=0.58 and R2val.=0.51, RMSRcal.=0.013 and RMSRval.=0.014 g g-1 for soil moisture at permanent wilting point; R2cal.=0.65 and R2val.=0.64, RMSRcal.=0.038 and RMSRval.=0.034 mm for GMD; R2cal.=0.39 and R2val.=0.38, RMSRcal.=0.078 and RMSRval.=0.100 g cm-3 for Bd and R2cal.=0.29 and R2val.=0.10, RMSRcal.=0.021 and RMSRval.=0.019 g g-1 for θfc. Regarding to these results, the use of soil spectroscopy provides an alternative to traditional routine laboratory analysis.

Keywords：*Continuum removed spectra; spectral reflectance; soil properties; stepwise multiple regression*

P4-530

[WG8] Proximal Soil Sensing

Unravelling the Research Gaps in Technology Based Soil Inference Systems

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Optimal integrated technology-based agronomic decision result in a faultless process of interpretation . An example of this is by procurement of information of soil characteristics by diffuse reflectance infrared spectroscopy, which enables to predict several soil properties non-destructively and no less reliably then the traditional analytical laboratory methods. Thus, diffuse reflectance infrared spectroscopy is a straightforward and sometimes more accurate than laboratory conventional soil analysis. Although, every instrument and technique requires precision and calibration but they are far less cumbersome than the traditional soil carbon measurements. One main advantage of the sensor technology is its environmental adaptability and on the go field use, making it easier to be used and leading to time saving in the laboratory.

These technologies provide good predictions of soil carbon, but there have not been substantial significant studies on robust calibration models for an area or a spectroscopic instrument. This is because most of the existing Vis-NIR calibration libraries were created using legacy soil datasets. These legacy soil datasets were compiled from data acquired over a long period of time and by different laboratories, which inevitably employed diverse methods of analysis. This is likely to reduce the accuracy of the overall prediction of SOC employing these datasets. Here, our primary aim is to establish a new soil carbon spectral library, using Vis-NIR emissions determined over a variety of soil landscapes and climatic regions in NSW.

Major research gaps include:

1. Soil spectral libraries under field condition should be created as most of the soil libraries are acquired from air-dried ground samples.
2. Robust calibration models for samples in field condition have to be made.
3. Soil spectral library should contain a large area, to encompass soil carbon, soil type, land use, climate and topography variability

To build a spatial soil carbon spectral library for Australia, a Conditional Latin hypercube sampling was conducted using four covariates i.e. topography, gamma radio metric data, landuse and the predicted soil carbon to encompass spatial soil carbon variability. This covered the three major bioregions of New South Wales, Australia, namely the south eastern highlands, south western slopes and Brigalow belt south south (with a total area of ~158,000 km2). The scanning was done through the soil profile using Vis-NIR spectroscopy instrument to get a set of Vis-NIR reflectance spectra under field condition. Further each soil profile (~ 100 cm) was subsampled based on soil horizons and re-scanned. This study will present results of soil carbon variability at a regional scale and comparison of calibration models between spectra acquired under field and dried ground condition.

Keywords：*Soil carbon, Spectral libraries, Vis-NIR spectroscopy.*

P4-531

[WG8] Proximal Soil Sensing

Predicting Organic Carbon Content of Canadian Prairie Soils Using Vis-Nir Spectroscopy: A Comparison of Pretreatment and Validation Methods

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Visible-near infrared (vis-NIR) spectroscopy provides a rapid and inexpensive tool for soil organic carbon (SOC) measurement. The objective of this study was to determine the feasibility of vis-NIR combining with partial least square regression method for measuring SOC in the Canadian Prairies. Effects of spectral data pretreatment method, validation method and number of latent variables considered on SOC prediction were emphasized. Two perpendicular sampling transects (NS transect and WE transect) in 1,600 m long were set up in the St. Denis National Wildlife Area and an adjacent area in Saskatchewan, Canada. A total of 256 sampling points at intervals of 6.3 m were set up at each transect. Soil sample of 0-30 cm at each point was air-dried, sieved and scanned by a vis-NIR spectrophotometer. Soil organic carbon content at a given transect was predicted by models calibrated at another transect. This study verified the potential of vis-NIR spectroscopy in predicting SOC in this area. In terms of SOC prediction, smoothing using cubic smoothing spline outperformed other pretreatment methods, and leave-one-out cross-validation outperformed test set validation. For test set validation, more samples considered as predictors in the calibration period resulted in more

accurate SOC prediction in the validation period. About 35% (WE transect) and 58% (NS transect) of total samples should be randomly selected in the calibration for the best SOC prediction. The SOC prediction performance increased and then decreased with the increase of number of latent variables considered for both validation methods. The optimal number of latent variables determined in the calibration period did not necessarily produce the best SOC prediction in the validation period. This study improved the protocol for SOC measurement with vis-NIR spectroscopy in terms of selection of pretreatment and validation methods.

Keywords：*Keywords: Soil organic carbon; Partial least square regression; Spectrometry; Near-infrared; Spatial*

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[WG8] Proximal Soil Sensing

Potential of Soil Proximal Sensing for Mapping of Key Soil Features of an Alfisol in Sri Lanka

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Coarse-scale choropleth soil maps are the main source of soil information available in developing countries. Soil management practices, such as the application of fertilizer and liming, are undertaken on the basis of large-scale soil variability depicted by these maps. However, in the presence of short-scale soil variability this can lead to under and over applications of soil inputs to some parts of the cropped fields and consequently a poor efficiency in soil input use. Therefore, there is a need of generating detailed soil information of key soil variables. This information (maps) can then be used to facilitate optimal use of soil inputs. The soilscape of the Dry Zone in Sri Lanka is dominated by Rhodustalfs. Their agricultural potential is largely affected by the presence of a compacted, subsurface gravel layer, found at varying depths, and the occurrence of moderately well drained patches of colluvial soil materials. These features have however not been delineated on the existing soil map. Therefore, detailed mapping of these features is required. However, the traditional soil surveying process is laborious and uneconomical. Therefore, a study was conducted to explore the potential of proximally sensed soil apparent electrical conductivity (ECa) as a secondary information for the detailed mapping of depth to the gravel layer and distribution of colluvial patches.

A three hectare field located in the Dry Zone was selected (80 6.651'N, 800 27.471'E). An ECa survey was conducted using a DualEM-1S soil sensor at a 1x2 m measurement density, which resulted in 6800 measurements of ECa in perpendicular geometry (ECa-PRP) and horizontal co-planar geometry (ECa-HCP). The ECa-PRP and ECa-HCP measurements are sensitive for the electrical conductivity of the top (0-50 cm) and subsoil (0-150 cm), respectively. After exploratory data analysis, continuous maps of ECa were constructed using ordinary kriging. Depth to the gravel layer was measured at 2 m intervals along a 100 m long trench (1m deep and 50 cm wide), which was excavated across the field representing the data distribution of ECa. At each sample location, ECa was measured again, soil samples were taken at 20, 40, 60 and 80 cm depths, and soil color and texture were recorded. In addition, 65 topsoil (0-30 cm) samples were taken according to a grid combined with a random sampling scheme, and soil texture and EC (1:5 soil to water suspension) were measured in the laboratory.

The ECa measurements indicated a large spatial variability. The ECa-PRP ranged from 1.1 to 61.5 mS/m, whereas the ECa-HCP ranged from 1.2 to 107 mS/m and both data distributions were skewed to the right. Ordinary kriged maps indicated strong spatial structure with distinct areas having extremely large, large, moderate and small ECa values. Patches with a ratio of ECa-HCP to ECa-PRP exceeding 1, indicating the presence of high conductive subsoil, were found within the field. The laboratory measurements of topsoil EC indicated an accumulation of salts over a small part of the field which overlaps the area with ECa-PRP values higher than 55 mS/m. The correlations between topsoil texture and ECa were not significant (e.g. r = 0.04 between clay % and ECa-PRP). The depth to the gravel layer along the trench ranged from 25 to >100 cm indicating a considerable variability. A 16 m segment of the trench contained brown coloured colluvium, while rest of the soil materials were reddish brown (Munsell colors 7.5YR 4/3 and 2.5YR 4/4, respectively). The correlation analysis indicated strong linear relationships between depth to the gravel layer and ECa-PRP (r = 0.67) and ECa-HCP (r = 0.73). Further, the measurements with ECa-HCP/ECa-PRP higher than 1 resembled the segment with clay loam colluvial soil material. Therefore, ECa measurements can be used as secondary information for the spatial prediction of these key soil features of the rest of the field.

The present study indicated a strong potential of proximal sensing of ECa for spatial prediction of three key soil features of the selected Alfisols landscape in the Dry Zone of Sri Lanka.

Keywords：*Alfisol, DualEM-1S, Detailed soil mapping*

P4-533
[WG8] Proximal Soil Sensing

Soil Water Content Estimation Using Visible and Near Infrared Spectroscopy

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The soil water content is an important parameter that we need to know either in hydrology or soil science and agronomy. Hence, the measurement of this parameter is of crucial importance. One of methods that could be useful, rapid and non-destructive is visible and near infrared spectroscopy. It's then of great interest to better understand the interaction of soil water with electromagnetic radiations. The objectives of this study were i) to establish the relationships between water content and reflectance at specific water absorption band around 1920 nm, with an attempt to explain those relations according to the characteristics of considered soils; ii) to establish an independent soil type relationship between soil moisture parameter and reflectance. Our study is based on two experiments that were carried out independently on French soils from Brittany and Australian soils from New South Wales (NSW). Measurements of reflected radiation ranging from 400 to 2500 nm were acquired in a laboratory setting for the whole samples at various moisture contents. In France, soil aggregates of 3 cm length were collected from split-plot experimental field between 0-7 cm, 7-15 cm and 15-20 cm depth. Four replicates were collected at each depth from different plots that combine different soil tillage (conventional, superficial and no-tillage) with mineral or organic fertilizers (poultry litter, cow manure, pig slurry). The soil aggregates, once saturated with deionized water, were first placed on suction table apparatus and then in a pressure cell. The spectra of the aggregates were then acquired at different suction matric (pF from 1 to 4.2). In Australia, we used 6 soil profiles from different locations in NSW. At each site soil samples were collected from the main horizons that were identified at different depths ranging from topsoil to 1.20 m depth. Each sample was sieved at 2 mm, saturated with deionized water and then oven-dried at 70°C until the mass no longer changes. Spectral measurements were acquired simultaneously with soil water content at different time between wet and dry states by weighing. The dry bulk density was measured at the end of the experiment. For the whole soil reflectance spectra we have applied the continuum removal (CR) technique to identify particular absorption features. We focused on the moisture effect on the depth of 1920 nm absorption feature (CR1920). Our results showed that the reflectance decreased with increasing water content for all soils as demonstrated by numerous studies. Moreover, the changes in CR1920 revealed a nonlinear variation with volumetric water content well described by an exponential function already reported in the literature. While this relationship is soil type dependent, our results showed that the relation between effective saturation and effective CR was not, and the best fit was obtained with a polynomial of second degree order ($R^2 = 0.96$ and RMSE = 0.06).

Keywords：*Water content; Visible-Near InfraRed spectroscopy; soil reflectance*

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[WG8] Proximal Soil Sensing

Apparent Electrical Conductivity (eca) Based Potential Management Zones for Site Specific Nutrient Management in Paddy Soils of Sri Lanka

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Paddy being the main crop and staple food that greatly influences the socio-economy of Sri Lanka. At present, efficient management of nutrients in paddy soils is of prime concern due to heavy dependence on inorganic fertilizer inputs amid stagnated productivity and potential environmental risks. Site Specific Nutrient Management (SSNM), which is based on the inherent variability of the soil resource, is one of the potential approaches for efficient use of soil nutrients. The key step in SSNM is demarcation of "management zones" which express within-field homogenous areas. Apparent Electrical Conductivity (ECa) has been proven as a secondary information for spatial prediction of soil properties that directly determine crop growth and yield. In addition, recent developments in proximal soil sensing has made soil ECa surveying a time, cost and labour effcient task. ECa based mangement zones have been already established for SSNM in large agricultural fields especially in temperate regions of the world. Therefore, a study was conducted to delineate ECa based potential management zones for SSNM in paddy soils of Sri Lanka.

A two and half hectare field located (70 27.208'N, 800 27.951'E) in the Intermediate Zone was selected. An on-the-go ECa survey was conducted using a DualEM-1S soil sensor after mounting on a wooden sled. Data were generated at a 1x2 m measurement density, resulting 9388 measurements of ECa in perpendicular geometry (ECa-PRP) and horizontal co-planar geometry (ECa-HCP), which are sensitive for the electrical conductivity of the top (0-50 cm) and subsoil (0-150 cm), respectively. Topsoil (0-30 cm) and subsoil (30-60 cm) samples were taken according to a Latin hyper cube sampling scheme based on ECa data. Then, soil textural fractions, organic C, P, K, Ca, Mg and EC (1:5 soil to water suspension) were measured in the laboratory using standard methods. An exploratory analysis was performed for all measured properties. Geostatistical analysis on ECa data followed variograpghy, ordinary kriging and fuzzy-k means classification to obtain continuous maps and ECa based management zones. Resulted management zones were characterized using mean separation of all measured soil parameters.

ECa measurements indicated a large spatial variability. ECa-PRP ranged from 5.3 to 73.2 mS/m, whereas ECa-HCP ranged from 15.5 to 84.9 mS/m. Ordinary kriged maps indicated strong spatial structure with northern part having large ECa values, whereas southern part is of moderate to low ECa values, despite a patch of moderate ECa at the north-eastern corner. Soil EC was positively correlated with both ECa-HCP and ECa-PRP at topsoil ($r = 0.54$-0.58) and subsoil ($r = 0.73$-0.75). Correlations between ECa and textural fractions were significant at both topsoil and subsoil ($r > 0.75$ for clay and silt, $r > -0.80$ for sand), whereas gravel content was not significantly correlated with ECa. Insignificant correlations were found between ECa and organic C, P and K. But, interestingly, Ca, Mg and Na content strongly correlated with ECa at both topsoil and subsoil.

Fuzzy-k means classification depicted two ECa based management zones; zone 1 with higher mean values of ECa (ECa-PRP=37.3 and ECa-HCP=56.8) compared with zone 2 (ECa-PRP=15.0 and ECa-HCP=29.7). Laboratory measured EC values between the zones confirmed the above pattern. Zone 1 is characterized with sandy loam topsoil (12% clay and 76% sand) and sandy clay loam subsoil (26% clay and 60% sand). Zone 2 is of loamy sand down to 60 cm depth (<10% clay and >80% sand). Mean values for organic matter, P and K in zone 1 were slightly higher than that of zone 2, although these differences were not statistically significant. However, significantly higher contents of Ca, Mg and Na were found in zone 1 than that in zone 2.

Therefore, present study indicated a strong potential of proximally sensed ECa based potential management zones for SSNM in selected paddy soils of Sri Lanka.

Keywords：*apparent electrical conductivity , potential management zones, paddy*

P4-535
[WG8] Proximal Soil Sensing

Estimation of Soil Organic Carbon in Indian and Australian Soils Using Reflectance Spectroscopy

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Assessment of soil organic carbon (SOC) by the reflectance spectroscopic approach as a non-intrusive method is fast developing. Several studies over the last decade have shown that the chemmometric method of partial least square regression (PLSR) may be effectively used to derive SOC from spectral reflectance with moderate to excellent accuracy. However, most of these studies use a part of the same data to validate the PLSR model. Validation across different soil groups collected from different parts of the world is rarely attempted. We used a spectral database of alfisols and vertisols from India and a pool of different soils from Australia to examine if the chemmometric model developed in one soil database is effective in estimating SOC in other databases. Results show that the chemmometric model derived from a single database fails to estimate SOC in other databases. However, when all the databases were pooled together across continents it was able to estimate SOC for each of the databases. This show that inter-continental database of spectral reflectance may be effectively used to estimate SOC in local soils.

Keywords：*Soil carbon,Vis-NIR spectroscopy.*

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[WG8] Proximal Soil Sensing

How Much Can We Reduce the Number of Calibration Samples?

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When using visible and near-infrared spectroscopy (VIS-NIRS) for soil analyses reducing the number of calibration samples is a major concern since it is related to cost and time reduction. In literature, most papers describe procedures using 2/3 of samples for calibration and 1/3 as a separate dataset for validation but it is really important to know how much that number can be lowered without altering the robustness of a calibration. At the farm scale, operating an on-the-go VIS-NIR sensor allows to further reduce the number of calibration samples but also to improve the description of soil spatial variability. However, even with proximal sensing, the concern remains as to whether we can reduce that number of calibration samples.

Using grid sampling, several models of SOC prediction were built using different numbers of samples. In the light of our results it seems that 80 samples are needed to obtain robust models and precise maps of SOC content and of soil texture (clay content) at the farm scale but also at the national scale (Poland). With an on-the-go VIS-NIR sensor there are few differences when using 10 or 20 calibration samples (selected by means of fuzzy c-means clustering) for SOC prediction on a 20 ha field.

Also, the method of calibration sample selection is very important to build models using the more representative calibration samples. Four different calibration sample selection methods were tested. The K-means clustering algorithm seems to be the best for sample selection and it can further reduce the number of calibration samples required.

Keywords：*Soil organic carbon, VIS-NIRS, calibration, on-the-go*

P4-537

[WG8] Proximal Soil Sensing

Scope to Predict Soil Properties at Within-Field Scale from Small Samples Using Proximally Sensed Data

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The demand for more detailed soil data is increasing as applications in precision agriculture, ecohydrology, planning, and hazardous site characterization are being found. In order to increase the efficiency of data generation at the field level, digital soil mapping (DSM) methods are being employed. Here, we present results where we combine proximally sensed gamma-ray spectrometry and electromagnetic induction (EMI) data to predict the variation in topsoil properties (e.g. clay), which can have a profound effect on land use and how the soil could be managed to improve agricultural productivity. In the first instance, our aim is to use these two disparate geophysical methods, coupled with a fuzzy k-means (FKM) clustering algorithm, to identify contiguous classes within a site characterised by a broad range of textural variation at the Shelford Earth Observatory, Nottinghamshire UK. The fuzziness performance index (FPI) and normalized classification entropy (NCE) did not provide conclusive evidence for the number of classes from the range k = 2–10 that should be selected from these ancillary data sets. We computed the mean prediction error variance of the class mean as a predictor for various soil properties (i.e. clay and pH) with k = 2–10 and this indicated that values of k = 7 and 8 were ideal. Of interest is that the overall approach is consistent with previously defined soil series across a multi-farm scale.

Keywords：*EM, gamma-ray spectrometry, numerical clustering*

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[WG8] Proximal Soil Sensing

Identification of WRB Soil Classification Units from Vis-Nir Spectral Signatures

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Diagnostic horizons and properties are characterized by a combination of attributes that reflect results of soil formation processes, and indicate specific conditions of soil development. Some of the features are perceptible with naked eye, or can be measured by using simple methods in the field. However, a wide range of diagnostic attributes require laboratory measurements. The applications of most of these methods are expensive, time-consuming, and often environmentally harmful.

Reflectance measurements in the visible and near-infrared region of the electromagnetic spectrum (350-2500 nm) provide an alternate or supplementary method to the conventional physical and chemical laboratory soil analysis for estimation of a wide range of key soil properties. The method is rapid, cheap, non-destructive, furthermore a single spectrum allows for simultaneous determination of various soil properties.The objective of this work is to develop methods to identify diagnostic horizons based on spectroscopic measurements, and to classify soils based on the spectral signatures through their profile.

In the frame of this study the vertical differences in spectral properties of soils developed under different geological, topographical, limatological, biological and temporal conditions were investigated in Hungary. During the field work mollic, calcic, cambic, argic and vertic horizons were identified. These horizons are diagnostic to establish the Chernozems, Kastanozems, Phaeozems, Calcisols and Cambisols, Luvisols and Vertisols reference soil groups of the WRB (World Reference Base for Soil Resources). Profiles were sampled by genetic horizons and by 25 depth intervals (in 5 cm increments to 1 m and in 10 cm increments between 1 and 1.5 m). The soil organic carbon (SOC) and CaCO3 content, pH and soil texture of samples collected from genetic horizons were determined by standard conventional laboratory methods, and used as reference data. The reflectance spectra of the samples collected in 25 depth intervals were acquired by using the Analytical Spectral Devices (ASD) FieldSpec 3 MAX portable spectroradiometer.

In order to identify classification units which are defined by organic carbon, CaCO3 and clay content spectral sub-regions were defined. The region between 400 and 1000 nm was selected based on the spectral properties of organic matter (and carbon). In order to identify diagnostic units which are defined by clay and CaCO3 content the absorption features near 2200 and 2340 nm were selected, respectively. Principal component analysis (PCA) was performed on these spectral regions. By plotting the principal component score values of the first principal component against the depth there was possible to visualize the main spectral changes along the soil profile. Similarity studies of the vertical (profile) distribution of the laboratory measured reference data and the principal component score values enabled the identification of the diagnostic horizons.

Based on the principal components score values distance measurements were performed in order to define the similarities and dissimilarities between the studied profiles. Based on the

The Euclidean distances between the spectral patterns of the profiles reflected the taxonomic relationships. Plotting the soils in a multidimensional data space, the clusters can be related to WRB reference soil groups.

The work demonstrates the significance of VIS-NIR spectroscopy in soil characterization and classification. It can supply integrative measurements of soils, and improve the cost and effort efficiency of data collection and analyses for large areas.

The research was supported by the HU-KTIA-AIK-12-12012-0012 Research Grant.

Keywords：*Soil, Reflectance, Classification, WRB, Diagnostics*

P4-540
[WG8] Proximal Soil Sensing

Potential of Using Portable X-Ray Fluorescence Spectroscopy XRF for Assessing Plant Nutrients in Soils

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X-ray fluorescence (XRF) spectroscopy is a method for assessing the elemental composition of solid and liquid samples. XRF spectroscopy can offer a very efficient way for analysing soils because the method is fast (within seconds) and needs no or very little sample preparation. In particular, mobile XRF spectroscopy has been successfully tested in the assessment of heavy metals in soils. However, due to its measuring principle XRF spectroscopy is more sensitive to elements with higher atomic numbers like heavy metals than to elements with lower atomic numbers (light elements) like some of the plant nutrients (P, Mg, K). In the recent years XRF technology has improved and the manufacturers of portable are promising an improved accuracy in the detection of light elements.

In the study presented here, a state-of the-art portable XRF analyser (Thermo Fisher Niton XL3t-980 (He)) was used to analyse soil samples for the content of Al, Ca, K, Fe, Mg, Mn, P, and Zn. Different measurement setups were used. Results for Al, Ca, K, Fe, P, and Zn were encouraging. Thus XRF analysers are potential candidates to be integrated into proximal soil sensing systems for high resolution soil mapping. However, the emission of harmful x-rays and the legal issues related to radiation protection may limit the wider use of XRF analysers.

Keywords：*X-ray fluorescence spectroscopy, light elements, plant nutrients, proximal soil sensing*

P4-541

[WG11] Soil Information Exchange Standards and Systems

An Australian-New Zealand Standard For Exchange of Soil and Landscape Data: Anzsoilml V2.0

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A wide range of environmental, economic and agricultural activities require access to current soil and landscape data from multiple data providers. Discovering, downloading, interpreting, reformatting and using this data present considerable challenges to the end-user. The Australian-New Zealand soil information model (ANZSoilML) is a Geography Mark-up Language (GML) schema specification that allows the discovery, query and exchange of standardised soil and landscape data via Open Geospatial Consortium (OGC) Web Feature Services.

We designed ANZSoilML re-using Unified Modelling Language (UML) patterns established by the geoscience community for GeoSciML. The content is based on the concepts described in the Australian and New Zealand soil description handbooks, the Australian Soil Information Transfer and Evaluation System (SITES) database design and exchange protocols and the New Zealand National Soils Database. Other abstract soil domain models (SoTerML, ISO 28258 SoilML, INSPIRE), and non-soil domain modelling activities, such as GeoSciML, have also influenced the design.

ANZSoilML enables the delivery of soil and landscape features and associated properties commonly collected as part of field surveys and laboratory analysis, and stored in databases. Soil feature concepts range from individual soil samples and specimens, through to more complex features such as soil bodies, profiles, layers and horizons, and the contextual landscapes and landforms in which soils are developed. The ANZSoilML inclusion of soil features, within a broader landscape context (including climate, geology, hydrology and anthropogenic features) could be used as a model to integrate various environmental domain specific data models, such as may be required for implementing the Australian national environmental information system, or GEO's global earth observation system of systems GEOSS.

Test and production ANZSoilML Web Feature Services have resulted in considerable improvements to the initial versions of the soil exchange standard (OzSoilML, ANZSoilML v1). Ongoing testing and deployment is expected to see the standard develop to further meet broader community use case requirements. This development is being conducted through close collaboration with the activity of the IUSS working group on soil information standards.

Keywords：*ANZSoilML, Mark-up Languages, standards, UML, Soil, Landscape, Web Feature Services*

P4-542

[WG11] Soil Information Exchange Standards and Systems

Standardising Cosmoz Probe Based Soil Moisture Measurements

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The Australian Cosmic Ray Sensor Soil Moisture Monitoring Network (CosmOz) [1-4] is a near-real time continental scale soil moisture monitoring system being developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO), Monash University, Charles Darwin University and the University of New South Wales. CosmOz aims to test the utility of Hydroinnova cosmic ray soil moisture probes for water management, water information and hydrological process research applications, and the feasibility and utility of a national near-real time soil moisture measurement network. CosmOz also aims to support the evaluation of remote sensing products and hydrological models across Australia [2-3].

The cosmic ray soil moisture probe measures the neutrons released when cosmic rays interact with hydrogen atoms in water molecules found in the soil. The neutrons are emitted into the atmosphere where they mix instantaneously, whereas the density of the fast neutrons is inversely correlated with the soil moisture. Australian CosmOz was originally inspired by the Cosmic-ray Soil Moisture Observing System (COSMOS), a continental scale network consisting of instruments that provide intermediate scale average soil moisture by measuring cosmic-ray neutrons above the land surface. COSMOS is an inspirational novel work by Zreda et al [5] which was designed to improve the continental-scale soil moisture measurement and availability of soil information. CosmOz has already deployed Hydroinnova CRS-1000 cosmic ray soil moisture probes [4] at 11 different locations throughout Australia. Each probe generates a massive amount of data relating to area-average soil moisture over its horizontal footprint.

Current calibration of cosmic ray sensors are very time consuming and expensive. A protocol to determine a standard calibration has been applied. Corrective equations are presently used to nullify the effects of universal cosmic radiation, lattice water in soil, pressure and humidity. However, there are uncertainties and questions about the effectiveness of these calibration equations in order to produce real-time accurate soil moisture estimations. Uncertainties and data resolution issues related to these new cosmic ray probes are still under serious research, due to the lack of field data, lack of understanding about highly variable micro area soil characteristics, unknown effects of universal solar radiation etc. [5]. The interpolation and normalization equations used in the soil moisture measuring calibration method are prone to error being based on limited experimental data and theoretical assumptions.

To complement this situation with additional soil information, the Australian Soil Resource Information System (ASRIS) [6] was integrated with the data from the cosmic ray probes. This ASRIS database provides online access to the best publicly available information on soil and land resources in a consistent format across Australia. These datasets provide information on the source of the data and hence indicate quality of the individual soil attribute datasets.

In this paper we propose a generic ontology for describing cosmic ray probes and ASRIS based integrated data sets to represent "probe manufacturer's specification", "probe location demography", "local soil chemistry", "calibrated fast neutron counts", "standard calibration methods to convert recorded neutron counts into area wise soil moisture", along with "localized soil profile information and soil attributes" extracted from ASRIS. This ontology will be used to standardise the information about the way cosmic ray could be used for area wise soil moisture measurements. Nodes of the CosmOz network, measured data from the cosmic ray probes, and complementary soil information will be represented within the same ontology to make a unique knowledge representation across the sensor network. In future we aim to use this ontological representation to filter any poor quality data from cosmic ray probes, and to interpret the cosmic ray probe data into soil moisture with a soil context in place.

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[WG11] Soil Information Exchange Standards and Systems

Making Apsim Open Data Driven

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Sustainable agriculture information is on high demand for farmers to make informed decisions in the crop management process. There are some tools available for predicting the crop yield and agricultural business profitability, among which is the Agriculture Production System Simulator (APSIM) [1-2]. The APSIM is a modelling framework which is developed by the Australian Commonwealth Scientific Research Organization (CSIRO) and the Queensland Government Agency. This modelling framework is used for simulating the biophysical process in a farming system for crop system management or risk prediction with environmental inputs such as rainfall, humidity, temperature, solar radiation, and wind speed. It follows the "plug-in/pull-out" approach in which users can configure the model with crop, soil and utility modules for the crop management. The model can simulate more than 20 crops and forests, e.g. alfalfa, eucalyptus, cowpea, pigeonpea, peanuts, cotton, lupin, maize, wheat, barley, sunflower, sugarcane, chickpea, and tomato. All simulation processes of the APSIM model are based on the data from the BOM-SILO database [3] which is maintained by the Queensland Climate Excellence within the Department of Science, Information Technology, Innovation and the Arts (DSITTA). The data was collected from 4760 BOM weather stations from 1889 until today. Most of the data used in the model are historical data.

Being a closed system, APSIM is not suitable for dynamic information integration. As there is no external plug-in available for accessing the model, it is hard to run the model for prediction within external applications. Furthermore, while recent trends in dynamic decision support systems are very much inclined to the use of mobile applications, there is no web based services around APSIM for that purpose.

To solve this issue, we propose to develop an open data driven model which extends the existing APSIM model with domain knowledge by following the Linked Data principles [4]. Domain knowledge is often represented as ontologies, which provide a common understanding of the concepts and their relationships within a domain of interest (in our case, the agricultural domain). We plan to express ontologies based on Semantic Web technologies, e.g. Web Ontology Language (OWL) [5] and Resource description framework Schema (RDFS) [6], which are suitable for web-based automated reasoning and decision making processes.

In our proposed data driven open model, we plan to incorporate into the model complementary data sources i.e. Australian Water Availability Project Data (AWAP) [7], Australian Soil Resource Information System (ASRIS) [8], and Australian Cosmic Ray Soil Moisture Measuring Network (CosmOz) [9]. We intend to use these complementary data sources, together with the ontologies developed for the agricultural domain, as inputs to the model to perform real-time simulation and prediction. For this purpose, we have developed a knowledge integration framework [10] based on the Environmental Spatio-temporal ontology [11]. We are

currently developing a crop ontology that will be used by the proposed open data driven model. In addition, a web service framework will be provided so people can easily access the model.

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P4-544

[WG11] Soil Information Exchange Standards and Systems

Global Soil Information Facilities: Towards a Soil-Wiki

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GSIF (Global Soil Information Facilities) is ISRIC's framework for production of open soil data. It comprises seven main components: WorldSoilProfiles.org, WorldGrids.org, R packages GSIF and plotKML, WOSIS DB / WebServices, SoilGrids and SoilInfo App (an App for mobile devices allowing live access to SoilGrids and WorldSoilProfiles). Each of the components has been developed following the FAO standards for soil data collection and international classification systems such as World Reference Base and Keys to Soil Taxonomy. In addition, R classes are soil data are used to import and process soil data to derive maps, tabular data and data summaries. The maps can be further exported using common Open Geospatial Consortium standards such as GeoTiff for gridded data and KML for web-visualization. The presentation will discuss remaining challenges of soil profile data harmonization, communication of uncertainty to the end users, multiscaling and data fusion.

Keywords：*global soil information, harmonization, crowdsourcing, web applications, open source*

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[WG11] Soil Information Exchange Standards and Systems

Reflections on the Implementation of Anzsoilml in Queensland

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The Australian and New Zealand Soil Mark-up Language or ANZSoilML is the developing standard for soil information transfer. It is an XML based complex web feature service. The Australian Collaborative Land Evaluation Program and its partners are leading the development of the new generation of soil information standards within Australia. The Queensland Government has partnered with CSIRO and the Terrestrial Ecosystem Research Network to trial an implementation of ANZSoilML from the Queensland Government soil database. The Soil and Land Information (SALI) system is a complex Oracle database with over 100 tables describing soils, their attributes and features as well as their spatial location. The SALI system holds some $75 million worth of soil information for the Queensland Government.

This paper will discuss the learning's from implementing the new breed of soil information standards using limited resources and having a very low knowledge base to start from. In the new open data and standards based paradigms, how do agencies start to make the technology shift as painlessly as possible?

Keywords：*ANZSoilML; data exchange standards*

P4-546

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Challenges and Potential Solutions to Quantifying Soil Property Predictions Uncertainty for the Globalsoilmap Using Legacy Data (US and Llanos Orientales, South America Case Studies)

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GlobalSoilMap project aims at creating digital soil property maps in a raster format for 6 standard depths and for the first time with estimates of uncertainty for predicted soil property maps. At least initially, it is expected that the majority of the predicted soil property maps will be derived from legacy soil data. The quantification of uncertainty in particular presents real challenges due to the inherent nature of legacy data coming from varying scales, formats, degree of completeness, differences in methods of observations, measurements and classifications. The presence of such diversity requires flexibility in the approaches used to meet the GlobalSoilMap standards.

Data driven methods and expert knowledge methods have been proposed both presenting unique challenges. We discuss the merits of each approach and potential solutions using two case studies from US and Llanos Orientales, South America. Both case studies have limited data with insufficient point observations for a true statistical approach for the estimation of uncertainty. The available point measurements in the US are not adequate for uncertainty quantification at soil map unit level and in addition have been purposively collected to support the assignment of mean, upper and lower property values to soil map units. Comparisons between soil map unit upper and lower limits and measured pedon ± 2σ for selected soil properties (pH, sand, silt, clay and CEC) indicate strong correlations with adjusted R2 varying from 0.37 to 0.99. The results suggest that the upper and lower values from soil map units can be used for estimating the uncertainty at least initially until other independent measured data becomes available. The available points in Llanos Orientales were collected for soil fertility evaluations and were independent of soil polygon map units. However, they were surficial samples, clustered, and biased toward cultivated fields. As a result the range of upper and lower 90% confidence interval was as wide as the range of the mean predicted soil property. These examples highlight the need for more measured point data and suggest that a versioning approach be implemented which would allow for the incorporation of more measured data as they become available.

Keywords：*Uncertainty, digital soil mapping, legacy data*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Comparison of Aggregation Ways on Soil Property Maps

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The soil property maps are usually provided at a high resolution and they need to be aggregated to a low resolution in applications such as climate and hydraulic modeling. Some basic soil properties including sand, clay, organic carbon and bulk density are used to estimate soil hydraulic parameters by pedotransfer functions. In this study, we used five up scaling methods and two aggregation orders to aggregate a polygon-based derived soil dataset. The dataset is at 30 second resolution. It was aggregated to the resolution of 1°, 30', 20', 10', 5', 3' and 1'.The up scaling methods were Window Average (WA), Widow Median (WME), Widow Modal (WMO), Arithmetic Average Variability-Weighted method (AAVW) and Dominant Class Variability-Weighted method (DCVW). The aggregation can be done before the estimation of soil hydraulic parameters or after. The difference between aggregation first and aggregation after was up to 30%, while differences between aggregation methods were about 0.1%. The aggregation did not change the original dominant features of probability density distribution. The performances of different aggregations were close according to root square mean error (RMSE). The RMSE increased rapidly when the resolution was higher than 20'.

Keywords：*up scaling, aggregation, soil data*

P4-548

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Mapping Soil-Landscape Features Using Image Object Analysis as a Spatial Framework for Soil Attribute Analysis and Communication

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Different 'soils' and spatially defined areas of 'soil type', are easily and commonly delineated in the real world. Classifying (e.g. using The Australian Soil Classification, US Soil Taxonomy or FAO World Reference Base) or naming soils (e.g. soil series or types using local, regional or national naming systems) allows us to broadly communicate about soil characteristics and provide summaries of typical soil type property values.

Digital soil mapping (DSM) is now regularly used to estimate the spatial and temporal variance of soil properties through statistical elationships with spatially extensive environmental data sets (e.g. elevation, terrain derivatives, airborne gamma ray spectrometry and satellite imagery) (Boettinger et al. 2010). A variety of such covariate data are commonly used in soil attribute modelling as surrogates to represent soil forming and process factors (Jenny 1941, McBratney et al. 2003). Analyses show that 'soil type' itself is a significant predictor of many soil properties (Viscarra Rossel 2011) since variance within the soil body (or type) is likely to be less than the variance of properties between soil types. Maps of soil type are therefore a valuable input to DSM predictions.

Soil maps available currently in Australia are often broad scale (e.g. atlas of Australian soils 1:2m, land systems 1:1m to 1:250k, or soil associations 1:100k). Such surveys usually delineate soil and landscape complexes rather than homogeneous soil types. As a consequence, DSM projects which use these maps as inputs often contain obvious spatial artefacts of the mapping in their outputs.

This paper presents the initial results of a trial in northern Australia which used object-based image analysis software to improve both the spatial registration and delineation of mapped soil 'regions' and to disaggregate complex soil landscapes into more spatially explicit and homogeneous features. Master image segmentation was initially performed using gamma radiometric and terrain derivative data along with optical satellite imagery. This delineated regional objects which were classified into landscape units, a process similar to mapping broad scale physiographic regions. Within each region (or zone), further detailed object segmentation was undertaken on the basis of local covariate relationships. Object spectral difference was then used to classify and map similar landscape (land system and unit) and soil (type) features.

Further work is being done to determine the best methods for attribution of mapped features. This could be done using site data and existing soil map descriptors where they exist. Another approach being investigated is to use spatially detailed DSM derived attribute estimates to create feature based average and variance descriptions. Such spatially summarized data can then be used for communication of general soil type characteristics, in the way that traditional map products are currently used. They can also be applied within suitability assessment frameworks to determine the likely suitability of an area of interest for a particular land use.

Mapping soil digitally (MSD) through automated image feature extraction will provide improved spatial inputs to DSM approaches which may assist in reducing uncertainty in attribute estimation. Providing summary statistics and generalised descriptions of the soil property values within spatially explicit areas of land (defined within a nested hierarchy of scales) provides a good communication mechanism for users.

Keywords：*image object analysis, soil type, spatial framework, communication*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Mapping and Updating Soil Series Using Random Forest and Conditioned Latin Hypercube Sampling in the Loess Soils of Northern Iran

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Soil maps are major sources of information for the management of lands, natural resources and other environmental aspects. Many areas in Iran have older soil maps that need to be updated. Conventional methods of soil mapping are expensive and time-consuming. Therefore, using a digital soil mapping approach for updating soil surveys is particularly useful, especially in sparsely sampled areas as for the Golestan province in Iran. In this paper, topographic attributes, and legacy soil maps, land use and the soil adjusted vegetation index (SAVI) were used as environmental covariates. Conditioned Latin Hypercube Sampling (cLHS) was used to determine the position of 99 soil sampling locations in the study area (approximately 85,000 ha). At each sampling location soils were classified to soil series level according to Soil Taxonomy.

Random forests (RF) were used to identify relationships between soil series and environmental covariates and to predict soil series, both with and without SAVI and the conventional soil series map. Results indicated that RF can predict soil series classes when small data sets are used. SAVI, the conventional soil series map, geomorphology, land use, elevation and aspect were the most relevant covariates. We found that updated maps with RF were 10% more accurate than the existing conventional soil map.

Keywords：*Soil Mapping, Random Forest, Prediction, Loess, SAVI, cLHS, Golestan.*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Spatial Representation of Soil Properties in Earth System Models

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Soil properties such as organic carbon stocks and active-layer thickness are used in earth system models (ESMs) to predict anthropogenic and climatic impacts on soil carbon dynamics, future greenhouse gas concentrations, and associated climate changes in permafrost affected regions. Accurate representation of spatial and vertical distribution of these soil properties in ESMs is a prerequisite for reducing existing uncertainty in predicting carbon-climate feedbacks. We compared the spatial representation of soil organic carbon (SOC) stocks and active-layer thicknesses predicted by the coupled model intercomparison project phase 5 (CMIP5) ESMs with those predicted from a new geospatial model, based on observation data, for the state of Alaska, USA. For the geospatial modeling, we used soil profile observations (472 for SOC stocks and 153 for active-layer thickness) and environmental variables (climate, topography, land cover, and bedrock geology) and generated fine-resolution (60-m spatial resolution) predictions of SOC stocks (to 1-m depth) and active-layer thickness across Alaska. We found large inter-quartile ranges in CMIP5 modeled results (0.35-4.4 m in predicted active-layer thickness and 7-56 kg m-2 in predicted SOC stocks). The spatial coefficient of variability of active-layer thickness and SOC stocks were substantially lower in CMIP5 predictions compared to our geospatial estimates when gridded at similar spatial resolutions (23.5 compared to 30% and 29 compared to 52%, respectively). However, prediction errors, when calculated for independent validation sites, were several times larger in ESM predictions compared to geospatial predictions. Primary factors leading to observed differences in spatial heterogeneity and prediction errors between ESM and geospatial predictions were (1) lack of spatial heterogeneity in ESM predictions, (2) differences in assumptions concerning environmental controls, and (3) the absence of pedogenic processes in ESM model structures. Our results suggest that efforts to incorporate these issues in ESMs could help to reduce current uncertainties associated with ESM predictions of carbon-climate feedbacks.

Keywords：*soil organic carbon, active-layer thickness, earth system model, CMIP5*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Australia's Globalsoilmap - The System and its Components

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The Australian soil information community is now releasing the nation's first version of GlobalSoilMap. It is both a complete realisation of the minimum concept of GlobalSoilMap and a more complex information system connected to the diverse Australian soil information legacy. In addition to the soil functional attributes and the soil-depth relationships detailed in the GlobalSoilMap specifications (at 3 arc second resolution), the Australian system includes new landscape surfaces (1 and 3 arc second), a soil inference system capable of predicting more complex functions (especially simulation model parameters) and an online storage and access system allowing free data delivery. It is part of the Australian Soil Resource Information System and a comprehensive enhancement of that system. It has also been recognised as an essential component of Australia's scientific infrastructure to give new support to, for example, the biophysical modelling community. The paper explores the features of the new systems and describes the increase in utility gained from this addition to the continent's soil information system.

In the process of building the Australian GlobalSoilMap system, new tools, methods and scientific understanding have been generated. These include new methods for disaggregating legacy soil maps, new approaches for continental estimations, innovation in covariates, preparation and use of legacy site data, the incorporation of soil inference systems, a new approach to regolith depth estimation and methods to match spatial soil information to simulation modelling. A feature of the Australian experience in contributing to GlobalSoilMap has been the investigation and application of methods to reconcile bottom-up (soil polygon disaggregation) with top-down (continental scale inference) prediction methods. Three complementary datasets now exist – the enhanced legacy mapping for the those parts of Australia with good quality correlated soil mapping, the continental estimates of soil attributes and the official national system derived from both.

Keywords：*globalsoilmap , soil information, soil estimation*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Application of Spatial Simulated Annealing Method on a Soil Sampling Scheme in the Road Surrounding Region

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This study is conducted to clarify the impact of different sampling schemes on accurate interpretation of soil knowledge, such as the spatial variation of soil organic matter (SOM). Based on the spatial distribution of the road, the sampling schemes were formed. First, the simulated annealing was carried out for optimising the sampling layout patterns of SOM in the five different road surrounding regions among eastern part of Zhongxiang county. Second, based on surface analysis, the topographic factors were extracted from DEM data, including slope, aspect, plane curvature, profile curvature, topographic wetness index (TWI), stream power index (SPI) and sediment transport index (STI). After that, the topographic factors and optimised SOM samples were used for finding out the quantitative soil-landscape models, which would be used to forecast the SOM level. The models were developed by means of multiple linear regression (MLR) and multilayer perception (MLP) separately, and their accuracy was distinguished by MSE, NMSE, et al. The results reveal that exactly soil-landscape knowledge can elicit from optimised sampling scheme, and the predicted accuracy reaches the significant level and it is better than the accuracy of the original samples. According to the study, the low cost and high efficiency sampling pattern can be designed by taking advantage of the available information, such as the spatial distribution pattern of the road, historical samples and soil survey data. The study proposes a reasonable, theoretical and scientific means for displaying and surveying the spatial distribution pattern of soil organic matter in the whole region of Zhongxiang county.

Keywords：*soil-landscape model; spatial simulated annealing; multilayer perception; sampling optimization*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Spatial Prediction of Soil Variables Based on Primary Terrain Attributes in a Gentle Area

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Primary terrain attributes derived directly from the DEMs without additional inputs have been used widely for mapping soil properties. However, to our knowledge, little attention has been paid to the effect of primary terrain attributes which calculated by various methods on the distribution of soils and its properties. This paper aims to investigate the relationships between local topographical properties derived from DEM and soil distribution by incorporating them into co-kriging method. The study area is located in the south-east area of the Anhui Province in China, range from 118.4◦to 119.0◦E and 30.5◦to 31.3◦N, is situated in the Qingyijiang watershed and has a total area 2533 km2. We collected 70 soil samples at different topographic locations in July 2012. We dug 1.2 m-depth profiles at each location, and collected samples from the A-horizon. The locations of the samples were determined by GPS handset. The samples were analyzed for gravel capacity, soil bulk density, SOM, N, P, K, available potassium, pH, CEC, coarse sand content, silt content and clay content.

In this paper, four mathematical methods are utilized to compute local terrain variables. Among the four methods, the Evans method (Evans, 1980) and the Horn method (Horn, 1981) are based on a quadratic polynomial, the Zevenbergen-Thorne method (Zevenbergen, 1987) and the Shi method (Shi, 2007) are based on a Lagrange polynomial. Seven local terrain variables derived from SRTM DEM with a 90-m resolution are slope gradient, slope aspect, profile curvature, planform curvature, tangent curvature, minimal curvature, maximal curvature and curvature. The software tool used to generate these layers is ArcSIE. Six curvatures are computed by Zevenbergen-Thorne method and Evans method. Slope gradient and slope aspect are calculated by all these four methods. Finally, twenty layers are derived from DEM.

After a comprehensive Pearson correlation analysis between all these layers and soil properties, we find that the correlation coefficients between available potassium and four aspects is 0.16, 0.13, 0.005 and 0.055 respectively. The Pearson correlation between coarse sand and four aspects is 0.15, 0.1, 0.3 and 0.005 respectively. Furthermore, the aspects with relatively high and low relation are selected as the ancillary information of co-kriging. The available potassium and coarse sand are selected as the predictive objective for the comparison of different methods. Co-kriging is adopted for the prediction of the available potassium and coarse sand. Co-kriging is a multivariate extension of kriging that combines a sparsely measured primary variable with a denser set of ancillary data as secondary variable that is spatially cross correlated. Mean error (ME) and root mean square error (RMSE) are used to verify global prediction accuracy. The ME and RMSE of predication of available potassium content with Evans method and Shi method are 7.33, 27.28 and 7.88, 29.25 respectively. The ME and RMSE of predication of coarse sand content with Shi method and Zevenbergen-Thorne method are 2.31, 8.53 and 2.60, 8.87 respectively. The experimental results show that appropriate local terrain attributes may enhance the estimation even if the cross-correlation between primary and secondary variable is not remarkable.

This study is supported by National Natural Science Foundation of China (Integration Program No. 91325301, Key Program No. 41130530, and General Program No. 4137122).

Keywords：*Co-kriging; Digital soil mapping; Terrain variable*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Alpha Beta Gamma of Radiometrics for Enhancing Digital Soil Mapping

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Measurements of soil gamma emissions are attractive covariate data in digital soil mapping because aerial gamma data can cover large areas (generally entire countries) and its abundance and type provides inferences on type and weathering extent of parent material. Naturally, measurements of gamma emissions provide an independent compliment to inference gained from topography and its associated attributes. Historically, gamma-ray spectrometry was used to identify uranium deposits and the United States Geological Survey (USGS) wanted to locate these deposits. In the late 1970's, the USGS conducted multiple aerial surveys across the nation to collect gamma data at window energies representing potassium, uranium, and thorium gamma emissions. The surveys were typically flown at 120 meters with line spacing between the ranges of 8 to 16 km. This dataset was then interpolated onto a 2 km grid and is available for visual inspection on their website. One of the flaws of this interpolated raster image is that not all surveys were properly calibrated and was thus never properly levelled. At first glance of the United States, however, dose rate (a weighted combination of K, U, and U signals) correlates with lithological units. Furthermore, spatial patterns of variable dose responses are still visible once zoomed in at the intra-geology scale. Currently, gamma data exhibit patterns with soil clay content, type of parent material, and weathering extent on a field scale. If gamma radiometric data is to be considered useful, the previously mentioned relationships must expand beyond the field scale and into the regional and national scale. For this transition to take place, many questions on gamma response between rock types, within rock types, and the use of proximal surveys to calibrate and support aerial surveys need answering.

To begin the exploratory analysis, we investigated how the USGS gamma-ray dataset responded to rock type and soil clay content by using geo-referenced soil characterization data. The soil data was obtained and analyzed by both the Texas Agrilife Research Soil Characterization Lab as well as from the USDA-NRCS National Soil Lab in Lincoln, Nebraska. The first investigation involved the prediction of surface clay content using backward stepwise linear regression across Texas using only the gamma-ray data. The results indicated that variation within rock types were poor, with unconsolidated deposits accounting for the most amount of variability. Next, Texas geology data (from USGS) and physiographic region vectors were included in a linear-mixed effects model, along with the gamma-ray data, to identify the components best accounting for clay content. Results indicated that the gamma-ray signal primarily responded to rock type and very little to changes in soil clay. Although these cursory findings are not encouraging, they are not conclusive for two reasons: 1) clear spatial patterns exist in dose response within apparently uniform parent materials, and 2) the pedon data used for validation were not optimally spatially distributed for calibrating or investigating aerial (inter and intra geology) gamma-ray data. The next step in assessing the usefulness of aerial gamma data includes proximal passive gamma surveys in four parent materials and under the footprint of aerial survey tracks. These results will be reported and we expect they will provide information on 1) the spatial averaging of aerial gamma data and 2) improved calibration information for converting aerial gamma data into soil information.

Keywords：*gamma radiometrics, digital soil mapping, proximal sensing*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

A New Digital Soil Resource for Tasmania, Australia

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A Digital Soil Assessment (DSA) totalling 70,000ha was piloted for the Tasmanian Government in 2012 to provide a measure of suitability of various agricultural enterprises in two newly commissioned irrigation schemes in Tasmania, Australia. The DSA generated various digital soil and climate grids at 30m resolution from 930 soil cores, which were applied to suitability rule-sets for twenty different enterprises to identify limiting soil or climate parameters (www.dpipwe.tas.gov.au/wealthfromwater). This work has progressed into development of soil and climate surfaces for the entire state (68,401km^2) using existing soil information and re-deployment of temperature sensors during 2013 and 2014, primarily to extend the suitability mapping but also contribute to the TERN (Terrestrial Ecosystem Research Network Soil and Landscape Grid of Australia, www.tern.org.au) and the GlobalSoilMap collaborations (www.globalsoilmap.net).

The soil grids are being generated to GlobalSoilMap-specified depths and properties at 80m resolution (corresponding to a 3 arc-second grid system for Tasmania, approximately 10.5 million pixels) in addition to the soil properties required for the Enterprise Suitability Assessment (ESA). Surfaces include pH, EC, particle size fractions, exchangeable cations, soil drainage, and organic carbon %, modelled from existing Tasmanian soil point-source information. Specified standard depths were computed for each soil site by fitting mass-preserving depth-splines. State-wide covariates (spatial environmental predictors) were prepared and re-sampled to a standard 80m grid system, including terrain derivatives (eg. slope, eastness, northness, plan-curvature, topographic wetness index) generated from the 3-arc-second SRTM-DEM; persistent-greenness index (from LandSat multispectral imagery); annual rainfall (ESOCLIM); a “distance-to-coast index”; and gamma-radiometrics (Uranium, Potassium, Thorium and Total Count). DSM surfaces were modelled using regression-trees (RT) for continuous soil properties, and decision-trees (DT) for discrete or ordinal properties, with 30% of sites held-back for validation. Existing (legacy) soil sites have various soil property attributions at different depths; this ranges from 6,500 sites with pH in the top-soil, to approximately 3000 organic carbon sites, to only 300 bulk-density sites. Consequently, validations for soil properties and depths are variable, for example clay % has a validation concordance (Lin’s Concordance Coefficient) of 0.51 and RMSE of 11.26 (%) for the 0 to 0.05m depth range, reducing to 0.40 and 16.38 respectively between 0.60 and 1.00m. Uncertainties (in the form of upper and lower predictions) are being derived using a measure of distance of each pixel to the fuzzy k-mean centroid of the covariates used for predictions (Malone et al in prep 2013). Various pedotransfer functions are applied where required soil property data is limited.

Tasmanian legacy soil sites are concentrated in agricultural land resulting in generally lower uncertainties of prediction in these areas, but higher uncertainties in forested or conservation areas, or when extrapolating into areas with under-represented

environmental covariate values. Sites in the south-western World Heritage-listed wilderness are scarce; however this is a considered a very important region for environmental or ecological modelling activities, having some of the highest biodiversity and organic carbon levels in Australia. Initial DSM of organic carbon is tending to under-predict this. To improve predictions in these areas disaggregation of existing land-systems polygonal mapping is being tested using the DSMART approach (Odgers et al 2013) to identify minor un-mapped components and apply modal soil profile property information. This will be integrated with the point-prediction DSM surfaces where uncertainties are highest, or incorporated into predictions as an additional environmental covariate. In a concerted effort to improve the DSM modelling but limit the potential resources required for additional sampling, a further 3,500 legacy soil sites have been unearthed which will be quality-checked and digitally captured during 2014, before being incorporated into DSM model re-runs.

Preliminary GSM surfaces have been requested and found useful by agricultural and ecological modellers for various analyses; for example, clay % and soil drainage as covariates for Eucalyptus obliqua and E.nitens species-abundance modelling, and developing climate-change adaptation strategies in response to projected pasture-yields. The product is envisaged to provide a dynamic resource that will be widely used and improved in future years as DSM techniques evolve and more soils data and covariates are collected, and identify priority areas where future soil-sampling is required.

Keywords：*Digital Soil Mapping, GlobalSoilMap, Land Suitability, Legacy Data*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Evaluating Soils for Rural and Agricultural Development: Putting Human Face on Soil Survey and Mapping for Sustained Ecosystem Services in Mosiro, Kajido County, Kenya

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In Kenya, biophysical land resources information has been generated at various scales for the analysis of land resources potentials through soil and agro-ecosystem based investigation and mapping. This has been mainly for enriching the national biophysical databases for multi-purpose land use planning. The approaches employed in soil survey, mapping and evaluation are pegged on standards, based on scientific principles and criteria developed by FAO and Kenya Soil Survey Staff. However, this paper demonstrates how human face has been put in these approaches to fine-tune them to be in line with the Vision 2030, which is the country's development bleu print. In this regards, soil survey and mapping with human face was employed in Mosiro, Kajiado County, Kenya by considering various development projects, which are currently being implemented in the country, which focus on catchment conservation and management for enhanced water supply and quality; irrigation development for improved food security and income; and rural cantered development through enhanced energy supply. This paper explains how cluster-based soil survey was employed as human-development oriented approach to arrive at clusters of soils through analysis of the capacity of the soil to control soil erosion in the upper and lower regions of the project area, using semi-qualitative land evaluation processes. Cluster 1 was identified as the upper regions which comprised the upper level catchment, intensively cultivated rolling uplands and steep valley sides, while cluster 2 was the lower regions comprising mainly the irrigated lowlands. The results showed that the irrigated lowlands had the highest run-off potential of 130% with sediment yield of more than 65%. The steep sides of the valley sides had run-off potential of 123% with sediment yield of 29%, while the upper level catchment had run-off potential of 111% with the highest sediment yield of 75%. The lowest run-off potential was recorded in intensively cultivated, rolling uplands with values of 21 and 25% for run-off and sediment yields respectively. These results indicate that the dam constructed for hydraulic electric power generation and irrigation scheme downstream are at the risk on increased siltation and collapse of the hydraulic structures unless appropriate strategies are put in place for controlled soil erosion and land degradation in the upper regions.

Keywords：*Soil quality, productivity index and land degradation*

P4-557

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Spatial Distribution of Soil Organic Carbon in Southern Greenland Assessed Following the Globalsoilmap.net Specifications

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Soil organic carbon (SOC) stocks in the Arctic are generally poorly constrained due to limited data and large soil variability. The current and anticipated future climatic changes in the region are furthermore demanding more detailed knowledge on soils organic carbon here. It is anticipated that soil temperature change in combination with land use change will drive changes in soil organic matter turnover which in turn will affect CO_2 and N_2O emissions. This is of paramount importance since large part of the sub-arctic areas are peatland (Helama et al., 2011). Recent studies have suggested that SOC stocks in arctic and subarctic ecosystems may be underestimated by a factor of two (Hugelius et al., 2013). This is mainly considered to be due to underestimated storage in cryoturbated permafrost soil and peatlands (Burnham & Sletten, 2010). As an example is the current understanding of SOC stocks and variation in southern Greenland based on a limited number of pedons and field data (e.g. Jacobsen & Eiby, 1997). A soil map of greenland was published recently (Jones et al, 2010) but sampling was designed for large scale maps only.

It remains thus to be re-assessed how large the SOC stocks are in southern Greenland, and as part of this, to assess how soils in general will respond to the predicted warming climate and anticipated expansion of agricultural cultivation in this region. We will present the basics for establishing methods for a soil resource database following the Globalsoilmap.net specifications (Minasny & McBratney, 2010) with special focus on SOC which can address the above questions.

A pilot study was established near Qaqortoq in Southern Greenland to study soil variability by Digital Soil Mapping applications (McBratney et al, 2003). One of several objectives was to map and predict the spatial distribution of SOCand its stock in the top soil layers. The study site was chosen to be representative for southern Greenland in a future, warmer climate where fields for winter fodder production dominate in suitable low elevation areas, whereas higher landscape positions have grazing land or is bare rocks. This insured the best unbiased representation of all geomorphologic units characterizing the area. Soil samples were collected in intervals from 0 to 15 cm depth at each 200 m grid intersection within a study area of approximately 6.5 km^2. The elevation was 0-400 m a.s.l. Permafrost is considered discontinuous and found above our max. height of sampling only. Samples were analyzed for SOC (g kg^{-3}), stone content and bulk density (g cm^{-3}).

A prediction soil organic C model based on SCORPAN' kriging was produced where the relationship between observed SOC content and SCORPAN variables was quantified with regression techniques. The maps generated at a grid size of 90x90 m for the entire study area. These maps of SOC content may serve as a first basis for a more detailed assessments of SOC stocks and

variability in southern Greenland, and allow us to evaluate whether current estimates of SOC storage in this area are underestimated.

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Keywords：*Greenland, Globalsoilmap.net, Soil organic carbon*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Using Time-Series Covariates to Improve Predictions of Subsoil Properties

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Many catchment-scale digital soil mapping studies have found that the prediction quality for subsoil properties is worse than those obtained for topsoil properties. This has been attributed to the lack of useful covariates which directly or indirectly measure subsoil properties. For example, gamma radiometrics directly measures the top 20 cm of soil while other covariates such as slope are more useful for predicting topsoil as they relate more to surface erosional processes. A commonly used covariate is remotely sensed images of the land surface which in vegetated landscapes should reflect soil properties to the rooting depth of the plant. However in most cases a single image is used which in a landscape with different crops and vegetation may not be representative of a typical canopy reflectance for a particular soil. For example the same soil with different crops would have different reflectance at any point in time. An alternative approach would be to use a time series of images and use parameters which describe its distribution as covariates (e.g. measures of centre and spread, maximum, minimum). This would negate some of differences due to using single images.

Another approach is to use space-time model predictions of dynamic soil property and use these to predict a static soil property. This is the approach we focus on this work where we use a simple water balance model based on the difference between rainfall (R) and evapo-transpiration (ET) to give prediction in space and time of soil moisture. Rainfall estimates are given by interpolated rainfall gauges and ET estimates are provided by the MODIS 16 ET product. Together this gives profile soil water predictions (R-ET) at a spatial resolution of 500 m and temporal resolution of 8 days. At each location we use parameters extracted from the distribution of the time series of soil moisture predictions as covariates to predict subsoil clay content.

We compare the three approaches (one image, a time series of images, a time series of soil moisture maps) in a case study from eastern Australian for the prediction of subsoil clay content. The remote sensing platform is MODIS.

Keywords：*digital soil mapping, remote sensing, subsoil*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Ensemble Model to Predict the Available Water Capacity of Australian Soils

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Soil available water capacity (AWC) is the main source of water for vegetation and it is the potential amount of water available for atmospheric exchange. Its spatial distribution is crucial for agricultural planning and management. The aim of this work is to obtain a continuous spatial prediction of AWC for Australia's wheat-belt (around 1.61637x106 km^2) up to 100 cm deep. We used a data set compiling 806 soil profiles to model drainage upper limit (DUL) and crop lower limit (CLL) at five depth intervals (0-5, 5-15, 15-30, 30-60 and 60-100 cm) using environmental information (topographic, climatic, soils, Landsat imagery, gamma-ray spectrometry) as covariates. We decided to model DUL and CLL separately (and not AWC=DUL+CLL) due to the different factors and related uncertainties governing both water retention processes. The modelling techniques used were symbolic regression (genetic programming), Cubist (regression tree), and support vector machines. After the modelling process, an ensemble model was generated using the ordinary least square estimates of a multiple linear regression of the models' predictions as weights. The use of an ensemble technique led to obtain better performance compared with any of the individual models. To assess the uncertainty of each property, presented as upper and lower prediction limits, the fuzzy k-means with extragrades algorithm was used. The obtained R^2 values presented an expected decrease in depth and with higher magnitude for the usually highly dispersed DUL (from 0.60 in surface to 0.38 in depth for DUL and 0.66 to 0.46 for CLL). Finally, the ensemble model was applied to a grid spacing of 500 m generating the final AWC map and the lower and upper prediction intervals maps associated with it.

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Artificial Neural Network for Mapping and Mitigation-Orientated Characterization of Acid Sulfate Soils: Application to Sirppujoki River Catchment, South-Western Finland

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Finnish acid sulfate (a.s.) soils originate from sulfide-bearing sediments deposited at the bottom of the Baltic Sea since the Litorina-Sea stage (Holocene). These soils constitute a major environmental problem as they can release a toxic combination of acidity and metals in the recipient streams and estuaries, causing severe ecological damage. Small a.s. soil areas may affect large water bodies and pinpointing these hot spot areas is critical for effective mitigation. A cooperation network headed by the Geological Survey of Finland was established in 2009 in order to create a nationwide a.s. soil map, which will be completed by 2015. Conventional mapping and sampling in the field is expensive and time-consuming, and complementary spatial modelling techniques may be used in order to define and narrow down areas of interest. Among the diverse spatial modelling techniques available, a method utilizing an Artificial Neural Network (ANN) was selected, in particular owing to its good pattern recognition and classification tools with the ability to generalize from imprecise input data. The method is implemented within R environment and its results can be visualized within a Geographic Information System (GIS).

The aim of this study is to assess the predictive classification abilities of ANN not only for a.s. soil mapping, but also for a more elaborated mitigation-orientated characterization of these soils (i.e. modelling different soil parameters). The selected study area is the Sirppujoki catchment (460 km2), located in south-western Finland. This study is also conducted within the framework of the VALUE doctoral program which focuses on integrated catchment and water resources management.

A Radial Basis Function (RBF) -based ANN is applied in order to create probability maps both for a.s. soil occurrence in the study area, and for modelling the contents of organic matter and sulfur, and the risk depth. The network requires aerogeophysical, quaternary geology and elevation data, as well as known occurrences of a.s. and non-a.s. soils. The a.s. soil occurrences are defined by soil profiles containing sulfides within 3 m depth (i.e. profiles comprising an oxidized acidic layer as well as underlying transition and reduced sulfidic horizons, and/or a decrease in pH after incubation by 0.5 units to a value lower than 4.0). The known occurrences are divided into two sets: the training and validation points. First, the RBF network is trained, basically by associating the different data layers with the training points and learning to classify these points accurately. Then, the accuracy of the classification is assessed using the validation points: the more points that are correctly classified, the more accurate is the classification. Finally, the neural network is classifying the rest of the study area in the same manner, which leads to the creation of a probability map. Among the modelled soil parameters, the organic matter content (%) is determined by loss on ignition, and the sulfur content by CHNS Elemental Analyzer (i.e. flash combustion followed by gas chromatography). The risk depth is here defined as the upper limit of the sulfidic soil material which has a field pH higher than 4.5 due to limited oxidation, but will reach a pH lower than 4.0 upon 19 weeks of incubation. The use of a probability map for a.s. soil occurrence in conjunction with the modelled soil parameters may allow a more precise characterization of a.s. soils in the study area. Development of more levels of modelling could enable a mitigation-orientated identification of a.s. soils, which would constitute an advance for future soil and water management.

Keywords：*neural network, acid sulfate soils, characterization, mapping, modelling*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Digital Soil Mapping in Regional Agricultural Resource Assessment

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Northern Australia is a region of approximately 1.2 M Km2 occupying tropical Australia north of latitude 20 S. While covering approximately 20% of Australia's land mass, it contributes approximately 2% of national wealth. Land use is dominated by a cattle industry on extensive rangelands. Since European settlement there has been a recurring goal to intensify land use in the North. The contemporary drivers for this include the desire to open markets near to the growing economies along the Asia-Pacific rim, and to hedge against human induced climate variability in Australia's main southern agricultural zone, which appears vulnerable. Given these drivers, the Office of Northern Australia commissioned the Flinders and Gilbert Agricultural Resource Assessment (FGARA) project to evaluate the scale of opportunity at a broad, strategic level for agricultural intensification through irrigation in the Flinders (109,000 Km2) and Gilbert (46,000 km2) river catchments in Queensland's Gulf Country.

The project entailed conducting crop suitability assessments for 40 crops under various irrigation scenarios. Significant project challenges were identified during scoping, the largest of which included: limited existing ('legacy') soil data, 1.5 year project timeframe effectively only permitting one field season for new soil survey, and an unpredictable open and close to the field season due to flooding. Given these operational challenges, a pragmatic digital soil mapping (DSM) approach was called for to supply the soil mapping needs of the crop suitability assessment. The main attractions of a DSM approach in this instance included: ready access to a comprehensive database of environmental covariates suitable for fine scale (30 m ground resolution) mapping outputs, a consistent and simultaneous whole-of-study-area mapping approach, rapid soil modelling and map compilation on receipt of soil training data, and finally, capability to generate reliability mapping for each variable.

Here we describe the DSM methodology to generate soil variable maps to satisfy the crop suitability needs of the FGARA project. Included in the discussion are: design of a pragmatic statistically-based survey design (flexible Latin hypercube sampling), creation of a model training dataset by blending legacy and newly acquired FGARA soil data, development of a rules-based modelling framework using an environmental correlation style of DSM applying the RuleFit3 analytical toolset, and an analytical suite to evaluate quality of variable mapping using internal cross-validation, independent validation, and non-parametric bootstrapping. While we used DSM to generate a suite of 16 soil variables feeding into the crop suitability assessment, for brevity we focus on three output data categories, namely: pH (numerical), absence/presence of surface rocks (binary), and soil permeability (categorical).

We report that DSM and allied technologies are sufficiently advanced, adaptable and robust to supply a pragmatic, operational solution for large area mapping (here, 155,000 Km2) of multiple soil variables. DSM can be used as a standalone soil resource assessment method to support regional soil inventories, or as described here, a method to feed into model-based assessments such as crop suitability studies. Furthermore, mapped estimates of reliability facilitate discussions based on mapping reliability between land resource scientists and stakeholders of the land.

Keywords：*agricultural resource assessment, digital soil mapping*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Prediction Interval Analysis of Clay, Soil Organic Carbon, and Ph for Globalsoilmap from Statsgo2, Ssurgo, and Disaggregated Ssurgo Data in West Virginia, USA

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Of the different approaches to producing soil property data for GlobalSoilMap (GSM) standards, leveraging legacy vector soil surveys has potential to produce much of the initial version of GSM property grids in many countries. This project evaluates using different scales of legacy soil map data to produce GSM surfaces with attributed prediction intervals (PI) to address uncertainty. Direct use of the USDA-NRCS State Soil Geographic (STATSGO2) database and the USDA-NRCS Soil Survey Geographic (SSURGO) database were compared with more appropriately scaled disaggregated SSURGO (dSSURGO) data for producing property grids with PI. An equal area spline was used to adjust soil property estimates from these sources to the six standard GSM depth intervals. The dSSURGO data was created from SSURGO using random forest models that trained satellite imagery, terrain metrics, and lithology maps to typified locations of soil series classes. Underlying probabilities from the random forest model were used to specify fuzzy membership of soil classes for querying actual soil property values from the original SSURGO attribute tables. Property maps and associated PI of soil pH, organic carbon, and clay percentage of fines were produced with all three data sources. High, representative, and low values listed in the soil series property description tables were used to create property value grid estimates and PI boundaries. To create a grid cell estimate for each property, source data were aggregated (i) by map unit polygon component percentage of soils in each map unit as a weighted average for the STATSGO2 and SSURGO versions and (ii) by using probabilistic fuzzy membership of soil series for dSSURGO from the underlying prediction frequencies of the random forest model. The PI were created using the highest high value and lowest low value for all soils included as components in STATSGO and SSURGO, and from the soils included with a minimum membership threshold in the dSSURGO random forest model. Property maps and associated PI produced by these methods were evaluated in the Eastern Allegheny Plateau and Mountains of southern West Virginia using laboratory characterized soil profile descriptions.

Keywords：*Uncertainty, Prediction Intervals, Soil Property Maps*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Pedoecological Mapping to Improve Forest Management

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Conventional soil maps (CSM) like the USDA-NRCS Soil Survey Geographic (SSURGO) database have been used for land management since their inception in the early 20th century. Although CSM have been widely used, modern demands for high resolution soil information at a field-scale are not suitable applications for CSM in many cases. Spatial disaggregation of CSM using digital soil mapping (DSM) methods in recent studies bridges the resolution gap needed for implementation into field-scale management schema like Ecological Site Descriptions (ESD). ESD integrate information on soil, vegetation, habitat, ecosystem service, and land management by grouping areas with soils of similar ecological potential (climate, physiography, natural vegetation composition, hydrologic function, vegetative productivity, habitat, and resilience to disturbance). To further utilize these resources, mapping could integrate both ESD and disaggregated CSM into pedoecological maps (PEM). ESD use state and transition models to illustrate and attribute the different potential reference biological communities (mainly vegetation descriptions) and also degraded states that result from both natural and human disturbance. Each of these states has an associated set of vegetation production amounts and dynamic soil property measures (e.g. O horizon thickness, aggregate stability) that distinguish them from other states within the same ecological site. If these states can be integrated with DSM and disaggregation techniques, it can greatly increase our ability to target specific areas for management actions (e.g. selected harvest of timber). We present a PEM example using a disaggregated soil map and forest classification data in the Monongahela National Forest (MNF), West Virginia, USA. Disaggregated soil maps were created using geomorphic descriptors to guide the training of a machine learning classification model. Forest composition field plot data and inventory maps were used to create a forest vegetation classification to combine with the disaggregated soil maps to create PEM maps that distinguish both what type of ESD and the state (reference or disturbance and type) of all pixels in the study area. With these data we can begin to monitor and make spatiotemporal predictions regarding pedoecological responses to management within human timeframes. In the MNF study area, this is especially important with respect to potential carbon sequestration via conifer forest restoration and the health of much of the Potomac and Ohio River watersheds, which are vital to large areas of the eastern US.

Keywords：*disaggregation, pedoecology, digital soil mapping, ecological sites*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Soils in the Soyang Lake Watershed: Soil Sampling Design and Early Soil Description

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Soil in the complex mountain areas is one of the most important factors to provide ecosystem services, such as carbon storage, water purification and as the basis for plant and soil live development. The knowledge about spatial distribution of soils and the soil forming processes is limited. We need to extend the information about soils in the complex mountain areas. For that purpose, a soil sampling design has been developed to get representative impressions of the spatial distribution of physical and chemical soil properties in Soyang lake watershed. Conditioned Latin Hypercube Sampling (cLHS) is one of the stratified random sampling methods offeringan optimal coverage of the variability of environmental variables' covariates in feature space. Because of the variety of soil forming processes, several of environmental variables are included in the soil sampling design, e. g. geology, elevation, incoming solar radiation, surface curvature, upslope contributing area, NDVI and landuse. Due to the limited accessibility (e. g. landmines, steep slopes and time), 300m-bufferzones along the roads and footpaths are also considered in the sampling design.

n addition to the soil description in the field physical soil parameters are measured like shear ratio and soil humidity. We further take disturbed and undisturbed soil samples to analyze physical and chemical soil properties in the laboratory related to ecological functions, e. g. soil organic carbon, nitrogen and water retention. The collected soil properties will provide us with the required data to describe spatial distribution of soil types and will give us additional hints on soil development in the study area.

Digital soil mapping (DSM) will be used to identify statistical relationships between soil properties and environmental variables. The resulting functional maps will provide us with information on ecological land potentials and soil related environmental risks in Soyang lake watershed. Key words: chemical and physical soil properties, digital soil mapping, Soil Sampling design, environmental variables, soil ecological functions

Keywords：*chemical and physical soil properties, digital soil mapping, Soil Sampling design, environmental var*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

A Novel Approach for Validating Digital Soil Datasets with Categorical Data

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Digital soil maps are often derived using digital soil mapping tools, satellite imageries and digital terrain models as environmental covariates. Therefore several new datasets are raster based data representing soil classification categories, like WRB reference soil groups. Validating raster datasets with categorical data is not well researched and supported. No procedure and validation datasets exist that can take categorical diversity and similarity (taxonomic distance) into consideration. This approach would require an input validation dataset describing the categorical diversity of the spatial units to be validated. The aim of this study is to introduce a novel method and validation dataset design developed for this purpose.

Keywords：*WRB, validation, DSM categorical data*

P4-566

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

The Utilization of Empirical Knowledge in Digital Soil Mapping

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Digital soil mapping (DSM) is advancing soil science discipline. DSM methods are expected to yield spatially accurate and semantically rich soil information in the future. At the moment, polygon –based soil maps are generally available. They are of different scales and were produced using different, yet similar methodology. The accuracy and semantics varies largely. Traditional soil mapping is expert knowledge driven, time and resource consuming process and thus difficult to be implemented in large-scale mapping. The spatial distribution of soil types is predominantly determined on the basis of geomorphologic features and the understanding of soil formation processes. During the delineation of soil polygons the soil surveyor subjectively defines soil mapping units (SMUs) following field observations, knowledge on functioning of dominant soil forming factors and available data. In the past, spatial soil forming data sources were in general modest. The data availability has improved significantly in last two decades. The earth observation, air borne and other data collection method yields adequate digital information on main soil forming factors which can be utilised for spatial and semantic improvement of polygon soil maps to produce raster based information on soil properties as well as soil maps of better scale.

The vector based 1:25,000 Soil map of Slovenia is of small scale and accuracy and that for unsuitable for modelling at regional/municipality levels. Individual SMU polygons are defined by three predominant soil typological units (STU) and the proportion of the SMU they occupy. The spatial location of STUs within SMUs is not defined. The SMU geometry (shape and size) and the STU composition were defined by field observations and expert knowledge assessments and are that for to various extents subjective and imprecise. Nevertheless, on the country level the 1:25,000 polygon soil map represents valuable information which should be spatially improved and semantically upgraded in order to be utilised on regional/local level. Newer digital spatial data of the main pedogenetic factors, that were not available at the time of the soil mapping, enable the spatial and semantic improvement of the SMU geometry and semantic information.

In the study spatial soil property/ soil type prediction models for two different yet lithological and climatic uniform test areas were developed and tested. The 12.5 and 5m DEM were used to derive slope, exposition, curvatures. Lithology was rasterized from 1:25,000 geology map and land use from 1:5,000 scale map to 12.5 or 5 m grids. In the first stage individual soil forming factors were related to the existence/depth of individual pedogenetic horizons which develop within catenas present in the test areas. The probability of the appearance of individual horizons was determined by soil surveyors; some of them carried out the 1:25,000 soil mapping several years ago. The surveyors' experiences were used to elaborate a series of expert knowledge based models to spatially predict occurrence (presence/thickness) of dominant pedogenetic soil horizons. Soil profile data and limited field work were used to calibrate the models. The semantics of models were implemented in scripting routines and run in raster GIS. The result was a number of individual raster layers/dataset presenting the distribution of individual soil horizons. The relational database management within the soil information system was used to link soil horizon attribute data and to derive raster soil properties datasets. In the second stage, the soil classification algorithm was elaborated and implemented in raster GIS script to predict the distribution of individual soil types (STUs). The decision tree is based on national soil classification. The outputs were the raster based soil maps in 12.5 m resolution which were compared to the 1:25,000 soil map.

This two stage soil properties / soil type modelling demonstrate the possibility to improve the geometry of existing vector based soil information and to develop spatial information of individual soil properties. The results are of better spatial resolution and due to the utilization of measured digital information on soil forming factors significantly less subjective. The outputs of this two-stage method can a) instantly replace existing coarse polygon soil map based information, and b) be further utilized to produce relevant covariate information for other soil inference / digital soil mapping methods.

Keywords：*digital soil mapping, expert knowledge, raster modelling, soil properties, soil map*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Digital, Optimized, Soil Related Maps and Information in Hungary; Dosoremi.hu

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A great amount of soil information is available in Hungary due to former mappings and surveys. Presently soil data requirements are fulfilled with the recently available datasets either by their direct usage or after certain specific and generally fortuitous, thematic and/or spatial inference. Due to the more and more frequently emerging discrepancies between the available and the expected data, there might be notable imperfection as for the accuracy and reliability of the delivered products. The gaps can be filled with optimized DSM products heavily based on legacy soil data, which still represent a valuable treasure of soil information at the present time.

The main objective of the DOSoReMI.hu (Digital, Optimized, Soil Related Maps and Information in Hungary) project is to significantly extend the potential, how demands on spatial soil related information could be satisfied in Hungary. Primarily the national demands are intended to be treated, which in one hand cannot be considered independent of the GSM.net objectives and on the other hand similar or identical specifications could be applied.

Due to the simultaneous richness of available legacy soil data, spatial inference methods and auxiliary environmental information, there is a high versatility of possible approaches for the compilation of a given soil (related) map. This suggests the opportunity of optimization. For the creation of an object specific soil (related) map with predefined parameters (resolution, accuracy, reliability etc.) one might intend to identify the optimum set of soil data, method and auxiliary covariables optimized for the resources (data costs, computation requirements etc.).

In the frame of our project we executed the spatial and thematic data mining of significant amount of soil related information available in the form of legacy soil data as well as digital databases and spatial soil information systems. In the course of the analyses we leaned on auxiliary, spatial data themes related to soil forming factors as well as to indicative environmental elements. Based on the established relationships we started to convert and integrate the specific data sets for the regionalization of the various, derived soil parameters. By the aid of selected and optimized geostatistical, data mining and GIS tools we multi-mapped and optimized some basic soil properties, but we also plan to carry out the spatial extension of certain more sophisticated pedological variables featuring the state, processes (including degradation), functions and services of soils. We plan to compile digital soil related maps which fulfil optimally the national and international demands from points of view of thematic, spatial and temporal accuracy.

The specific feature of GlobalSoilmap.net project, the estimation and reporting of the uncertainty associated with soil property predictions could be utilized for the identification of better performing approaches. Based on more extended data infrastructure, national initiatives could produce more accurate and reliable products. Since the European node is explicitly inclusive for the co-operation, DOSoReMI.hu results are planned to contribute to the European part of GSM.net products.

Keywords：*legacy data, , novel soil related map, optimized DSM product*

P4-568

[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

An Approach to Help Formalizing the Purposive Sampling Strategy of Classical Soil Surveys

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Soil surveyors usually employ a purposive sampling strategy, whereby sampling locations are selected according to their expected information content about the soil. It relies on a mental model of soil-landscape relationships. This mental model is built with pedological knowledge and field experience. Its accuracy depends on the surveyor's experience and knowledge of the study area and the dominant processes that shaped the soil. However, the sampling strategy is rarely formalized, hindering the transmission of knowledge. This study presents an approach to help formalizing the purposive sampling strategy of classical soil surveys. It is illustrated using a dataset consisting of n = 340 point soil data from a survey carried out by two soil surveyors in Southern Brazil between 2008 and 2011. The approach includes (1) point pattern analysis, (2) elicitation of expert knowledge, and (3) articulation of psychological theories of perception and motivation. The results show that the sampling strategy used by the surveyors yielded a spatially inhomogeneous point pattern (i.e., spatially varying sampling intensity). A non-stationary Poisson point process model fitted to the data indicate that sampling intensity depends on physiographic strata, land use, and sampling date (time). Elicited expert knowledge and psychological theories suggest that these co-variates are proxies of the factors that drove the sampling process. First (conceptual factor), the surveyors had a better knowledge of soil-landscape relationships in some areas than in others. This is explains why some physiographic strata and land uses were more densely sampled than others. Second (operational factor), the surveyors faced access limitations that revealed an inadequate planning of field campaigns (underestimated access time to sampling locations). The temporal budget fluctuation required the initially planned number of samples (500) to be significantly reduced (300). Last (psychological factor), the topography might have influenced the perception of distances (enclosure effect). This helps explaining the higher sampling density in valley bottoms compared to plateau areas. The interplay of these driving factors caused motivation shifts (increase and decrease of motivation over the course of the survey) that intervened in the sampling process. These motivation shifts can be divided into three stages. At the first stage the surveyors were highly motivated to follow previously established sampling rules, that is, select sampling locations according to their expected information content about the soil. Their main goal was to test hypotheses posited according to the mental model of soil-landscape relationships. The second stage is marked by a decreased motivation to follow previously established sampling rules. Operational constraints required the surveyors to shift their attention from testing hypothesis to maximizing the number of samples given the available budget. Sampling locations continued to be selected according to their expected information content, but approximately regularly spaced to optimize the geographic coverage of the area. Convenience sampling was employed in areas difficult to access. When 300 soil samples had been made, giving a satisfactory geographic coverage of the area, there still was a small budget available. This marks the beginning of the last stage, when surveyors became motivate again to test their hypotheses in areas were their confidence about soil-landscape relationships was weaker, and thus obtained a few more samples. Modern psychological theories of motivation describe this sequence of motivation shifts with the U-shaped pattern of multi-goal pursuit. According to these theories, people are naturally more motivated to follow previously established working standards in the beginning and end of the course of an activity, and loosen up them in the middle. This occurs since many operational constraints appear with time, decreasing motivation, and because beginning and end (vs. middle) actions have a greater weight on the image people make about themselves. The support of these theories gives a sound foundation to the approach illustrated here, since soil surveyors usually pursuit many goals and face several operational constraints when sampling the soil. Assessing the reliance of the approach depends on its replication using other datasets. The next step will consist of building a mathematical representation of the sampling strategy formalized here. This will enable conducting simulation exercises regarding budget scenarios to evaluate the effect of different sample sizes on the performance of digital soil mapping models. The objective is to help in the efficient planning of soil observation campaigns.

Keywords：*Pedometrics; Sampling strategy; Point pattern analysis; Expert knowledge; Means-focused motivation.*

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[WG13] Progress in Digital Soil Mapping and GlobalSoilMap

Building Digital Soil Maps of Canadian Managed Forests at 250 M of Resolution Using the K-Nearest Neighbour Method

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Abstract: Mapping Canada's forest soil is a nation-wide challenge considering the size of the country and low population density. At the same time global need for large-scale soil mapping with high resolution is increasingly sought after in environmental resource management but production of this kind of dataset is still time and money consuming. This study generated digital national maps of selected soil variables (C, N and soil texture) for the landbase Canadian managed forests at the resolution of 250 m using the k-nearest neighbour method (k-NN). The k-NN soil mapping method was computed utilizing a training dataset containing 538 field plots from the National Forest Inventory (NFI) across Canada, and 18 environmental predictor variables. The best predictor variables were selected (6 topographic and 6 climatic variables) using the hybrid LASSO selection. The performance of the k-NN approach was assessed with the root mean square error (RMSE). The relative RMSE indicates values ranging between 22% and 99%, depending on the soil variables tested. RMSE values < 40% can be considered a good imputation considering the low density of points used in this study. The study demonstrates strong capabilities for mapping soil at 250 m resolution, compared to the current Soil Landscape of Canada System, which is largely oriented around the agricultural land base. The production of these soil maps, in addition to the ease of use, could certainly meet the national and international need for high quality soil and spatially explicit information in resource management science.

Keywords：*Climate, Euclidean distance, managed forest, raster, soil texture, topography, SCORPAN*

P4-570

[WG23] Progress in Digital Soil Mapping and GlobalSoilMap

Changes in Soil Properties in the Agricultural Fields of Korea

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Historical soil data in agricultural fields can provide an idea of soil properties change with time with regards to farming practices and environmental conditions. A Korean soil database used in this study was compiled based on soil fertility database which was continually collected as a part of the National Soil Survey Projects and Fertilizer Recommendation Program in Korea since 2980. Soil surface samples from 0 to 25 cm were randomly collected for soil fertility recommendations: (amount, type, and the timing of fertilizer application for optimum plant growth) from diagnosis of soil nutrition in the field and for monitoring purpose as well. The number of soil data accumulated in the database is up to 7 million samples as of 2022. Soil organic matter, pH, available phosphate, potassium, calcium, magnesium were analyzed in the laboratory of soil testing and diagnosis at Agricultural Technical Center of each city or county and provincial Agricultural Research Center. Soil and Environment Information System of Korea provide a web-based fertilizer recommendation system to Agricultural Technical Center and provincial Agricultural Research Center with their own ID and password to access the system to use the data management and functions of the system. When the farmers utilized the system for fertilizer prescription, they input the soil data analyzed on the system, the soil data automatically are uploaded to the database server with format in the Soil and Environment Information System of Korea. We converted the soil property data to GIS format with parcel information as a key for spatial inference. We grouped soil fertility data by land use into paddy field, upland field, orchard, and plastic film house. We also grouped the data into 5 year intervals to investigate soil property change in time. Soil property change in regard to environmental conditions and farming practices will be presented.

Keywords：*Soil fertility database, soil change, soil property, Korea*

P4-571

Soil Organic Carbon Sequestration Rates under Crop Sequence Diversity, Bio-Covers, and No-Tillage

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Climate change may be mitigated through soil organic carbon (SOC) storage under no-tillage, however, crop management influences on SOC are not well defined in all systems. Our objective was to compare long-term carbon fluxes under two no-tillage sites at Research and Education Centers (REC) in Milan (RECM) on Oxyaquic Fragiudalfs and at Middle Tennessee (MTREC) on a Typic Paleudalf, in a split-block design with four replications. The whole-block was cropping sequences of corn, soybeans, and cotton with split-block bio-cover treatments of: winter wheat, hairy vetch, poultry litter, and a fallow control. Same sequences were carried out at MTREC without cotton. Soil carbon flux was calculated at surfaces (0-5 cm) and sub-surfaces (5-25 cm) during yr-0, 2, 4, and 8. During the first 2-yrs, carbon losses occurred in all treatments and locations (2.40 and 2.20 Mg ha^{-2} at RECM and MTREC, respectively), with stabilization initiating by yr-4. By yr-8, sequences with high frequencies of soybean and greater temporal complexity gained more surface SOC. Poultry litter bio-covers gained more surface SOC compared to wheat, vetch, and fallow bio-covers (P<0.05). After 8-ys, surface SOC surpassed initial levels (9.20 and 8.79 Mg ha^{-2}), with mean gains of 2.33 and 2.26 Mg C ha^{-2} at RECM and MTREC, respectively. Losses occurred in subsoils at MTREC and RECM, but by yr-8 several treatments had recovered to near baseline levels. Results suggest surface carbon storage may be enhanced by crop sequence diversity combined with poultry litter bio-covers in no-till systems, whereas, sub-surface levels may require more time.